Novel Devices in the Rehabilitation of Children with Cerebral Palsy

Ph.D. Thesis Booklet

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1. Introduction

5.1.1. What is the topic?

Our aim is to evaluate the efficacy and clarify the role of novel devices in the rehabilitation in children with cerebral palsy.

5.1.2. What is the problem to solve?

The main purpose in cerebral palsy children rehabilitation is to mitigate the loss of function caused by (the origin of the disease) the brain injury, however, the primarily neuromotor disorder is non-progressive in the greater part of cases, the motor function and the physical condition deteriorates with age. The rehabilitation for disabled children can take a considerable part of their lives. Although the usual rehabilitation techniques achieve good results, the need for new innovative tools has naturally arised, but their effectiveness has not yet been proven. These techniques attempt to improve impaired function by leveraging the neuroplasticity of the brain, however, the therapeutic impact and possibilities of these new methods still need clarification.

5.1.3. What is the importance of the topic?

Cerebral palsy occurs by damage to the developing brain, which may cause movement disorders. The incidence of the disease is 2-3 out of 1000 live births. Continuous rehabilitation plays a prominent role in the lives of these children in order to prevent the loss of those functions. From that standpoint finding the adequate rehabilitation tools with the appropriate indication circle is crucial and increases the efficacy which offers a chance to decrease the unnecessary time spent on rehabilitation and make decisions easier for therapists and clinicians. From an economic point of view, the therapy becomes more target-oriented thereby easing the situation of parents worldwide.

5.1.4. What would be the impact of our research results?

The pressure from parents and therapists is understandable to use these modern tools in the rehabilitation of children with cerebral palsy, however, this investigation helps to push our knowledge towards showing reality. The objective determination of the

therapeutic possibilities of the new devices thereby improves the quality of life of children with CP. By assigning a more precise range of indications, it is possible to make the therapeutic programs more targeted and to use them in a more target-oriented manner thereby increasing the cost-effectiveness and reducing the time spent on unnecessary therapy.

2. Objectives

2.1. Study I. – Evidence for gait improvement with robotic-assisted gait training of children with cerebral palsy remains uncertain

Walking for healthy individuals doesn't mean any difficulties however for the population of children with cerebral palsy it can require significant effort due to the impaired gait pattern. Although the underlying disease is not progressive the primary injury may lead to loss of function with advancing age. In most cases, this injury resulted in inadequate posture control and impaired balance with weak stability.

Robotic-assisted gait training (RAGT) is a novel method that aims to improve posture control, stability, and balance. It has the potential effect to promote the neural circuits with forced walking movement on high intensity in order to reach gait improvement through spinal cord and brain plasticity.

Numerous authors reported that RAGT can be an effective tool in the rehabilitation of children with CP, but the roles

and guidelines for this therapy remained undetermined. The aim of this meta-analysis was to estimate the RAGT effect on gait parameters and function in contrast to usual therapy or treadmill training at children with cerebral palsy.

2.2. Study II. – Effectiveness of Video Game-Based Therapy to Improve Hand Function in Children with Cerebral Palsy: A Systematic Review and Meta-analysis

The main goal of rehabilitating the upper limb in children with CP is to reduce the impairment of function resulting from brain injury. The possible advantages of video game-based therapy can be the relatively low prices of gaming consoles, the opportunity to perform functional tasks multiple times, the alterable of the virtual environment with different levels of difficulty, the promise of sensory and cognitive stimulation through auditory, and visual and tactile signals with feedback and the ability to increase patient motivation.

Although VGBT theoretically contains all the essential components needed to promote or stimulate neuroplasticity, it is still uncertain whether this leads to successful practical application. Several authors found the benefits of video game-based therapy in the rehabilitation of neurological disorders, however, only a few studies have investigated the effectiveness of this therapy in children with cerebral palsy.

3. Methods

These systematic reviews and meta-analyses were conducted by the Cochrane Handbook and the PRISMA 2020 guidelines were followed. The protocols of the studies were registered on PROSPERO: Study I.: CRD 42022312513, Study II.: CRD42021284957.

3.1. Study I. Evidence for gait improvement with robotic-assisted gait training of children with cerebral palsy remains uncertain

A systematic search was conducted in five databases: MEDLINE (via PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), Embase, Scopus, and Web of Science on October 14th, 2021, with the following search key: Cerebral palsy AND robot* AND random*. The authors did not use filters or restrictions related to language, publication date, or research types. Inclusion criteria Only randomized controlled trials published in peer-reviewed journals were eligible for inclusion, provided their population was children with cerebral

palsy, and at least one study group had robotic-assisted gait training. A meta-analysis was performed when at least three studies were present for an outcome. For continuous outcomes, pooled Mean Differences (MDs) along with their 95 % Confidence Interval (CI) were calculated to investigate the differences between the compared treatments. A random effects model was applied for meta-analyses. The change in mean was calculated by subtracting the mean before treatment from the mean after treatment. The standard deviation of change (as correlation was not available) was calculated using an upper approximation, i.e., we assumed a correlation of – 1

3.2. Study II. Effectiveness of Video Game-Based Therapy to Improve Hand Function in Children with Cerebral Palsy: A Systematic Review and Meta-Analysis

A systematic search was performed in five databases: MEDLINE (via PubMed), Cochrane CENTRAL, Embase, Scopus, and Web of Science. The original search was conducted on April 27th, 2022, and was updated on

January 26th, 2024, with the following search key: Cerebral palsy AND (virtual reality OR game OR nintendo OR playstation OR xbox). The authors (OG and MV) searched all fields in all databases except in Scopus, where only titles, abstracts, and keywords were searched.

Only randomized controlled trials published in peer-reviewed journals were considered, all other study types were excluded. The population had to consist of children with CP under 18 years of age, and at least one study group had to receive VGBT with or without accompanying traditional physical therapies, partially eligible studies were excluded.

The authors conducted a meta-analysis for each outcome when at least three studies were available. To assess differences between the groups being compared, standardized mean differences (SMDs) and their corresponding 95% confidence intervals were calculated for continuous outcomes. The change in mean was calculated by subtracting the mean before treatment from the mean after treatment. The SMD results obtained in this way can be pooled in the meta-analysis because the unit is the same in all studies.

4. Results

4.1. Study I. Evidence for gait improvement with robotic-assisted gait training of children with cerebral palsy remains uncertain

A total of 7,363 articles were screened. After the selection process, thirteen full texts were suitable. Seven articles were eligible for meta-analysis and the other five studies for qualitative analysis due to the inadequate reported form of outcome and due to the crossover study design. Four papers found evaluated the effect of RAGT in GMFM E and D. The RAGT group reached an insignificant improvement in GMFM D with 5.78 %, (95 % CI − 7.46, 19.03) and in GMFM E 5.67 % (95 % CI − 6.13, 17.47) compare to the control groups. Step length and cadence were assessed by four investigations. The pooled result was an insignificant 5.45 (95 % CI − 11.65, 0.76) step number /min decreasement and an insignificant 0.03 m, (95 % CI − 0.03, 0.10) step length increasement

in favour of the RAGT group. The detected gait speed improvement, which was assessed by six papers shows a 0.10 m/s, 95 % CI [0.02, 0.19] improvement for the intervention group. Two articles evaluated the step width changes after RAGT. In one of them, an insignificant improvement was seen after the RAGT in the other a statistically significant decrease was detected between the groups (P=0.022).

4.2. Study II Effectiveness of Video Game-Based Therapy to Improve Hand Function in Children with Cerebral Palsy: A Systematic Review and Meta-Analysis

The meta-analysis used 20 papers to assess the effectiveness of VGBT on upper limb function with 8 outcomes. Grip strength assessment showed an insignificant increase in the study group with an SMD of 0.46 (95% CI -0.18, 1.10). VGBT improved grasp function statistically significantly with the SMD 0.80 (95% CI 0.06, 1.55)**.** When we assessed the manual

dexterity with physical tests, the SMD was 0.12 (95% CI -0.14, 0.37), which, means an insignificant change in favor of the treatment group**.** According to hand function questionnaires and upper limb fine motor function, we found a statistically significant improvement in both cases, the result in the questionnaires was SMD 0.36 (95% CI 0.04, 0.68), and in the motor function, the SMD was 0.42 (95% CI 0.03, 0.81). The WeeFim (self-care) score increased with a Mean Difference (MD) of 4.22 (95% CI -2.12, 10.55) in favor of the intervention group. When the Abilhand-Kids and Jebsen Taylor Hand Functions were evaluated separately a non-significant improvement was seen in the experimental groups compared to the control groups, the Jebsen Taylor Hand function showed an SMD of 0.07 95% CI -0.16, 0.31), while the in Abilhand-Kids the MD was 0.60 (95% CI -0.20, 1.39).

5. Conclusions

Our results suggest that these novel methods which are supposed to take advantage of using the brain's neuroplasticity through forced repetitive movements (RAGT) or leveraging neuroplasticity of the brain (VGBT) are at least as effective as other usual methods for rehabilitation in upper and lower limb function in children with cerebral palsy. It is worth considering integrating it into the daily routine and combining these tools with standard techniques. Although the expectations are understandable contrary to these demands, their breakthrough beneficial effects do not significantly overtake the traditional forms.

6. Bibliography

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