

# REVIEWS

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## Wheelchair Development from the Perspective of Physical Therapists and Biomedical Engineers

### Rozwój wózków dla niepełnosprawnych z punktów widzenia fizjoterapeutów i inżynierów biomedycznych

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#### Abstract

Wheelchairs are basic equipment for many disabled people, providing them with independent mobility – usually their primary means of mobility. The purpose of this paper is to appraise them from the common point of view of physical therapists and biomedical engineers working on the development of wheelchairs. The paper expands on the concept of “the disabled person’s integrated environment” and, as a part of it, “the disabled person’s integrated IT environment”. The premise is that this will improve physical therapists’ understanding of wheelchair development, and enhance their ability to improve their patients’ quality of life and functional possibilities (*Adv Clin Med* 2010, 19, 6, 771–776).

**Key words:** rehabilitation, biomedical engineering, rehabilitative engineering, wheelchair.

#### Streszczenie

Wózek jest podstawowym elementem zaopatrzenia rehabilitacyjnego dla wielu osób niepełnosprawnych. Zapewnia mobilność, zwykle jako podstawowy środek transportu. Celem niniejszej pracy jest omówienie wspólnego punktu widzenia fizjoterapeutów i inżynierów biomedycznych na kierunku rozwoju wózków dla niepełnosprawnych. Szczególny nacisk został położony na koncepcję „zintegrowanego otoczenia osoby niepełnosprawnej” i jego części, jaką jest „zintegrowane środowisko teleinformatyczne osoby niepełnosprawnej”. Przyniesie to fizjoterapeutom lepsze zrozumienie kierunków rozwoju wózków dla niepełnosprawnych oraz da sposobność ich przewidywania i kształtowania. Pomoże również podwyższyć jakość życia oraz możliwości funkcjonalne ich pacjentów (*Adv Clin Med* 2010, 19, 6, 771–776).

**Słowa kluczowe:** rehabilitacja, inżynieria biomedyczna, inżynieria rehabilitacyjna, wózek dla niepełnosprawnych.

The use of assistive technology is an increasingly widespread way for people to adapt to disabilities, and wheelchairs are basic equipment for many disabled people. Their rapid development started about 150 years ago, but the idea and basic principles have existed since the 15th century. Typical wheelchair users are individuals with spinal cord injuries, balance disorders, etc., as well as older and weak people. Wheelchairs provide them independent mobility, usually as their primary means of mobility, and can give them a chance to lead an independent life. Developing wheelchairs is a joint responsibility of medical professions (especially physical therapists) and biomedical engi-

neers. The former perceive the wheelchair as an assistive device, necessary for patients with walking disabilities and limitations (both ageing and severe illness). The thinking of physical therapists can be described as patient-oriented: Physical therapists observe the patient’s functional possibilities and limitations and, on this basis, help him/her in goal-setting procedures in order to achieve as much as possible during and after therapy. Patients with different combinations of symptoms can benefit from different types of assistance and have different contraindications; different wheelchairs, assistive devices and additional equipment will be optimal for different patients [1, 2]. Research in-

dicates that the majority of wheelchair users have customizable wheelchairs (97% of manual wheelchairs and 54% of powered wheelchairs) [3]. In contrast, the thinking of biomedical engineers can be described as mechanism-oriented: They perceive the wheelchair as a useful mechanism, made according to biomechanical rules and implementing many modern solutions. This mechanism can easily be adjusted to the requirements of individual patient. Working together, physical therapists and biomedical engineers can maximize the potential of a complex human-mechanism (i.e., patient-wheelchair) system. At the same time, problems with wheelchairs can result in secondary injuries or a severe decline in independence, which can require increased assistance [4–10]. Frequent wheelchair breakdowns can negatively impact a disabled person's life, not only in terms of health and safety, but terms of community participation as well.

## Divergent Viewpoints

Figures 1 and 2 show how both of the aforementioned professions perceive wheelchair design. Comparing the two, it is not hard to find the common question: *How can the patient's functional possibilities be maximized?* But the key question is: *How can these different approaches to the same problem be consolidated?*

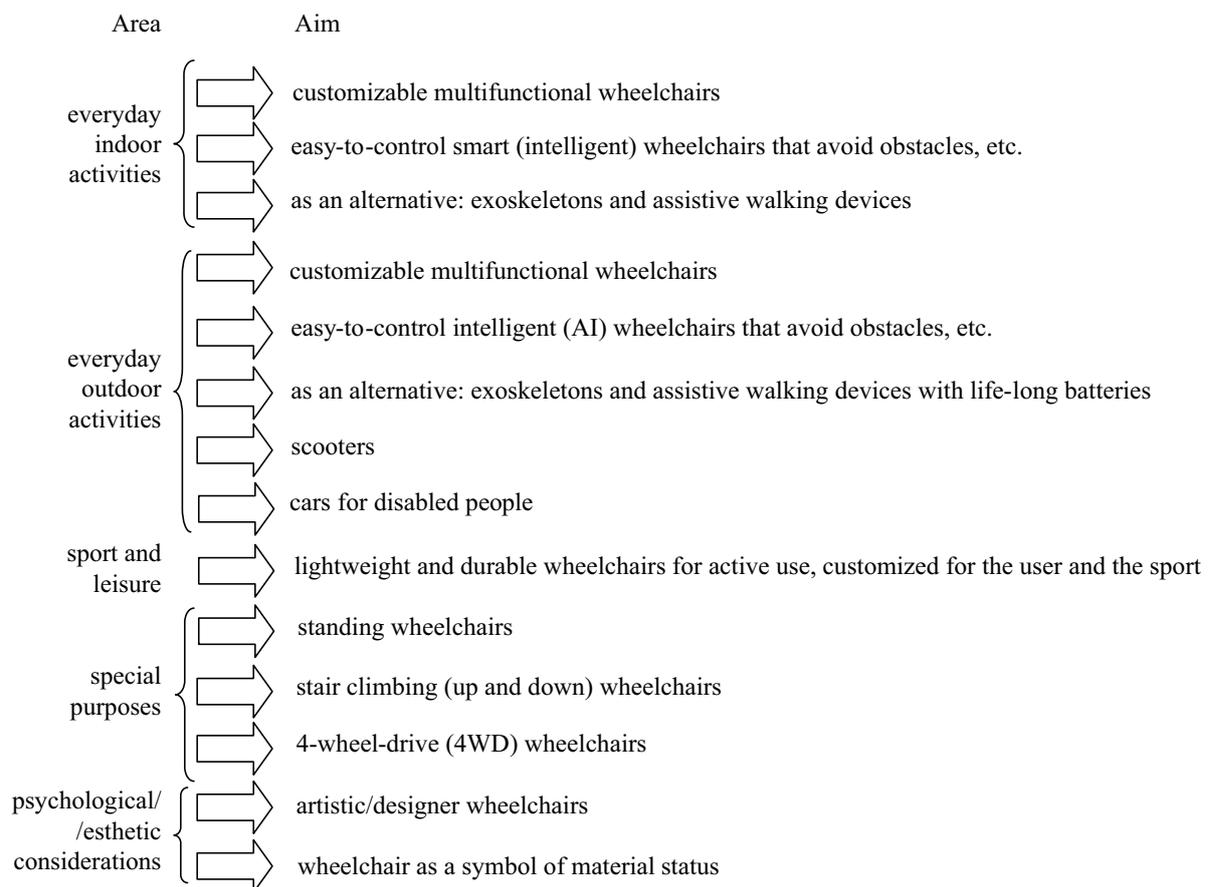
The main aims are to make wheelchairs:

- safer,
- more effective,
- widely available,
- easy to use, so that even people with reduced physical, perceptual and cognitive skills can operate them independently, and

– easy to modify.

It is crucial to provide:

- wheelchair quality and ergonomics,

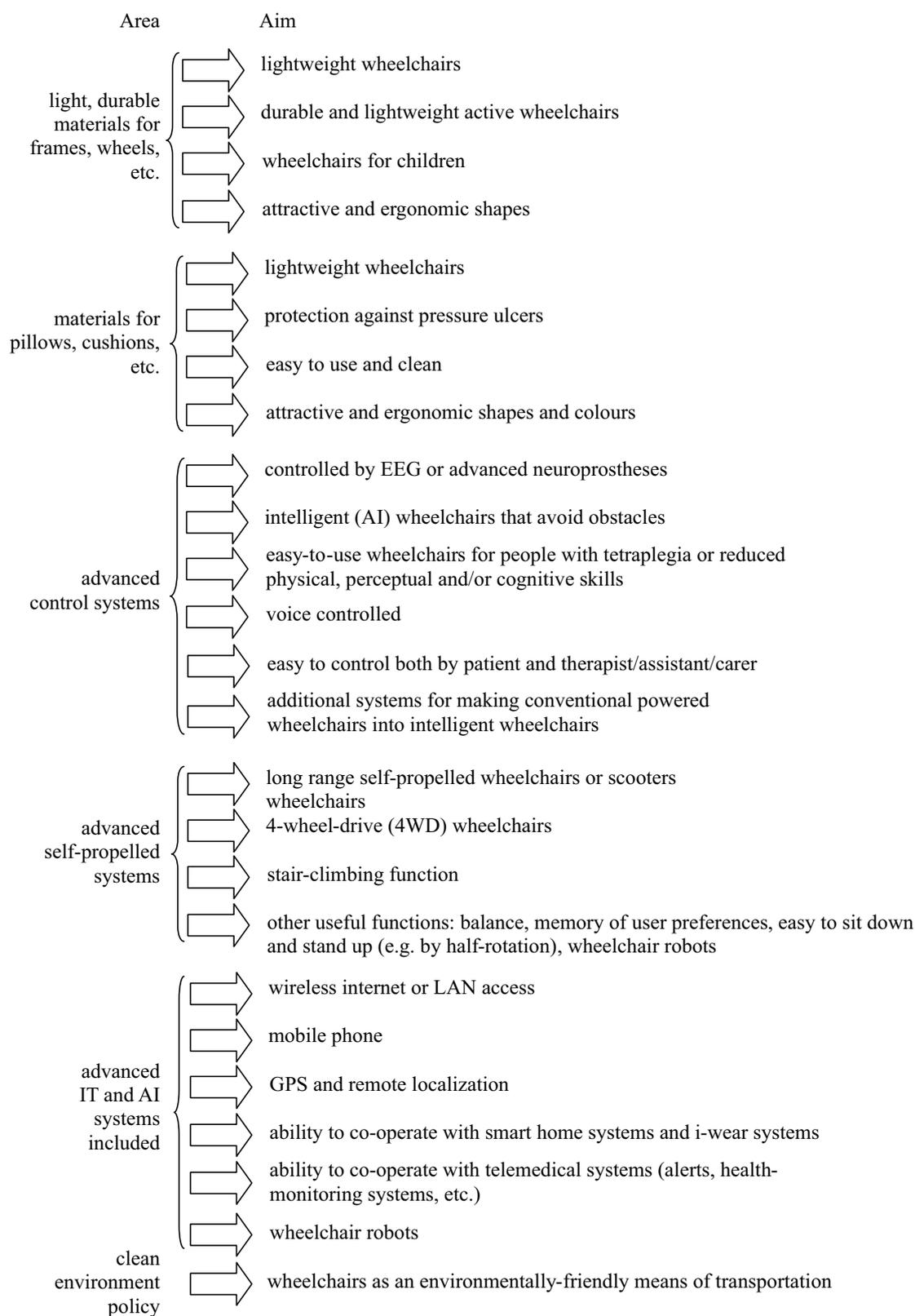


### Remarks:

- 1) *Priorities: health conditions, goals set by the user and therapist, impact on life quality and well-being of the patient, social cost and significance.*
- 2) *External influences include general progress in medicine and assistive technology.*
- 3) *Development of low-cost wheelchairs, both powered and manual, is necessary for poor countries.*

**Fig. 1.** Directions in wheelchair development from the perspective of physical therapists [1, 2]

**Ryc. 1.** Kierunki rozwoju wózków dla niepełnosprawnych z punktu widzenia fizjoterapeutów [1, 2]

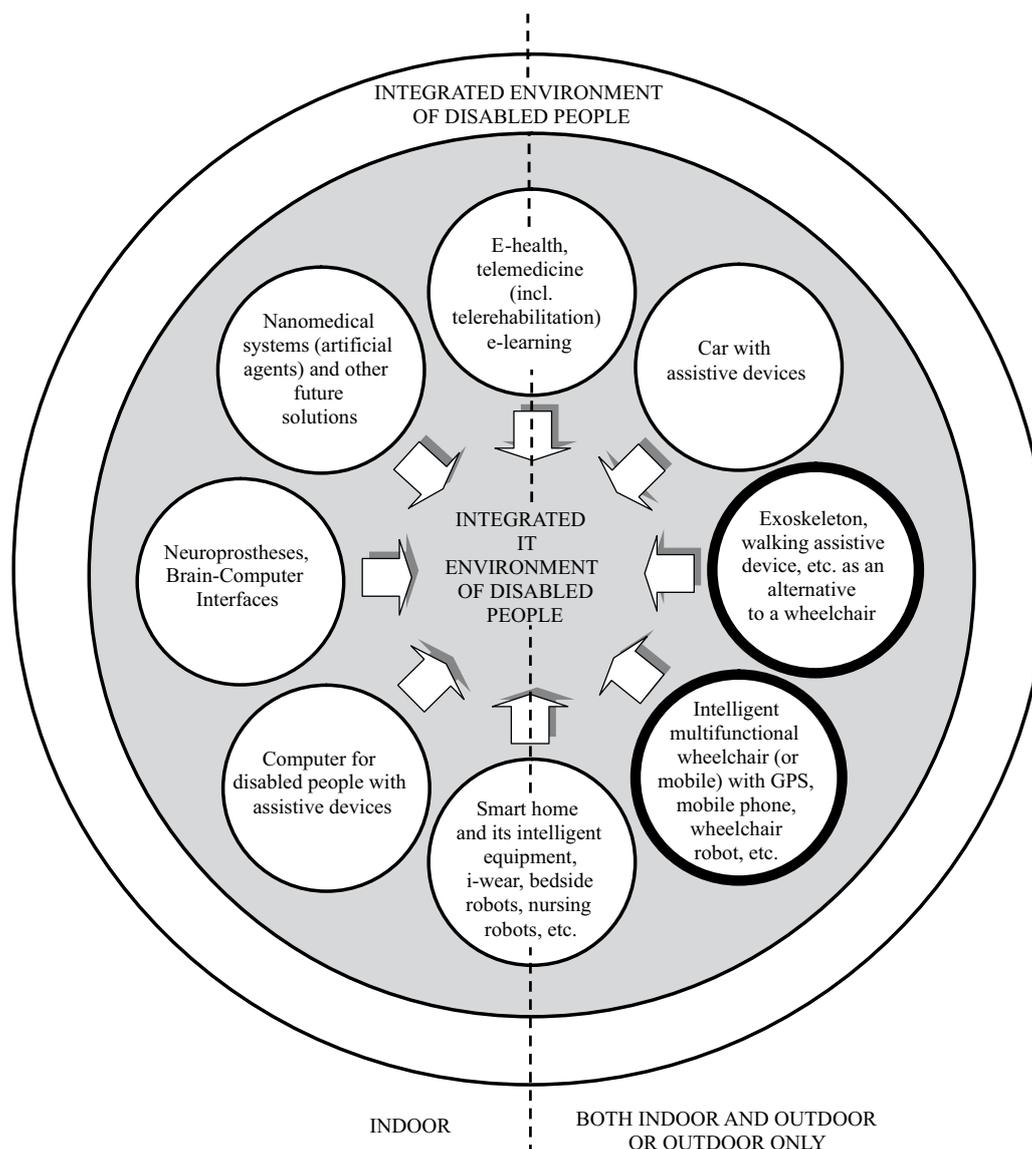


Remarks:

- 1) *Priorities: cost/outcome analysis and evaluation of results.*
- 2) *External influences include general progress in material engineering, LAN, batteries, new standards, recommendations and guidelines.*
- 3) *Advanced technology will require specialists to choose/adjust/service wheelchairs and additional equipment, and to instruct patients and their carers.*

**Fig. 2.** Directions in wheelchair development from the perspective of biomedical engineers [1, 2, 11–19]

**Ryc. 2.** Kierunki rozwoju wózków dla niepełnosprawnych z punktu widzenia inżynierów biomedycznych [1, 2, 11–19]



**Fig. 3.** The concept of disabled people's integrated IT environment (it can also be easily adapted for severely ill or ageing people) [7, 8, 15, 20–24]

**Ryc. 3.** Koncepcja zintegrowanego środowiska teleinformatycznego osoby niepełnosprawnej (może być łatwo dostosowane do potrzeb osób przewlekle chorych lub w podeszłym wieku) [7, 8, 15, 20–24]

- standardization (especially in the area of new technologies),
- clear clinical prescribing criteria,
- patient education and training,
- a reduction of secondary injuries and wheelchair-related accidents.

Additionally, some wheelchair users find operating them (both manual and powered wheelchairs) difficult or impossible. In these cases human-robot integration can be a useful solution, taking full advantage of the abilities of both the patient and the wheelchair.

## A Common Perspective

A common perspective can be found in defining the *integrated environment of the disabled person*. This is a set of elements in the disabled person's environment (home, work, commercial settings, etc.) which together can help increase his/her functional abilities or made his/her life and care easier. To avoid mistakes, this environment should be created with professional guidance. In the case of wheelchair users, one of the aims of the disabled person's integrated environment is to make it easy to use the wheelchair. Technical developments, especially in the areas of information technology (IT) and communication, can provide

a lot of solutions to suit the needs and preferences of the patient, which can help both patients and carers. Together, these solutions comprise the integrated *IT environment of the disabled person*. From the technical point of view it is essential to provide interoperability between solutions, taking all existing solutions in this area under consideration and choosing the best of them.

It seems very probable that in several years the disabled person's integrated IT environment of the will be treated as a very important part of his/her integrated environment. This will be a step toward supporting disabled people using Ambient Intelligence (AmI) [25, 26].

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## Conclusions

Progress in technology, including robotics, machine learning, IT and communication shows a great deal of promise in the emerging areas of assistive technology, assisted therapy and rehabilitation. Despite their different purposes and tools, physical therapists and biomedical engineers have to co-operate to achieve their common goals. This co-operation can help significantly in accelerating wheelchair development. Further significant advances in wheelchair design can be expected during the coming years, and physical therapists and biomedical engineers should learn to work together to plan and shape it.

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