Narrative Review

Approaches in Improving Hand Function in Cerebral Palsy Via Telerehabilitation: A Review

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ABSTRACT

Context: This study was conducted to evaluate the diversity of approaches for improving hand function through telerehabilitation in CP patients. Google Scholar and PubMed databases were consulted to perform an electronic search. A total of 12 studies were selected and reviewed.

Evidence Acquisition: This study was conducted to evaluate the diversity of approaches for improving hand function through telerehabilitation in CP patients. Google Scholar and PubMed databases were consulted to perform an electronic search. A total of 12 studies were selected and reviewed.

Results: The data demonstrated the usability of telerehabilitation in children with CP for improving hand functions. Their gross and fine motor functions were significantly improved. Meanwhile, the data reported the perception of the caregivers.

Conclusions: The conclusion based on the result of training hand function with telerehabilitation in the CP population showed promising results in improving grip strength, hand dexterity, motor skills, and so on. The secondary outcome was the satisfaction of caregivers.

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1. Context

Cerebral palsy (CP) is a neurodevelopmental condition that begins in early childhood and lasts a lifetime (1) and it is the most common motor disability in children (1). It affects roughly 15% to 20% of physically disabled children in India. CP has multiple risk factors in all 3 phases, namely antenatal, perinatal, and postnatal (2). CP is diagnosed based on chronological clinical observations and assessments (2). Some signs and symptoms appear shortly after birth, while others emerge as the child grows (2).

This disorder has negative impacts on children's health, social environment, and education (3). Some neuro comorbidities, such as difficulty in learning, visual impairment, perceptual disorders, and language and speech problems have detrimental effects on the child's life quality and development (3).

Rehabilitation specialists working with children with disabilities are continuously encouraged to consider the child's development and put greater importance on activity and function (4). Alternative solutions for rehabilitation models have been developed to increase the range by introducing modern resources, such as digital practice in situations where rehabilitation is required, however, it is implemented ineffectively (5). The COVID-19 pandemic has given rise to several new rehabilitation possibilities, such as shifting from in-person to technology-assisted care (6).

Telehealth includes telerehabilitation. It is a telecommunication-based system to monitor remote rehabilitation with the intent to enhance accessibility and adherence to treatment for vulnerable, geographically isolated populations with disabilities, along with saving time and resources in health care (5). Rehabilitation professionals use a variety of technologies, ranging from simple day-to-day applications (calls and emails) to more advanced devices (specialized equipment installed in a clinical setting and at home) (4). Telerehabilitation medicine enables the provision of patient- and family-centered rehabilitation care on a timely basis (6). With experimentally documented positive outcomes, neurodevelopmental disorders and human well-being have improved significantly (7).

Accordingly, the present study reviews the use of various hand function therapeutic approaches and the impression of parents and caregivers in CP patients through telerehabilitation. Different therapies have been compared and their effects are discussed.

2. Evidence Acquisition

Materials and methods

Google Scholar and PubMed databases were employed to perform an electronic search. The following keywords were entered into the databases, while their combinations were merged: "Cerebral Palsy," "CP," "Telerehabilitation," "TR," "Telephysiotherapy," "Hand function," "Telerehab," "Hand-arm training," and "Caregiver." To provide a brief explanation of the literature, a summary of the research table is included (Table 1). From 2005 to 2021, 12 studies focusing on hand function improvement through telerehabilitation were briefly reviewed.

Literature review

Golomb et al. (2009)

Golomb MR et al. conducted a clinical pilot study of in-home hand telerehabilitation (8). Virtual reality video games were used to train 3 teenagers with hemiplegic CP. The training could last from 6 to 11 months. The authors highlighted the importance of using multiple outcome measures to detect clinically meaningful changes. Accordingly, in-home telerehabilitation is the future of rehabilitation (8).

Brown et al. (2010)

In this uncontrolled trial, Brown SH et al. evaluated the effects of a home- and internet-based upper limb intervention program aimed at the motor and sensory function (9). A total of 12 adults in the age range of 12 to 57 years with gross motor function classification system levels I to III and asymmetric upper limb involvement participated in the upper limb training and assessment (ULTrA) program. Clinical and functional measures included the motor activity log, the nine-hole peg test, and grip strength. An upper limb training system with a laptop, webcam, target light board, and hand manipulation devices was installed in each participant's house. The training lasted 8 weeks and included unilateral and bilateral reach movements and a series of hand sensorimotor tasks, such as card turning, stereognosis, and tactile discrimination. The ULTrA program which is also a suitable and safe to use method was beneficial to adults with CP (9).

Table 1. Databases of the research

Author/Year	Method and Study Design	Number of Participants	Intervention	Outcome	Result
Golomb et al. (2009) (8)	Pilot study	3	Wearing sensing gloves to play games	Range of motion, pincer strength, grip strength, Jebson test of hand function, the Bruininks-Oseretsky test of hand function	In-home telerehabilitation is the future of rehabilitation.
Brown et al. (2010) (9)	Uncontrolled trial	12	Upper limb training and assessment program	Movement time, interlimb delay time, and performance on hand sensorimotor tasks	Affected limb reach movement time decreased significantly for unilateral and bilateral tasks. Significant improvements in hand manipulation tasks were observed.
Cankurtaran et al. (2021) (10)	Observational study	94	-	-	More attention should be given to telerehabilitation and telemedicine to prevent the negative effects of future pandemics.
Sgandurra et al. (2021) (11)	Randomized controlled trial, prospective study	24	Action observation training	Assisting hand function, Melbourne assessment 2, ABILHAND, participation and environment measure-children and youth, and cerebral palsy quality of life questionnaire	(Prospective study)
Rezk et al. (2020) (12)	Randomized controlled trial	30	Modified constraint therapy	Quality of upper extremity skills test scale and tele health satisfaction survey	Tele-rehabilitation using home-based modified constraint-induced movement therapy is effective in improving upper limb function.
Golomb et al. (2010) (13)	Pilot study	3	Sensor gloves to play	Finger range of motion, dual-energy x-ray absorptiometry, peripheral quantitative computed tomography and functional magnetic resonance imaging of the hand	Increased spatial extent of activation in brain motor circuitry at posttreatment compared to baseline; Telerehabilitation improved hand function and forearm bone health.
Molinaro et al. (2020) (14)	Pilot study	10	Action observation treatment	The Melbourne assessment of unilateral upper limb function scale and the assisting hand assessment scores	In a telerehabilitation setting, action observation treatment is a promising approach that can be used on a large scale.
James et al. (2015) (15)	Randomized controlled trial	102	"Move it to Improve it" program	Assessment of motor and process skills, assisting hand assessment, Jebsen–Taylor test of hand function, Melbourne assessment of unilateral upper limb function, Canadian occupational performance measure, and test of visual perceptual skills	The "Move it to Improve it" program provides individualized, web-based therapy to patients at their homes and has the potential to increase the therapy dose.
Ferre et al. (2017) (16)	Randomized controlled trial	24	Home-based hand-arm bimanual intensive therapy or lower-limb functional intensive training	The box and blocks test, the assisting hand assessment, and the Canadian occupational performance measure	Home hand-arm bimanual intensive therapy improved the dexterity and performance of functional goals. Home-based models offer a valuable, family-centered approach to increasing the treatment intensity, intervention, and telerehabilitation supervision.

Author/Year	Method and Study Design	Number of Participants	Intervention	Outcome	Result
Burdea et al. (2011) (17)	Interventional study	2	Virtual hand rehabilitation games using modified PlayStation 3 and 5DT sensing gloves	Grip strength, Jebsen test of hand function, and forearm bone health	Good retention in terms of grasp strength, hand function, and bone health
Glavic et al. (2016) (18)	Interventional study	1	Robotic-assisted telephysiotherapy training using the Armeo spring system	Fugel meyer score	Upper limb function improvement
Brisben et al. (2005) (19)	Pilot study	6	Tele-robotic technology with gestural sensors	Cosmobot TM	Improved gross and fine motor skills, improve upper extremity strength, coordination, and dexterity

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Cankurtaran et al. (2021)

The purpose of the study by Cankurtaran D et al. was to observe how the COVID-19 pandemic impacted CP children's utilization of health and rehabilitation services, along with their overall health and physical status (10). The second goal was to see how the COVID-19 pandemic impacted caregivers' quality of life and fear of the virus; therefore, the caregivers' fear of COVID-19 and their quality of life were investigated. A total of 120 caregivers were contacted, of which 94 agreed to participate in the research. The authors concluded that practitioners who work with children with CP and caregivers could perhaps give greater attention to telerehabilitation and telemedicine services to minimize the negative effects of future pandemics (10).

Sgandurra et al. (2021)

Sgandurra G et al. have designed a prospective study in which a randomized, allocation-hidden, evaluator-blinded clinical trial is conducted with two investigative arms (11). The experimental group is assigned to perform action observation training at home for 3 weeks with a tailored telemonitored upper limb children action observation training system. The control group receives standardized care for 3 weeks, which includes upper limb training. They were provided AOT at home after 3 weeks. For each of the 12 groups, a total of 24 children with unilateral CP are recruited. The primary outcome is to be measured via assisting hand. The Melbourne assessment 2, the ABILHAND questionnaire, the participation and environment measure for children and youth questionnaire, and the cerebral palsy quality of life questionnaire were used as secondary measures. The quantitative data from sensorized objects and participants wearing Actigraphs GXT3+ will be analyzed. The weekly assessments take place at week one plus after the AOT period for the waitlist group, at the eighth week, and after 24 weeks of AOT training. The result has not been discussed as it is a prospective study (11).

Rezk et al. (2020)

Rezk MR et al. conducted a study to see whether telerehabilitation can improve the quality of upper-limb functions in children with hemiplegic CP (12). A total of 30 children with hemiplegic CP, in the age range of 5 to 7 years were randomly divided into 2 groups of equal size. The experimental group received the same treatment as the control group 4 days a week, in addition to modified constraint therapy with selected play-based exercises that were delivered 3 times a week via telerehabilitation sessions which lasted for 90 minutes. The study lasted for 8 weeks. Using the quality of the upper limb functions test scale, each child's upper limb functions were assessed at baseline and after the treatment. Both groups showed significant improvements when comparing pre-treatment and post-treatment mean values of all measured variables. They concluded that home-based modified constraint-induced movement therapy can be an effective treatment option to improve upper limb function in children with hemiplegic CP (12).

Golomb et al. (2010)

Golomb MR et al. conducted a study to see whether telerehabilitation via virtual reality video games based at home can improve hand functions and forearm bone health in adolescents with hemiplegic CP (13). In addition, the study aimed to show the alterations in motor circuitry activation. The study duration was 3 months. Three participants' homes were fully equipped with a virtual reality video-game-based rehabilitation sys-

tem. The participants were instructed to use a sensor glove connected to a remotely monitored video game console in their home to exercise their affected hand for 30 minutes 5 days a week. The primary outcome measures were standardized occupational therapy assessments, remote assessment of finger range of motion based on sensor glove readings, plegic forearm bone health assessment with dual-energy x-ray absorptiometry and peripheral quantitative computed tomography, and functional magnetic resonance imaging of the hand grip task. Based on the virtual measurements, all 3 adolescents showed improvement in the affected hand functions during testing, including enhanced ability to lift objects and improved finger range of motion. The use of digitally monitored virtual reality video game telerehabilitation enhanced hand functions and forearm bone health (13).

Molinaro et al. (2020)

In CP children, Molinaro A et al. conducted a pilot study involving action observation training through telerehabilitation (14). A total of 10 children with CP in the age range of 5 to 12 years were enrolled in the study. They completed the action observation treatment rehabilitation program at home. The assisting hand assessment and the Melbourne assessment of unilateral upper limb function scale were the outcome measures. After treatment, scores were significantly different from the baseline and overlapped with those obtained in the 2-month follow-up randomized controlled studies conducted in a traditional setting. According to the study findings, action observation treatment is a promising approach in a telerehabilitation setting (14).

James et al. (2015)

James et al. conducted a study to see whether a web-based therapy program titled “Move it to Improve it” could help children with unilateral CP to improve their occupational performance, upper limb function, and visual perception (15). The participants were coupled and allotted to intervention and control groups. The outcomes were determined via the assisting hand assessment, the Jebsen–Taylor test of hand function, the Melbourne assessment of unilateral upper limb function, the Canadian occupational performance measure, and the test of visual perceptual skills. As a result, the participants completed “Move it to Improve it” in an average of 32.4 h. The experimental group had considerably higher post-intervention scores compared to the control group. They concluded that the program, “Move it to Improve it,” provides patients with personalized, web-based therapy at home and has the potential to raise the therapy dosages (15).

Ferre et al. (2017)

In CP children, Ferre CL et al. employed a randomized control trial to examine the effects of caregiver-directed, home-based intensive bimanual training (16). A total of 24 children with CP participated in home-based activities directed by a caregiver for 2 h per day, 5 days a week for a total of 9 weeks. The participants were randomly assigned to receive either the home-based hand-arm bimanual intensive training or the lower-limb functional intensive training. The dexterity and bimanual hand function were assessed using the box and blocks test and the assisting hand assessment, respectively. The Canadian occupational performance measure was used to assess the caregivers’ perceptions of functional goals. The home hand-arm bimanual intensive therapy improved the dexterity and performance of functional goals, but not the bimanual performance, in children with unilateral spastic CP when compared to the control group who received an intervention of the same intensity/duration that also controlled for increased caregiver attention. They concluded that increased treatment intensity can be achieved in a valuable, family-centered approach with home-based models (16).

Burdea et al. (2011)

In a study done by Burdea GC et al. , 2 hemiplegic CP children played virtual hand rehabilitation games using modified PlayStation 3 and 5DT sensing gloves, as described in this paper (17). Extended interventions were enabled when the training is provided in the patient’s home, such as through telerehabilitation, considering their easier accessibility and less impact on the school or work activities. The study included 2 hemiplegic CP subjects who continued to practice for about 14 months and 6 months, respectively. On the other hand, long-term remote rehabilitation comes with its own set of difficulties as concluded in the study (17).

Glavić et al. (2016)

According to Glavić J et al., recent research has shown that robot-assisted training can be used to supplement traditional therapies of CP in children (18). The most common lifelong disability affecting motor development in children is CP. The case of an 18-year-old girl with spastic hemiparesis has been presented in this study. After intensive technology-enhanced

physical rehabilitation via the Armeo spring system, the CP patient showed significant improvement (18).

Brisben et al. (2005)

The CosmoBot™ system was created for use in therapy, education, and play. While actively targeting their therapy goals, children interact with CosmoBot™, controlling the robot's movements and audio output using a variety of gestural sensors and speech recognition (19). The usability of CosmoBot™ as a physical therapy intervention for upper extremity movements was investigated in CP children of the "Outpatient Rehabilitation Program" at Mount Washington Pediatric Hospital in Cheverly. The CosmoBot™ system provided great motivation for the children during therapy sessions. It was simple to set up and use for the therapist and relieved the therapist of the task of trying to engage the children in therapy (19).

Analysis

The data were extracted from the tables in the paper along with the conclusion of the authors.

3. Results

Summary

This review aimed to provide information regarding telerehabilitation applications in improving hand function, chiefly in the CP population. In the present study, there is convincing evidence of the enhancement of hand function in CP patients.

Participants' characteristics

The total sample size, which included the intervention and the control group participants, ranged from 2 to 102 people. All included studies focused on children in the age range of 0 to 57 years. The type of CP population was hemiplegic in 9 studies and asymmetric upper limb hemiplegic CP in 1 study. Children with CP were the focus of all 12 studies.

Key intervention characteristics

The general goal of most interventions was to improve hand function via telerehabilitation. Various types of interventions were used, however, they can be classified into 3 categories: interventions focusing on an exercise program using sensing gloves (n=3), interventions providing action observation training (n=2), and interventions involving bilateral hand training and exercises (n=3). One intervention is an evaluative study (n=1).

Some telerehabilitation interventions targeted only CP children, while others included parents and caregivers as well. The most often used technology was video calls. For the frequency of the intervention, in most cases, telerehabilitation sessions were offered at least twice a week and session duration of 40 min. Offering training to the therapists before the intervention was observed in fewer than half of the studies.

4. Discussion

The data from the reviewed studies highlighted the feasibility and suitability of telerehabilitation to improve hand functions and independence in children with CP.

Of the total of 12 studies mentioned in this paper, each study appreciated and highlighted telerehabilitation for future use. In a study focusing on upper limb training programs via telerehabilitation, reach movement time decreased significantly for unilateral and bilateral tasks in the affected limbs. Meanwhile, the interlimb delay during sequential reaching decreased. Significant improvements in hand manipulation tasks were observed, as well (2). An evaluative study by Cankurtaran et al. stated that more attention should be given to telerehabilitation and telemedicine services of the clinicians who deal with children with CP, and their caregivers to prevent the negative effects of future pandemic periods (10). A positive outlook was noted in caregivers' perceptions of functional goals which makes telerehabilitation a family-centered approach to treatment (9). In the end, improvement was observed in grip, reaching, dexterity, and motor skills in hand activity concluding the usage of telerehabilitation for delivering therapies as a promising tool and strong future recommendations (2-4, 9, 10).

5. Conclusion

Telerehabilitation is a promising method for providing rehabilitation services to children with CP. The conclusion based on the result of training hand function with telerehabilitation in the CP population shows significant improvement in grip strength, retention, hand dexterity, motor skills, and forearm bone health, and the secondary outcome which is the caregivers' satisfaction. Few studies have reported the use of sensing gloves and other technologies in the upper limb rehabilitation process using virtual reality in

physiotherapy programs, which can increase the area of future research.

Limitations and future research directions

Of all the positive findings, this review paper has some limitations that include, the number of reviewed articles being low (only 12 articles). Additionally, the articles only contain the CP population. Furthermore, only improvement in hand function has been provided. Meanwhile, the technological solutions used were not customized.

- Future research directions in this framework should focus on the following topics:

- Expanding the population criteria by including other neurodevelopmental disorders;

- Increasing the number of articles for review;

- More specific outcome measures;

- More improvement parameters such as gait, mobility, cognition, quality of life, and so on.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Study concept and design, data acquisition, data analysis and interpretation, and drafting of the manuscript: Jagriti Modi; Critical revision of the manuscript for important intellectual content, statistical analysis, and administrative, technical, and material support: Jagriti Modi and Pooja sharma; Study supervision: Pooja Sharma.

Conflicts of interest

The authors declared no conflict of interest.

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