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ERGONOMIC CONSIDERATIONS FOR PHYSICAL THERAPISTS AND THE IMPORTANCE OF REHABILITATION TECHNOLOGIES

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Abstract: *Physical Therapists are specialists in human movement, biomechanics, musculoskeletal injury treatment and prevention. Worldwide physical therapy has been recognized as a very physical demanding profession with a high prevalence of Work-Related Injuries and Disorders. The review focuses on the existing literature with the purpose of better understanding the main factors for the injury of the physical therapist and if these can be prevented. We have concluded that there is an acute need for providing the physical therapists with the necessary assistive devices and rehabilitation technologies to prevent work-related injuries and improve ergonomics.*

Keywords*: ergonomics, physical therapy, work related injuries, work related disorders, rehabilitation technologies.*

1. INTRODUCTION

Physical therapy is part of the medical rehabilitation field. At its core it is focused on restoring function and helping patients regain their physical independence. Of course, physical therapy will approach the human body, taking into consideration the social and psychological factors and the impact of disability in all aspects of the patient's life.

Kinesiotherapy is very often used as a synonym for physical therapy but is more related to movement therapy, being initially known by the names of medical gymnastics or recovery gymnastics under specialized supervision. The name itself (etymologically) comes from Latin, where "kinesis" translates to "movement".

Physiotherapy, on the other hand, alongside medical exercise, is the science that studies and uses the action of physical factors (water, light, heat, electricity, massage) on the human body. Therefore, physiotherapy is the medical profession focused on restoring physical function of the human body, maximizing physical potential and improving quality of life with non-invasive techniques, helping patients to regain their physical independence. Physiotherapy is recommended at any age, teaching the patient to manage their conditions, recover and remain independent after the end of treatment.

Studies have shown that up to 91% of physical therapists report injuries related to work conditions, so it is mandatory to understand what leads up to these high numbers and to discover and apply strategies and solutions to remove or minimize these injuries. One of the main purposes of ergonomics is matching the job to the worker, especially when it is impossible to match the worker to the job [1].

2. PHYSICAL THERAPISTS AND WORK-RELATED DISORDERS

According to the Academy of Orthopedic Physical Therapy and the American Physical Therapy Association (APTA) one of the roles "of the physical therapist in occupational health includes examination and evaluation of individuals with work-related risk factor(s), impairments, activity limitations, participation restrictions, or other health-related conditions which prevent individuals from performing their occupational pursuits in order to determine a diagnosis, prognosis, and implement intervention as necessary.", including " analyzing work tasks, tools and work station design, redesigning

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workplace, work task, or work station, matching of work tasks, tools and work station design to the worker, providing exercises and postural training to prevent job-related disabilities" [2].

Despite this, working as a physical therapist has been proven to be one of the most physical demanding professions of our days, with up to 91% suffering from a work-related injury (WRI) in the first four years of practice, leading 1 in 6 therapists to change within or completely leave the profession [3] and [4] research compared WRI of physical therapists with the those related to employees in heavy manufacturing activities.

The Global Organization World Physiotherapy was reported in 2020, 128 member organizations and a global number of 1.917.615 physiotherapists worldwide [5] (Fig. 1). Sadly, worldwide, as well as in Romania, the number of people with disabilities is in continuous growth.

In 2023, the rate of persons with disabilities in the Romanian population was reported to be 4.05%, women representing 53.45% of all persons with disabilities. Another aspect is the aging population, with people over 65 years old representing 18.64% of all adults, a percentage expected to double by 2050 [6].

2.1 Leading causes for work related disorders regarding the physical therapy profession

Work Related Disorders are described as "a wide range of inflammatory and degenerative diseases and disorders that result in pain and functional impairment. They arise when individuals are exposed to work activities and conditions that significantly contribute to their development or exacerbation, but which may not be their sole cause" [7].

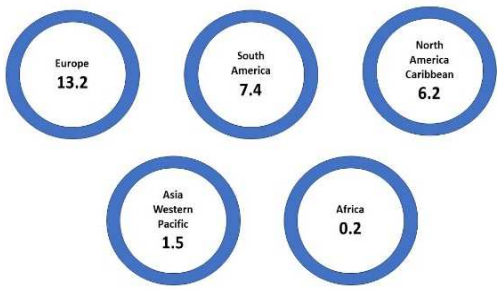

Fig. 1. World Physiotherapy Census 2022 – Number of Physical Therapists per 10.000 people [5].

There are several identified causes of injury as following [8]:

- Working in awkward and cramped positions or working in the same position for long periods;
- Standing, bent over, sitting, kneeling and repeating the same task repeatedly;
- Working near or at the physical limits and continuing to work while injured;
- Lifting or transferring dependent patients, carrying, lifting, or moving heavy materials or equipment (continuous passive motion machines);
- Working with confused or agitated patients;
- Unanticipated sudden movement and/or fall by patient;
- Assisting patients during gait activities;
- Work scheduling (overtime, irregular shifts, length of workday);
- High number of patients in 1 day;
- Insufficient rest breaks or pauses during the workday;
- Performing manual orthopedic therapies (joint and/or soft tissue mobilization).

While some authors corelate the age or the years of experience with work related injuries [9], others declare that "the right skills and knowledge of biomechanics do not prevent work related injuries" [7], with increase in symptoms affecting the older professionals more than the younger professionals, bearing the question if this professional domain presents an accumulating effect for work related disorders, with incomplete healing time and care [10].

2.2 Cognitive Ergonomics, Workload and Burn-out

Cognitive Ergonomics is the aspect of ergonomics that is concerned with the cognitive aspects of ergonomics, with mental processes, how people perceive, process, reason and respond and how it affects their interaction with work and environment. It takes into consideration, mental workload, decision making, performance, work stress and human reliability.

"Burn-out is defined as a state of physical and emotional exhaustion involving the development of both a negative self-concept and negative attitude towards one's job" [11]. This is caused

by an excessive and constant demand on resources (physical and emotional) that overwhelm the therapist leading to exhaustion, depersonalization and lower perception of personal achievement. [12].

3. THE OLE OF ERGONOMICS

3.1 Ergonomics and Physical Therapy

Ergonomics and physical therapy are related, both having significant surge around the First and Second World Wars [13]. Physical therapy in modern times was established in 1894, in England. On the other hand, ergonomics was more connected with the industrial revolution. The disguised difference between Physical Therapy and Ergonomics is that one is trying to reintroduce the human being in the working field and society, while the other is trying to optimize the working space where the individual is already in [1, 14].

3.2 Ergonomics in the Physical Therapy Profession

According to the International Association of Ergonomics, ergonomics or the science of work is defined as "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance" with physical ergonomics as the main domain [16]. The irony of the situation is that key components of prevention of physical injuries are part of the core training and knowledge of physical therapists worldwide, physical therapists being sometimes the main educators of patients regarding work related injury and workplace ergonomics, being part of nation-wide campaigns regarding posture and weight handling.

If we take into consideration the key factors for rehabilitation, there is an obvious consensus: high intensity that involves a high number of repetitions, adapted effort, high number of sessions at and high frequency of sessions, with patients requiring motivating therapies and constant feedback on performance and progress [17]. For the lower limb, research and clinical trials have shown the need for several repetitions between 1,000 and 2,000 to improve lower limb control and gait cycle quality for stroke patients. For the upper limb scientific research has shown a significant cortical reorganization and functional improvement compared to subjects in the control group after 1,200 repetitions of the same hand movement (difficult even impossible to be made by physical therapist). According to [3, 7], the main ergonomic and coping strategies adopted by physical therapists are the following:

- Outsourcing: calling a colleague to assist with a heavy task/ This proves to be harder and a harder strategy to use, with a significant increase in the need for human resources and the number of patients, with studies already reporting a higher demand on already scarce resources [5,6].
- Preventive and self-protective strategies: Increasing the number of breaks; warming up before sessions; adjusting chairs and bed's height; using ergonomical assistive devices.
- Reactive strategies: using electrotherapy instead of manual therapy; self-treatment and exercise; researching other types of therapies that can be applied; using another body area; leaving the profession or changing specialty; limiting patient time.

While the first three reactive strategies might not affect the treatment quality, the next three can influence treatment quality and patient experience. Using another body area is presented as a short-term solution, with increasing risk of enlarging the affected area through overusing a segment that is not the used for its main function.

Introducing assistive devices for the use of physical therapists might be one of the most useful approaches for the following reasons: decrease the human effort for the specific task (no need for a high number of repetitions performed by therapists alongside patients, long periods of time in the same position or lifting done by therapists), offering a physical break to involved therapists, lowering risk of injury because of unexpected movement, increase in constant highly qualitative and efficient treatment, adding variability to treatment and replacing direct prolonged physical mobilizations, increase number of patients

treated in the same time without increase in physical effort and decreasing total working time.

Manual gait rehabilitation can be easily replaced by robotic technology that has already proven results regarding feasibility and treatment efficiency. Alongside the physical part of weight bearing and repetitive movement, certain robotic rehabilitation devices can offer patients game-based therapy that increases motivation and encourages active participation, with real time biofeedback for performance and options to objectively monitor progress.

4. REHABILITATION TECHNOLOGIES FOR LOWER LIMBS AND GAIT

Robotics have been presented as a possible solution for gait rehabilitation, with the first commercial version being installed in the early 2000s. The Lokomat was introduced to unload the physical effort of the physical therapist by supporting the patient's weight and mobilizing the patient following the physiological gait pattern – offering objective, never tiring high quality gait therapy, the Lokomat (Fig. 2) is an exoskeleton that actively guides the patient's legs in a continuous mode, on a treadmill, while dynamically supporting the patient's weight. Today, the device has evolved, offering patients a highly motivating therapy through "Serious Games" played in Virtual Environments with real-time biofeedback, adapted to the patient's abilities and assisting as needed.

Performance and progress are also evaluated, becoming a useful tool in monitoring the patient. The body weight support is dynamic and the introduction of the FreeD module brought the gait pattern even closer to the physiological one, by taking into consideration the high involvement of the pelvis in the physiological gait. Patients can reach their number of repetitions without overstraining their therapists in a highly motivating environment.

The device is intended for patients with severe to moderate impairments in walking abilities and functional mobility, mainly caused by neurological diseases, but not limited to these. The Lokomat does not only take off the weight of the patient in a dynamic way (dynamic weight support is a type of support that follows the natural trajectory of the center of gravity during walking), but it takes the effort involved in the repetitive movement of the lower limbs during walking. The passive movement can be set to assistive movement, the device assisting the patient according to his abilities (up to 100%).

Andago (Fig. 3) is another device proposed by the Swiss company Hocoma with the purpose of assisting patients and therapists in their rehabilitation journey. The mobile robotic gait recovery system Andago provides an adaptable dynamic body weight support against gravity and a "following the patient" function, allowing the patient to self-initiate walking.

Fig. 2. The latest version of the Lokomat – Treadmill gait-therapy robotic medical device with body weight support. (Photo credits: Hocoma AG, Switzerland, used with permission).

Fig. 3 Andago – Overground gait-therapy robotic medical device with body weight support. (Photo credits: Hocoma AG, Switzerland, used with permission)

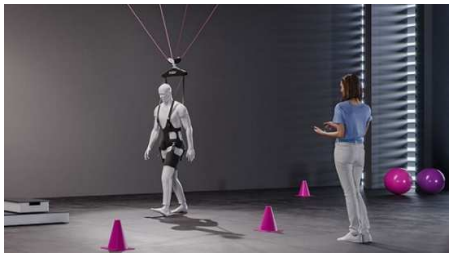

Fig. 4. Rysen – celling mounted 3D Body Weight Support. (Photo credits: MOTEK Medical B.V., The Netherlands, used with permission).

Andago is a mobile gait recovery robot that supports body weight and allows for an upright, hands-free position without spatial limitations (the device is not mounted on ceilings or walls), allowing training in a physiological way and in an extended workspace. The weight support can be adjusted symmetrically or asymmetrically according to the patient's needs. The device is intended for patients for which overground training is indicated, regardless of their diagnosis, with no specific product related contraindications. Andago lowers the strain on physical therapists and increases safety during balance and gait rehabilitation.

Developed by Motek, RYSEN (Fig. 4) is a rehabilitation technology that supports patients in an all-directional, assist-as-needed capacity to improve movement function. The RYSEN offers therapists and patients the opportunity to train movement, weight and balance in an unrestricted and safe environment, both for clinical and research purposes. Its technology combines adjustable vertical body weight support with horizontal and vertical assistive forces, maximizing a patient's freedom of movement, engagement, and recovery results.

A unique approach that has been introduced very recently is Intensive Visual Simulation (Fig. 5), the therapy is rooted in mirror therapy, action observation and motor imaginary. With a very ergonomic design, the therapy offered with IVS requires almost no physical effort from the therapist and an intense and effective therapy for the patient.

Fig. 5. Intensive Visual Simulation 4 – (Photo credits: Dessintey, France, used with permission).

Fig. 6. Vibramoov (Photo credits: Techno Concept, France, used with permission).

The system bridges the gap between command and result that is usually affected in neurological pathologies, through recording of the unaffected limb and overturning the image to create the illusion that the affected limb is moving. With no contraindications related to the system, this rehabilitation device is proving to be even more effective than the already recognized mirror therapy [18]. It is for upper limbs, as well as for lower limbs. The therapy is used in neurological and orthopedic pathologies, including pain syndromes.

Vibramoov or the Functional Proprioceptive Stimulation (Fig. 6) is another therapy used in rehabilitating the lower and the upper limb. Modulated within a specific frequency range (most frequently used between 40-120Hz) and applied on the tendons, it can stimulate the muscle spindle and create a kinesthetic illusion (movement sensation). The sensation activates the Central Nervous System and can be followed by a reaction (motor response) leading to an active movement by the patient. Used in specific sequences and on multiple joints, it is used for re-training functional movements like gait and different balance activities [19].

Again, this therapy can be used on a large range of pathologies, with almost no effort from the therapist, training the movements for multiple repetitions. The stimulators are easy to attach and therapy can be used in different positions for the patient: laying down for bedridden patients, during the verticalization process, in orthostatic position and during walking. It is indicated for neurological patients but not limited to it. While offering an intense and efficient therapy, it does not physically overstrain users in any way.

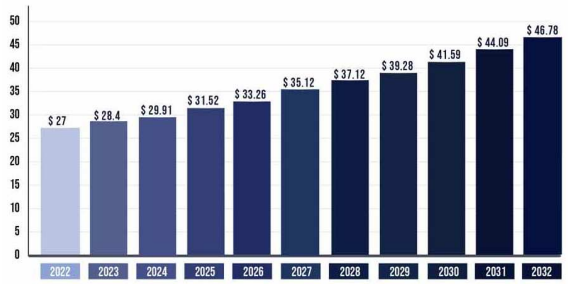

Fig. 7. Elderly and disabled assistive devices market size 2022 to 2032 [USD Billion] [18].

A study made in Canada reveals a very important aspect, taking in account the constantly growing number of assistive devices/equipment. According to [18], more than 2.5 billion people need one or more assistive products, and this number is expected to rise to more than 3.5 billion by 2050 as the world's population ages. The report also presents numerous cases that illustrate the profound impact that assistive products can have on the lives of people like patients and physiotherapists (Fig. 7).

The size of the rehabilitation equipment market exceeded 18.6 billion USD in 2019 and will grow by more than 7.8% CAGR (compound annual growth rate) between 2020 and 2026 (USD 31.2 billion). The compound annual growth rate is a dynamic indicator of commensuration. The growing interest in research and development to develop innovative products anticipates the growing need for efficient and accurate rehabilitation equipment [20].

6. DISCUSSIONS

Musculoskeletal conditions are prevalent and their impact is omnipresent, the most common causes of pain and severe long-term physical disability. According to data from the World Health Organization (WHO), 1.71 billion (21%) worldwide are currently living with a painful musculoskeletal condition, their prevalence increasing with age, as well as the adjacent socio-economic costs (Cieza et al., 2020; Rupali Swain, 2020; World Health Organization, 2022). These patients require rehabilitation treatment and access to rehabilitation services is essential with physical therapist playing a serious role in the rehabilitation team. Sadly, work related disorders are a common occurrence for physical therapists, with a prevalence of injury like those working in the heavy manufacturing industry.

Considering the main causes of injuries and today's technological development, it might seem to be the right solution to integrate technology in the equation as a way of improving work conditions for physical therapists and optimizing the rehabilitation process. The robotic devices are able not only to support weight and perform repetitive movements, they could help also the psychotherapist to give complete biofeedback regarding performance and to monitor and adapt to progress [21, 22, 23, 24].

Focal vibration and intensive visual simulation therapy as well, are solutions that can offer effective therapies, with minimum amount of physical effort and attention needed from the therapist [25, 26, 27, 28].

Introducing rehabilitation technologies will raise other kinds of issues and problems like, how much are technology developers willing to take into consideration not only the patient's needs, but the therapist's needs as well? A non-ergonomical designed product will lead to a mismatch between user characteristics and the activity and environment, with problems on functionality, quality, usability and even safety issues [29]. A close analysis of patient's and therapist's physiology, existing problems, activity and expectations is required to ensure comfort, well-being, efficiency and effectiveness for all parties involved [30]. Financial and economic availability are also significant aspects that need to be considered.

7. CONCLUSIONS

Based on the reviewed literature, we conclude that there is a valid concern regarding work-related disorders among the physical therapists and that there is a need for finding solutions for prevention. Considering that the main strategies for prevention adopted by therapists (that are most likely not useful strategies long term and could affect the quality of treatment), the aging population and the decreasing number of available human resources present as problem as well, already overwhelming the present resources, we believe that the introduction of technology is a viable solution, not only in

increasing the quality and efficiency of treatment, but preventing injuries for therapists and combating present ergonomic issues. In time, without sounding dramatic, it might be one of the few ways we can offer rehabilitation therapy.

There is also evidence of the economic and social return on investment in assistive technology, for the benefit of patients and therapists, too. However, despite the benefits, many people do not have access to assistive technology, with the largest differences in low-income and middle-income countries. This global inequality requires urgent research, attention and collective action.

We cannot ignore the inevitable challenges regarding the integration of technology, with all devices presenting a real learning curve that could be demotivating and discouraging at times. We believe that we need more research in understanding and discovering of what are the main barriers in technology integration – technical, financial, educational and psychological – and how to make technology more accessible.

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Considerente ergonomice pentru fizioterapeuți și importanța tehnologiei de reabilitare

În această lucrare am prezentat câteva considerente de ergonomie, ținând cont de faptul că fizioterapia a fost recunoscută la nivel mondial ca o profesie foarte solicitantă din punct de vedere fizic, cu o prevalență crescută a leziunilor și tulburărilor legate de muncă. Fizioterapeuții sunt specialiști în mișcarea umană, biomecanică, tratamentul și prevenirea leziunilor musculo-scheletale. Sunt prezentați principalii factori de afectare și accidentare a fizioterapeutului și metode ergonomice de prevenire ale acestora, inclusiv introducerea tehnologiei de reabilitare. Astfel, utilizarea dispozitivelor asistive în cadrul tehnologiilor de reabilitare poate preveni accidentările legate de muncă și pot îmbunătăți calitatea vieții și muncii fizioterapeuților, dar si calitatea tratamentului aplicat.

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