

# Equipment and facilities adapted for disabled people in recreation and sport

## Abstract

There are a growing number of disabled people who are interested in recreation and sport activities. Engineering has several devices to offer for activities in many places in the world. There are many examples of simple and sophisticated equipment, including computerized devices like wheelchairs for recreation and sport activities. There are sport competitions involving four groups of disabled sportspersons, namely 1) the deaf, 2) people with physical disability, 3) people with intellectual (mental) disability, 4) people supported by specially designed high level engineering equipment. All of them can use many kinds of equipment and facilities.

**Keywords:** recreation, sport, disabled persons, engineering, equipment, facilities

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## Introduction

Orthopedics and rehabilitation backed by substantial help of engineering offer people with disfunctions several kinds of orthoses and prostheses. They have also special fitness equipment, stands, and rooms to enhance their fitness level in order to improve their level of life and to use recreation and sport as a part of their off hospital rehabilitation.<sup>1</sup> For several years society increased its approach to disabled people in order to integrate them with able body people. But many years went through when society realized disabled people i.e. weak, injured, people with different sickness or physical limitations, and also old people needed recreation activity. The most often activities used by people in need are visits to the parks, forests, seaside, lake areas, or mountain valleys. Today recreation areas can be reached by several transportation devices and tourist agencies have special offers for disabled people.

In the second half of the 20th century a movement of accessible tourism was developed. According to Darcy & Dickson<sup>2</sup> this kind of tourism enables people with disability, including mobility, vision, hearing and cognitive impairments, to function independently or with assistance of guides through the delivery of universally designed tourism products, services and environment. For many years disabled people, especially those who were disabled since their birthday or soon after, and also those who were active sportspeople and were involved within an accident living them in disability, wanted to be active within sport community. There are special classes for disabled sportspersons. Athletes with disability are categorized in classes defined by the degree of disfunction. This takes into account a kind, place, and level of disability.<sup>3</sup>

The aim of the paper is to present engineering products that help disabled people in their recreation and sport activity. In the paper interaction of engineering and disabled persons and also sport activists are presented who need special equipment and also facilities specially designed for disabled persons are shown.

## Review of the literature

Disabled people were spotted all over the world in the entire history of the mankind. This was due to the wrong genetic copies of DNA

(congenital disability), accidents or diseases during developmental and adult lives, many fights and wars that humans underwent through the centuries. As Kozma<sup>4</sup> mentioned there are plenty of statues, reliefs, records, drawings found from ancient Egypt showing people with disabilities. Mahran & Kamal<sup>5</sup> described it as body deformities and physical deformities of the movement system. They were given special equipment, e.g. sticks, canes, and crutches for better locomotion. Quite different approach appeared in ancient Greece and Rome where they empathized the beauty and perfection of the body. During the Renaissance there was rebirth in the history of prostheses. They were generally made of iron, steel, copper and wood.<sup>6</sup> Especially Ambroise Paré invented several upper and lower extremities' prostheses.<sup>7</sup> They helped disabled people in their everyday and recreation time. During the 18th and 19th centuries the situation with orthoses and prostheses did not foster much advancement. Following World War II on the demand of war veterans in order to have more advanced prostheses important project was performed. Inman & Eberhart<sup>8</sup> conducted at the Biomechanics Laboratory of the University of California, Berkeley research work on human normal and pathological gait. After World War II, investment emphasized the rehabilitation of disabled veterans. Medical rehabilitation and rehabilitation engineering flourished, especially in the development of prosthetics and orthotics.<sup>9</sup> The most advanced step in biomedical engineering happened when electronic/computerized devices were introduced for orthoses and prostheses.

Today about 1 billion (15% of the world's population) experience a disability. There are more than 10 million wheelchair users in developed nations. In developing nations, only 5-15% of people who need wheelchairs have them.<sup>10</sup> There are potentially huge population who would enjoy recreation and sport activities being disabled. Several authors in the 20th century up to recent times wrote on positive influence of physical activity on disabled persons and proposed many recreation and sport activities.<sup>11-16</sup> Institutions (e.g. United Nations) and national governments encourage or introduce rules for engineers to design equipment and facilities, including recreation and sport facilities, accessible for disabled people.<sup>17-19</sup> Also individual scientists and engineers presented their views or designed new technologies for disabled people to improve their physical activity.<sup>20-23</sup> Recreation and disability

## Engineering and disabled people

For many years people with disability lived at homes with no possibility of leaving their rooms and to take part in recreation activities. Today these people can use wide corridors, automatically opened doors, elevators, escalators, special ramps. They can use specially prepared both public transport (buses, tramways, trains) and private transport (bicycles, cars). These transport devices are equipped with low floors or with platforms or ramps so that disabled people can access the car or train's floor (Figure 1). Also public areas are prepared for disabled people. There are low level curbs for crossing the street by people with crutches, or riding the wheel chair. There are also special places at the parking lot designated for disabled drivers and/or passengers. Recreation areas are technically prepared for reception of disabled people. There are several kinds of special equipment which give disabled people an opportunity of utilization of these areas. European Network for Accessible Tourism<sup>24</sup> issued a Code of Good Conduct which includes among other the following: a) all people have the right to enjoy tourism, whatever their background or abilities; b) all customers are welcome, c) removing and preventing all access barriers of infrastructure, products, services and information, using a 'design-for-all' approach.

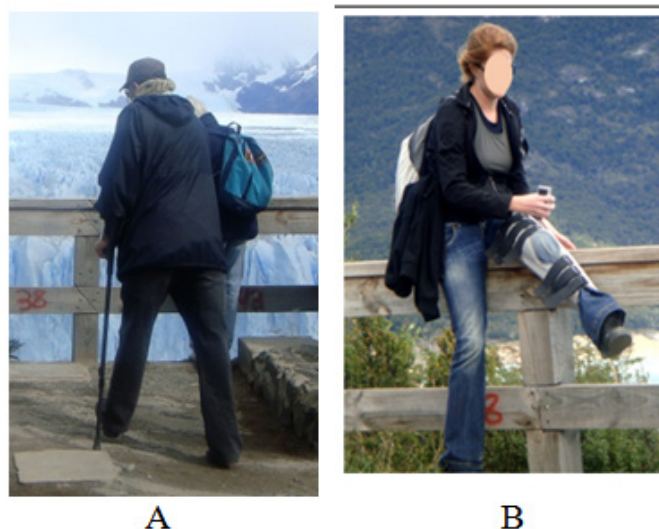


**Figure 1** Accessibility of transport devices: (A) car; (B) tramway.

## Special recreation equipment

Disabled people in order to take part in a recreation activity use rehabilitation equipment like canes, crutches, or orthoses. This enables them to go on their own legs at the tourist places (Figure 2). Endings of prostheses have sometimes crampons enabling people to walk across snow covered areas or across the glacier. Other people can use electric bicycles or standard or electric wheel chairs (Figure 3). Sometimes wheelchairs are equipped with adaptive tires or caterpillars for travelling across sand or snow. Other chair equipment has skis underneath enabling skiing with a partner or alone. Disabled people who can't walk and want to be immersed into the water at the swimming pool can use special chairs which are attached to the lift. The chair with a patient can be lowered so it can immerse into the water of a pool. Water equipment is designed in order people with disabilities can use kayak and rowing boats or sail boats. These boats are wider, with a possibility of taking a folded wheel chair, sometimes with special floating tanks on both sides of a boat. Robots can assist people with disabilities in their movement at the tourist places. Robots can carry luggage, can show the direction to the hotel facilities, can

answer on some questions. They can do it in different languages.



**Figure 2** Personal rehabilitation equipment ((A) crutch; (B) orthosis) enables people with disability to walk at the tourist places; here at the Perito Moreno Glacier tourist area, Patagonia, Argentina



**Figure 3** Electric locomotion equipment enables people with disability to move at different places: (A) at the Southern Patagonia, Argentina; (B) at the Kennedy Space Center, Florida, USA

## Special recreation facilities

There is growing demand from travelers who want better access in hotels, at holiday destinations and tourist attraction. According to Vos & Ambrose<sup>25</sup> there is still generally a lack of availability in terms of accessible accommodation, transport modes, attractions and activities for disabled people. Also in the opinion of Christoffe & Massiera<sup>26</sup> services offered to disabled tourists on the French Riviera are the product of a mixture of willingness and obligation by the regulation. Disabled people are not yet considered as real clients but as a separate population. Facilities for disabled people should be characterized by at least easy access to buildings, to the rooms, to the toilets, to the recreation areas. This can be achieved by accessible environment, i.e. even paths, specially prepared walkways sometimes with easy stairs (Figure 4), automated doors.





**Figure 4** Specially built walkway in order to use it by people who can't walk on steep sides of a hill; here: tourist area near the Perito Moreno Glacier, Patagonia, Argentina, where about 1 km walkway was built

## Sport and disability

### Engineering and disability of athletes

Disabled sports (adaptive sports, parasports) are sports performed by persons with physical and intellectual disabilities. There are four disability groups: 1) the deaf, 2) people with physical disability, 3) people with intellectual (mental) disability, 4) people supported by specially designed high level engineering equipment. Organized sport for persons with physical disabilities existed since 1911, when the “Cripples Olympiad” was held in the USA. Following the Second World War in response to the needs of many injured soldiers and civilians sport was introduced as an important part of rehabilitation.<sup>27</sup> For many years engineering is helping athletes with disability. This takes into account personal equipment, special stands, rooms and whole facilities.

### Special sport equipment

The oldest equipment for competitive sport for disabled athletes was wheelchairs used on the track. They were used at first in 1948 when Sir Ludwig Gutmann organized Stoke Mandeville Games, which evolved into the modern Paralympic Games.<sup>27</sup> In the following years wheelchairs were used in several other sport disciplines, like: different ball games, hockey, fencing, and weightlifting. Then many other designs appeared: handbikes, running prostheses, sleds, even exoskeletons. They are of different levels of assistive technology: a) simple, b) low tech, c) advanced technology, d) computerized technology. Today handbikes are of many different designs. There are handbikes for people with existing but paralyzed lower extremities (Figure 5) and for people without lower extremities (Figure 6). Very

popular among disabled athletes who lost their lower extremities are specially designed prosthetic devices. There are different types of these devices used for running, climbing, cycling, skiing (Figure 7).

There was and still is a controversy whether disabled athletes can participate within the competition together with able-bodied athletes. Unfortunately runners who use carbon fiber prostheses are in favor since their device returns much higher amount of energy than do a foot of able-bodied runners.<sup>28</sup> In addition these light prostheses have much lower moment of inertia giving much lower resistance to the propelling muscles.<sup>29</sup> Very special sport equipment represents ReWalk Robotic Exoskeleton (ReWalk Personal System) built by Argo Medical Technologies. This device was designed especially for people with tetraplegia. This exoskeleton is a wearable robotic exoskeleton that provides powered hip and knee motion to enable individuals with spinal cord injury to stand upright, walk, turn and climb and descend stairs.<sup>30</sup> It works based on feedback from the state of the patient's extremities. Steering is done from the pilot worn on the wrist and keys mounted on the crouches. Energy is supplied from the battery carried within the backpack. It can operate through the whole day. In 2012 Claire Lomas (UK) walked using a ReWalk the distance of the marathon (42195m) in 17 days. In 2016 Swiss Federal Technical University in Zurich organized the first competition for people with disabilities, who, supported by the latest assistant systems in various disciplines, competed against each other and solve everyday tasks (Figure 8). There were the following disciplines where robotic assistive devices were used:<sup>31</sup> 1) powered wheelchairs, 2) cycling with electrical muscle stimulation, 3) exoskeletons, 4) powered upper extremity (arm) prostheses, 5) powered lower extremity (leg) prostheses, 6) brain-computer interface race (Figure 9).

### Special sport facilities

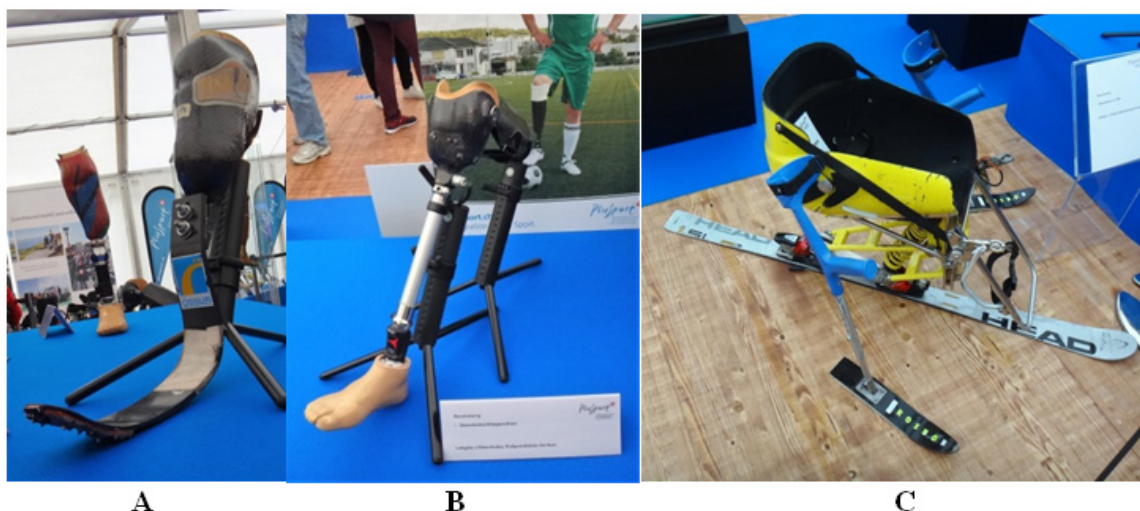
In a publication “Accessible sport facilities” the authors stated that good facilities are fundamental to developing sporting opportunities for everyone, from the youngest beginner to the world class athlete. The design and maintenance of sport facilities need to follow the Inclusive Design principle. This includes considering the needs of older people alongside the needs of disabled people—with sensory, cognitive and mobility impairments.<sup>32</sup> Sport facilities must have easy access for both competitors and spectators. Competitors need an access to the sport arena, locker rooms, toilets, rooms with equipment. Spectators should have access to the designated stands, to the service booths, to the toilets. There exists a high difference in sport facilities' accessibility for disabled people. Taking into account some big older stadiums there is no access for disabled persons, while the new designs include access for wheelchair people (Figure 10).



**Figure 5** Handbikes designed for disabled athletes with paralyzed lower extremities



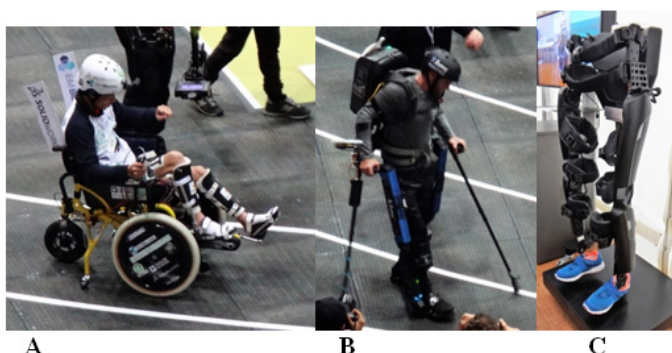
**Figure 6** Handbikes designed for disabled athletes without lower extremities.



**Figure 7** Prosthetic devices which substitute parts of lower extremities for: (A) running and jumping; (B) football; (C) skiing



**Figure 8** Cybathlon 2016: (A) general view of the sporthall in Zurich-Kloten; (B) wheelchair competitor on the track with obstacles.



**Figure 9** Cybathlon 2016: (A) competitor in a wheelchair; (B) competitor with exoskeleton, C-exoskeleton alone.



**Figure 10**: (A) friends are helping disabled person in access to the stand during football match in Rio de Janeiro stadium; (B) new design of a sport hall in Sao Paulo with a ramp for spectators using wheelchairs.

## Conclusion remarks

With ever improving areas of recreation, including tourism, and fitness and sport within the society, also improves quality of recreation and sport equipment and facilities. Such events like Paralympic Games, and covering of them by television broadcasters, help in better approach of the society to the problem of recreation and sport activities of disabled people. Also growing interest of recreation business and business of sport equipment is a motor for development of participation of people in tourism and sport. More and more tourist destinations have good access for all people despite of their age, level of mobility or mental level. In several countries administrators issued rules which deal with accessibility to public places. With the aging society the number of people with disability will be growing. Also the development of technical civilization and poor recognition



of dangerous devices or situations will raise a number of disabled people, especially among the younger generation. In order to prevent them against accidents an education campaign should be introduced. This must include biomechanics, physiology, hygiene where the interaction of the human body and equipment and environment should be explained.

The future work can encompass several other areas of recreation and sport, namely home equipment, free access open air stands for disabled persons as it is already now established for able bodied people. Also exploration activity, e.g. tracking high mountains, travelling across continents by disabled people, or extreme sports, e.g. parachute jumping, can be described.

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## Conflict of interest

Author declares that there is no conflict of interest.

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