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Polymers as a Chance for the Active Rehabilitation of People with Disabilities

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Abstract
The purpose of this article is to show the importance of polymers in the rehabilitation of people with disabilities. The article takes into account medical, sociological and economic aspects of the issue under study. It turns out that both medical and occupational rehabilitation have a significant impact on the professional activity of a person with a disability. What is more, there is a close interdependence between the type of disability and the ability to perform specific activities. Persons with disabilities, due to the damage to the body, do not lose all abilities and retain the ability to perform many activities necessary in life, work, etc. Some of the abilities, after being identified and improved, can be the basis for starting rehabilitation, training, and then s professional work. In many cases, early and properly conducted rehabilitation is invaluable. However, it would not be possible without many devices which are made using polymers. They are used for the production of prostheses for limbs, joints, tendons, as well as teeth. They are also used during medical diagnosis, rehabilitation and prophylactic activities. The review of domestic and foreign literature confirms that the use of polymers in medicine significantly improves the quality of life of people with disabilities and enables them, through rehabilitation, to return to physical and professional activity. And although all polymers used to produce the above-mentioned elements must undergo a special modification in order to increase their overall strength and provide them with essential properties for utility purposes, undoubtedly modern medicine cannot do without polymers.

Key words: *polymers, person with disability, rehabilitation, medical applications.*

Introduction

People with disabilities already account for over 15 percent of the population of the European Union. According to the definition included in the Charter of Rights of Persons with Disabilities, people with disabilities are those whose "physical, or mental capacity permanently or periodically impedes, limits or prevents daily life, study, work and performing social roles, in accordance with legal and customary norms, who have the right to independent and active life and cannot be subject to discrimination" [1]. In turn, World Bank experts recognize that "[...] disability includes health issues, [...] and the main goal of analyses should be to [...] indicate how to speed up the rehabilitation of disabled people" [2]. Disability from the medical point of view is defined as a limitation or loss of sight or hearing, or locomotor constraints. Social psychologists emphasise that "damage becomes significant when it becomes permanent, and damage in the emotional and psychological area turns into functional disorders" [3]. Numerous studies carried out by representatives of medicine, psychology and sociology show that although the type and scope of the disability is a direct contraindication to performing specific tasks, it can also be a determinant of the possibility to perform a different profession [2]. Persons with disabilities, due to the damage to the body, do not lose all abilities, but retain the ability to perform many activities necessary in life, work, etc [4]. Some of the abilities, after being identified and improved, can be the basis for starting rehabilitation, training, and then professional work [5]. The development of modern medicine has made it possible to use polymers in external implants and prostheses as well as in artificial and hybrid organs. Tissue and genetic engineering is also increasingly using macromolecular compounds of polymers. It turns out that both polymers and polymer composites are used in the treatment and rehabilitation of people with disabilities. However, in order for a person with a disability to be able to enter for the first time or return to the labour market, early and properly conducted rehabilitation is priceless.

Materials and methods of research

The analysis was made based on statistical-empirical material provided by the Central Statistical Office (GUS) within the framework of the quarterly Labour Force Survey (LFS) and on the results of European Union Statistics on Income and Living Conditions (EU SILC) 2010. The author used the analysis and criticism of the literature and supported it with statistical analysis.

Disability and professional competences

According to the results of the Labor Force Survey (LFS) conducted by the Central Statistical Office, in 2017, there were 1.680.000 people of working age who had a proven degree of disability (annual average) [6]. Taking into account only data on the professional activity of disabled people in Poland in 2017, we note that the activity rate was 28.9%; the employment rate 26.3%, and the unemployment rate 9.3 percent [6]. For comparison, the above-mentioned measures for non-disabled people in Poland were, respectively, 79.8%; 75.9% and 4.9 percent [6] (***Table 1***).

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According to the data obtained within the EU SILC in 2010, the most numerous group of people with disabilities were persons with injuries and diseases of sight and the musculoskeletal system. The next group includes disabled with diseases of the circulatory system, then people with neurological disorders, as well as those with injuries and diseases of hearing. Disabled people with mental retardation and mental disorders were less represented than those with other illnesses (***Table 2***).

Table 1. *Number of disabled people by age and disease group in Poland in 2010.* ***Source:*** *Author's own compilation based on the results of European Union Statistics on Income and Living Conditions (EU SILC) 2010.*

Disease group	Age							
	Total	15-19	20-29	30-39	40-49	50-59	60-69	70 and over
	in thousands of people							
Ocular impairments	2835.9	37.7	77.4	102.3	242.3	655.7	590.6	1129.9
Damage to the locomotor system	13388.7	25.4	40.6	29.3	87.9	279.2	299.9	623.3
Aural impairments	696.5	4.2	17.0	17.9	20.9	83.9	123.2	429.4
Circulatory system diseases	2520.6	10.1	28.2	23.5	139.5	559.1	637.6	1122.5
Neurological diseases	1676.1	33.6	77.6	85.8	160.3	399.5	334.5	584.9
Mental disorders	511.8	19.1	47.7	45.7	92.3	138.7	69.0	99.4
Mental retardation	201.9	25.8	49.6	25.4	36.5	30.0	10.4	24.3
Other illnesses	1378.5	23.6	58.3	51.7	127.4	329.0	318.3	490.9

The following types of disability are presented in the context of the professional competences of people with various disabilities. Physical disability (diseases of the locomotor system) was the first discussed, followed by vision problems and disability of the hearing organ and blindness.

One of the types of disability is that of musculoskeletal dysfunction (physical disability). The population of people with mobility disabilities is a diverse group, because they are people with both minor motion injuries and those with a complete movement disability who need support. It is a disability of the lower limbs, upper limbs or spine as a result of damage or underdevelopment of the brain, as well as damage to the nervous, muscular or bone system [8]. The above-mentioned limitation may be total or partial, congenital or acquired. The main problems of people with upper limb dysfunction are limitations or difficulties in performing manipulative activities. The damage may affect one or both hands. In the case of dysfunctions of one limb, occupational capabilities are much greater than those of both limbs, because in the second case manipulative activities are completely precluded. In the situation of one limb injury, these people can take up a mental job if they have the proper education, qualifications, and a work station suitably adapted to their disability. Employment in physical work depends on the type and severity of the disease of the organ. Persons with a lower limb dysfunction can perform production and manipulation activities performed in a sitting position or mental work. To be active, people with a disability of musculoskeletal dysfunction can adopt products manufactured with the use of polymers like tendon prostheses, prostheses of joints and bones of the hand as well as hip and knee joint prostheses.

Visual defects manifest themselves in a complete lack of vision or its serious limitation [9]. Eyesight can be damaged in a variety of ways. There is total blindness, high vision impairment and disability in the transition state and near-normal vision. Eyesight loss increases with age, although it depends to a large extent on the conditions of civilisation. Initially it impedes functioning, followed by delayed development of motor skills and difficulties in spatial orientation [3]. Most often, people with these use non-visual capabilities, which means that they mainly focus on performing activities with the help of other senses: touch, hearing, and smell. This category includes the completely blind and those with nearly complete vision loss [10]. Visually impaired people use the remaining visual capacity in the course of activities related to the performance of their profession and often do not require significant limitation as to the specificity of the work performed [10]. For people with visual defects, useful can be intraocular lenses or Braille display. applying shape memory materials, partly made of polymers.

The next group includes people with hearing problem who have difficulties in communicating through language and speech on their own. Hearing loss can concern the central and peripheral parts of the hearing organ. Difficulty of functioning due to hearing loss depends not only on the degree and type of loss, but also on individual variables conditioning development and behaviour. We distinguish the following degrees of hearing loss: mild, moderate, severe and profound. People with mild hearing loss do not have many hearing problems; they have minor problems with hearing sounds and difficulties in understanding certain words. In contrast, moderate loss means that a disabled person cannot correctly pick up sounds, distorts speech and requires a hearing aid. Severe loss manifests itself in difficulty hearing loud sounds. This person not only distorts speech, but often reads the lips of a speaking person. With this degree of loss, a hearing aid is necessary. The last type is profound loss, which disturbs the reception of sounds. What is more, the speech is incomprehensible and forces

Table 2. *Activity rate of the disabled for groups of diseases and the degree of disability in Poland in 2010.* ***Source:*** *Author's own compilation based on [7].*

	Diseases of the locomotor system	Damage to the eye	Damage to the hearing organ	Diseases of the circulatory system	Mental disorders	Mental retardation	Neurological diseases	Other diseases
	%							
Activity rate	16.5	17.5	11.9	16.6	15.6	8.5	19.2	19.3
Employment rate	14.3	15.5	10.8	14.0	10.3	6.4	15.9	14.5
Unemployment rate	13.7	11.4	9.2	15.2	34.1	25.2	17.4	20.7

Table 3. *Selected examples of medical applications of polymers.* ***Source:*** *Author's own compilation based on [13].*

Examples of medical use	Type of polymer
External prostheses, including parts of endoprostheses	Polyethylene (PE)
Artificial heart valves, elements of artificial kidney, elements of ear prosthesis	Polytetrafluoroethylene (PTFE)
Peritoneal dialysis catheter kits	Polypropylene (PP)
Tendon prostheses, skull bone prostheses	Polyesters (PET)
Orthopedic external dentures, intraocular lenses	Silicones
Elements of limb prostheses	Epoxy resins
Elastic and stiffening bands	Polyurethanes (PUR)

Table 4. *Selected examples of applications of bio-based polymer composites.* ***Source:*** *Author's own compilation based on [13].*

Application	Composite composition
Prostheses of joints and bones of the hand	Poly (ethylene terephthalate)/silicone rubber Carbon fiber/macromolecular polyethylene
Hip joint prostheses	Carbon fiber/epoxy resins Carbon fiber/polystyrene Carbon fiber/polyether ketones Carbon fiber/macromolecular polyethylene
Knee joint prostheses	Carbon fiber/macromolecular polyethylene
Prostheses of tendons and ligaments	Carbon fiber/polytetrafluoroethylene Carbon fiber/polyurethanes Carbon fiber/poly (L-lactide)
Prostheses and elements used in orthopedics	Carbon fiber/polyetherketones Carbon fiber/polycarbonates Carbon fiber/polystyrene Carbon fiber/polypropylene
Vascular grafts	Polytetrafluoroethylene/collagen Polytetrafluoroethylene/gelatin Polyurethane/block copolymers of lactic acid and ethylene glycol

the use of sign language on this group of people. Research has proven that hearing impairment depends on the degree and type of loss as well as on the time of occurrence. Limitations and possibilities in choosing a profession for a deaf person boil down to the need of communication. Frequent restrictions on speech or written language can be improved by using hearing aids and properly designed workplaces [11]. Deaf people are aware of the communication barrier, and this is a significant problem for them as they are afraid of isolation in interpersonal contacts; thus it is important that the work done by them is appropriate, that is, it does not require constant communication, etc. These people should choose the type of work themselves; they feel good in professions giving them the ability to control their work and compensate for damaged hearing [8]. These are occupations related to visual and tactile activities, where manual dexterity is needed. Hearing impaired people can perform activities that require them to be perceptive. Persons with a hearing problem can use not only elements of a ear prosthesis but also vascular grafts made of polymers and bio-based polymer composites.

Principles of the contemporary concept of rehabilitation

The contemporary concept of rehabilitation implemented by the World Health Organization, based on the principles of the so-called Polish rehabilitation school, created by W. Dega and M. Weiss, indicates that the effectiveness of rehabilitation activities is possible if the conditions regarding universality, earliness, continuity and comprehensiveness are met.

Thus the universality of rehabilitation means the right to rehabilitation services and treatments for all who need them, regardless of age, sex, ethnic or religious affiliation or property status. In turn, the earliest implementation of rehabilitation means the need to introduce specific interventions already at the first stage of treatment to prevent the consolidation of deficits and emergence of combined defects. In addition to the early implementation of rehabilitation, all the problems relating to people with disabilities must be solved in a comprehensive way – the activities of all necessary units must be integrated. In this context, the need for continuity of rehabilitation also appears. Systematic implementation of the streamline treatments indicated not only maintains proficiency but gives a chance for its development. The person gradually becomes independent of the environment. Thanks to continuous rehabilitation, a disabled person has the chance to improve their life situation, and somehow masters the art of living with a disability. The comprehensiveness of rehabilitation is the ultimate element. It requires the cooperation of many professionals responsible for the processes of prophylaxis, treatment, adaptation and integration. Therefore the comprehensiveness of rehabilitation forces the creation of a rehabilitation team in which specialists perform their complementary tasks and jointly contribute to reducing disability [12]. As noted earlier, both the time of starting rehabilitation, the manner of its implementation and the process of preparing disabled people for work are crucial for implementation of the activation objectives. K. Boshen points out that stimulation of professional development is most successful when the process begins as soon as possible, even after the end of medical rehabilitation. And all actions taken should be directed at disabled persons and consist in increasing their potential and compensating for their deficits. First disabled persons have to accept their condition. Then it becomes necessary to motivate them to act, stimulate their aspirations and get them to perform their real duties i.e., those that are feasible for them after taking into account the existing deficits. However, the nature of the work, the scope of activities or tasks depend on the type and degree of disability.

Polymers in the treatment and rehabilitation of people with disabilities

At this point, it is worth emphasising that the functioning of people with disabilities in their daily lives and their rehabilitation would not be possible without many devices manufactured with the use of polymers. It turns out that polymers and bio-based polymer composites are used in the treatment and rehabilitation of these people. They are used for the production of prostheses for limbs, joints, tendons, as well as for dental purposes. For example, nails made of polyamide are used in orthopedics with complicated fractures. Moreover, polymer is an integral part of the manipulator to support the knee after arthroplasty [14]. Another example is the electronic actuator module for Braille display, where an innovative research at-

tempt at a shape memory alloy made of polymers is used [15]. On the other hand, biodegradable polymers serve as scaffolds for building bone tissue. Polymers are also used to build numerous components of medical equipment, for example for hemodialysis, as well as during medical diagnosis, rehabilitation and prophylactic activities.

The large group of biomedical products includes implants that are placed inside the body, e.g., tendon prostheses or artificial heart valves. External prostheses are also made from polymers, i.e. limb prostheses, dentures and artificial parts of the face. Selected examples of medical applications of polymers (***Table 3***) and examples of applications of bio-based polymer composites are presented below (***Table 4***).

Currently polymers are used for external implants and prostheses in tissue and genetic engineering as well as in artificial and hybrid organ technology. For example, the plates that are inserted into the bone loss area are obtained from polyesters or polyester polypropylene yarn [16]. In contrast, hip prostheses are made of macromolecular polyethylene PE, and for the production of prosthetic joints of the fingers and wrist, silicone rubber is necessary. During orthopedic procedures, polyamides and polycarbonates as well as polyethylene are also used – for pins and nails [17].

In turn, in tissue and genetic engineering, macromolecular compounds have also been used in the treatment of articular cartilage injury as well as bone and tendon injuries. It seems, however, that the most interesting group of applications for polymers is their use in artificial and hybrid organ technology. It turns out that artificial organs are already used in surgery, orthopedics, laryngology, ophthalmology, and cardiology. Below there are some examples of applications of bio-based polymer composites.

And although all polymers used to produce the above-mentioned elements must undergo a special modification in order to increase their overall strength and provide them with essential properties for utility purposes, undoubtedly modern medicine cannot do without polymers. Increasingly, however, innovative multifunctional devices and verticalisers (devices for making the patient's posture vertical) are being produced, which are used not only for effective rehabilitation, but also to improve the comfort of life of people with disabilities. For example, technopolymers recently used in rehabilitation devices are characterised by low mass, lightness, coefficient of friction, electrical insulation and noise emission during operation as well as by a lack of reaction to a magnetic field. These features are important for users of devices because they increase the comfort of use.

Conclusions

The use of polymers in medicine significantly improves the quality of life of people with disabilities and enables them, through rehabilitation, to return to physical and professional activity. Those involved, and even those around them, are often unaware that a given device, implant or prosthesis has been made using polymers of bio-based polymer composites. It is important to restore at least partial physical fitness to disabled persons, but also to support them in acquiring and/or regaining new skills necessary in economic and social life. The developing of modern medicine is making it possible to use polymers in external implants and prostheses as well as in artificial and hybrid organs. Macromolecular compounds of polymers are becoming more and more popular in tissue and genetic engineering. It is highly likely that polymers and polymer composites will be used in the treatment and rehabilitation of people with disabilities. However, only comprehensive and systematic rehabilitation creates the chance to achieve tangible results. It turns out that regaining even partial fitness by persons with a disability strengthens their sense of dignity and is a "milestone" in their development, because it facilitates their functioning in conditions of full coexistence with healthy people. The considerations above confirm that people with dysfunctions using innovative solutions and rehabilitation devices for which it was necessary to use polymers, despite their limitations, are equipped with professional competences which allow them to be professionally active on the labour market. It is worth pointing out that there are many producers and suppliers of rehabilitation equipment on the Polish market in the field of physical therapy and diagnostic and measurement equipment. Using this equipment will certainly improve the quality of life of people with disabilities and encourage them to take up work in the labour market.

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