Effects of Virtual and Augmented Reality on Occupational Performance in Children with Cerebral Palsy: A Systematic Review

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- Virtual and Augmented Reality
- Occupational Performance
- Daily Living Activities
- Rehabilitation Therapy
- Evidence-Based Practice

Cerebral palsy (CP) is a non-progressive and permanent motor disability that affects the development of movement and posture due to abnormal brain development or damage to an immature brain. It often presents with motor, cognitive, sensory, and behavioral impairments that limit occupational performance and quality of life. CP affects about two to three children in every 1,000 live births, making it the most common motor disability in childhood (Metin et al., 2013). Virtual and augmented reality (V&AR) has emerged as an innovative therapeutic intervention that targets motor and cognitive rehabilitation in children with CP through its task-oriented, interactive, and intensive training system. However, there has been limited research on its effectiveness in the CP population due to its novelty and variety of interventions available. In this systematic review, a comprehensive literature review of 20 studies was conducted to evaluate the effects of V&AR on occupational performance in children with CP. The results of this review support the use of V&AR interventions in expanding and guiding rehabilitative practitioners who work with children with CP.

Focused Clinical Question

The purpose of conducting this Rapid Systematic Review (RSR) was to critically appraise relevant literature to address the following focused clinical question: In school-aged children with CP, what is the effect of virtual and augmented reality compared to conventional rehabilitation therapy in improving occupational performance?

Outcome Definitions

Occupational Performance

Occupational performance is the act of doing a selected action, activity, or occupation that results from an individual engaging with their environment. It is defined as routines and tasks that individuals engage in that they enjoy and find meaningful. According to the American Occupational Therapy Association (AOTA), occupations include: activities of daily living (ADL), instrumental activities of daily living (IADL), health management, rest and sleep, education, work, play, leisure, and social participation (2020). This RSR study is focused on school-aged children, in which the emphasis on occupational performance is geared towards kids and ADLs. Improving skills related to occupational performance leads to a higher satisfaction of engaging in meaningful occupations.

Virtual and Augmented Reality

Virtual reality (VR) incorporates computer-generated simulation to create an immersive virtual environment in real-time. Using a head-mounted display, VR users are placed in a 3-dimensional (3D) multimedia sensory environment, where they are immersed with the virtual environment and characters that feel realistic. Augmented reality (AR) utilizes these elements of VR in order to provide a real-world experience augmented by digital information or objects in real-time. AR uses the existing real-world environment and overlays virtual information on top of it. The RSR incorporates both VR and AR systems to evaluate its effects on occupational performance in children with CP. Examples of these V&AR systems include: XBox Kinect-based VR, Leap Motion Based Exergame Therapy, Nintendo-Wii, RAPAEL SmartKids, interactive video gaming (IVG), and personalized balance games from Gamification for Better Life (GABLE) online serious gaming platform.

Rehabilitation and Conventional Therapy

Rehabilitation therapy is defined as a broad area of treatment that includes physical, occupational, and speech therapy. Common conditions that are treated by the rehabilitation team include orthopedic and musculoskeletal, neurological, and multi-trauma conditions. This RSR incorporates multiple forms of rehabilitation that helps improve occupational performance of children with CP. Conventional occupational therapy (OT) is considered to be a specific type of rehabilitation treatment that is used in some studies. Conventional OT interventions vary based on the child's individual needs to focus on meaningful activities and place movements into context. For this RSR, all types of treatment are deemed functional and appropriate for the population being addressed.

Statement of Problem and Background

CP is a group of neuromuscular disorders that impacts movement, posture, and coordination, which often result in occupational performance limitations (El-Shamy & El-Banna, 2020; Roberts et al., 2021). This life-long, non-progressive condition is caused by damage to an immature brain or abnormal brain development (El-Shamy & El-Banna, 2020). Brain damage before or during birth can result in congenital CP, while damage that occurred more than 28 days after birth results in acquired CP (Centers for Disease Control and Prevention [CDC], 2022). Symptoms of CP vary from person to person, including neuromuscular, musculoskeletal, cognition, sensory, communication, and psychosocial impairments (Chang et al., 2020; El-Shamy & El-Banna, 2020; Roberts et al., 2021). Common motor impairments include muscle weakness, spasticity, and incoordination, which often lead to increased activity limitations and decreased functional independence (El-Shamy & El-Banna, 2020). Depending on the severity of symptoms, affected body parts, and severity of brain damage, there are four main types of CP: spastic, dyskinetic, ataxic, and mixed CP (CDC, 2022). Spastic CP is the most common type of CP that presents with increased muscle tone and continuous muscle contraction mainly in the lower extremities, resulting in stiff, jerky, and rigid movements (CDC, 2022). Dyskinetic CP is characterized by uncontrollable and involuntary movements in the hands, arms, and legs, while ataxic CP presents with imbalance and incoordination (CDC, 2022). Mixed CP is identified by the combination of different types of CP, such as spastic-dyskinetic CP (CDC, 2022). CP is also classified by limb involvements, such as diplegia, hemiplegia, and quadriplegia. Due to the vastly different types of CP, there is a gap in interventions that needs to be addressed.

The role of V&AR in therapy settings has been studied for a wide variety of disorders, such as stroke, anxiety, or psychiatric disorders. However, it is a relatively new method of treatment within the CP population (Sajan et al., 2017). Recently, VR has been explored as a training option in rehabilitation settings to improve motor performance in children with CP. This enables the creation of an exercise environment, in which children receive positive visual and auditory feedback both intensely and repetitively (Avicl et al., 2021). V&AR mimics real-world situations, and research is starting to show improvements in children's motivation, social validity, range of motion (ROM), and functional mobility (Jung & Choi, 2017; Shin et al., 2016). It has emerged as a cost-effective intervention, making it commercially viable and fun for children. Due to new technological advancements, it is important to incorporate this into rehabilitation therapy sessions in order to continue engaging and motivating children with CP. Therefore, the use of V&AR therapy to improve occupational performance in the CP population can improve overall health and increase independence with ADLs. This RSR hopes to bridge the gap in knowledge between V&AR and the CP population and bring attention to the need for more research regarding this clinical question.

Method for Conducting the Evidence-Based Review

A research group of occupational therapy students (OTS) selected occupational performance as an outcome measure that children with CP often struggle with and decided on an innovative approach of V&AR as a treatment method. After collaborating with professors and classmates, a PICO question was established, and the following search terms were used:

((Cerebral palsy) OR (CP) OR (Autism Spectrum Disorder) OR (ASD) OR (Attention deficit hyperactivity disorder) OR (ADHD) OR (Fragile X Syndrome) OR (developmental disabilities) OR (intellectual disabilities) OR (down syndrome) OR (fetal alcohol syndrome) OR (Tourette Syndrome)) AND ((Virtual Reality) OR (Augmented Reality) OR (gaming)) AND ((ADL) OR (activities of daily living) OR (IADLS) OR (Play))

This search was conducted by OTS with the assistance from librarians of the Ruth Lilly Medical Library. The search terms were inputted into two databases: PubMed and EBSCO. Articles that were not provided by databases described above were acquired by the Indiana University–Purdue University Indianapolis (IUPUI) Library of Medicine. By standards of the AOTA, the targeted levels of evidence were Levels I and II. However, due to limited research available on this topic, the searches were expanded to include Level III articles as well. The inclusion and exclusion criteria used are as follows:

Inclusion Criteria:
- Ages 3-20
- Diagnosis of CP (according to CDC guidelines)
- Studies $\leq$10 years
- $\geq$15 participants
- RCTs, Levels II & III (non-randomized studies, retrospective cohorts, or diagnostic studies that do not have a consistent reference standard)

Exclusion Criteria:
- Ages <3 or >20
- No diagnosis of CP
- Studies > 10 years
- <15 participants
- Level I (Systematic Reviews & Meta-analyses), Level IV(descriptive studies – case series or studies with historical controls), Level V (case reports)

Studies that met the criteria and search terms were inputted into Covidence for further screening and evaluation. 993 articles were imputed to Covidence, with 365 being removed due to duplication. 628 articles were included in the title and abstract screening, with 502 being deemed unfit for our study. 124 articles were then included in the full-text review. After reviewing the full article, 104 articles were excluded for the following reasons: not enough participants, wrong study design, wrong patient population, wrong objective, wrong outcomes, wrong indication, duplicates, ongoing study, research protocol, and wrong intervention. 20 articles were approved by all team members to be included in the final selection for the RSR. The 20 articles were put into three intervention themes to increase occupational performance in the CP population:

- *Theme 1:* Motor Rehabilitation
  - Subgroup 1: Balance
  - Subgroup 2: Upper Extremity Strength/ROM
- *Theme 2:* Cognitive Rehabilitation
- *Theme 3:* Activities of Daily Living Skills

Results

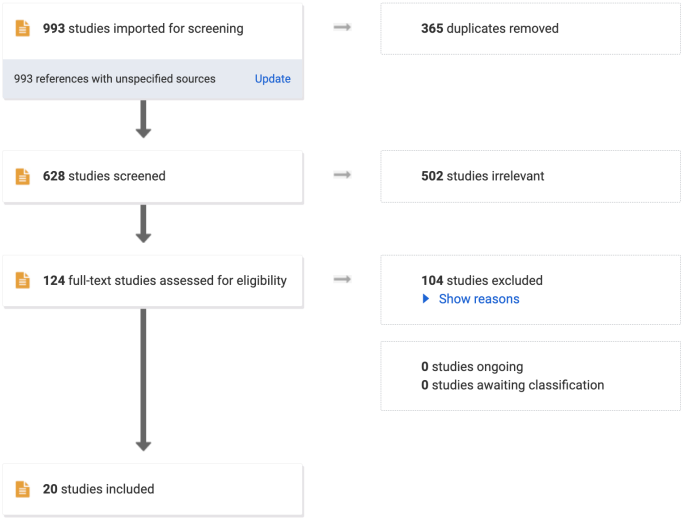

Figure 1: PRISMA Diagram

A total of 20 articles met the inclusion and exclusion criteria in Covidence, and all articles were used in the evidence table (Table 1) and this RSR. The results of these studies developed themes to address the clinical question. These broad themes include: motor rehabilitation, cognitive rehabilitation, and activities of daily living skills. Motor rehabilitation includes skills that help promote motor learning in order to obtain efficient motor control within different contexts. Subgroups noted for this section consist of balance skills and upper extremity (UE) strength and ROM. Cognitive rehabilitation includes a person's ability to complete cognitive tasks in order to engage in different contexts. Activities of daily living skills include basic activities that involve taking care of one's own body and completing basic routines. Of the 20 articles used in this RSR, there were 14 level I, one level II, and five level III studies. All of the studies aimed to improve occupational performance by focusing on important ADL skills.
It should be noted that some articles appear in multiple themes due to addressing multiple areas of interest. The results are as follows:

Theme 1: Motor Rehabilitation

V&AR has emerged as a novel motor rehabilitation intervention that addresses physical symptoms of CP. Motor rehabilitation, including motor learning and motor control, was found to increase motor skills in children with CP. Through its repetitive and intensive motor training system, V&AR is beneficial in enhancing balance and UE strength and ROM. Of the studies reviewed for this RSR, there were 11 level I studies, one level II study, and five level III studies that targeted motor rehabilitation skills to increase overall occupational performance.

Balance

Level I Studies
A level I RCT study showed that VR, when used alongside physiotherapy, appears to be beneficial in improving balance capacity in children with bilateral spastic CP (Jha et al., 2021). One RCT study also demonstrated that Wii-Fit balance-based video games are important components of CP rehabilitation and have the potential to generate improvements within balance parameters (Tarakci et al., 2016). Another RCT found that the Nintendo Wii alone showed statistically significant improvements in functional balance compared to routine physiotherapy in children with spastic hemiplegic CP (Uysal & Baltaci, 2016). Moreover, Gatica-Rojas et al. (2017) showed that the Nintendo Wii Balance Board was overall better than standard physiotherapy in terms of improving standing balance in the spastic hemiplegic CP population; however the long-term effects of Wii therapy were not supported due to waning effects two to four weeks after the intervention ended (Gatica-Rojas et al., 2017). Another level I pre-posttest RCT showed decreases in postural sway and increases in the Pediatric Balance Scale (PBS) dynamic scores within the experimental group (Hsieh, 2020). The study also concluded that using balance board interventions in the study group had more increased functional balance than the control group. Overall the results of these studies display strong evidence for the use of V&AR in balance training to support occupational performance in children with CP.

Level III Studies
A level III exploratory design study found statistically significant improvements in children with CP after two weeks of intervention with personalized balance games according to the following measures: Trunk Control Measurement Scale (TCMS) and Dynamic Balance Test

(DBT) scores (Kachmar et al., 2021). Another level III study indicated that an increase in motor function in the Gross Motor Function Measure (GMFS) scores were due to Xbox 260 Kinect interventions, such as gross motor function, sitting, crawling and kneeling, standing, walking/running, and jumping (Machado et al., 2017); the study also found statistically significant increases in standing balance after utilizing these Xbox 360 Kinect interventions (Machado et al., 2017). These two level III studies show good evidence for the use of V&AR for balance training, but the studies are limited by their weak level of evidence and lack of randomization. Further research needs to be conducted in order to strengthen the argument for these interventions.

Upper Extremity Strength/ROM

Level I Studies

A level I RCT study showed that video-based games can be used and designed as an effective treatment for upper limb (UL) functions. The study concluded that these video-based games are a feasible and alternative training for children who have a physical disability, including CP (Tarakci et al., 2020). Another level I study found that video game based therapy (VGBT), including the use of Nintendo Wii and Leap Motion Controller (LMC) games, showed superior effects on manual dexterity compared to neurodevelopmental therapy (NDT) intervention in CP populations (Aveil et al., 2021). There was another RCT study that indicated improvements in ROM and muscle strength of most UE joints in children with spastic hemiplegic CP after augmented reality interventions (Malick et al., 2022). Sajan et al. (2017) found IVG increased UL functions, especially grasp, in the IVG group in contrast to the control group that received conventional therapy. Similarly, Choi et al. (2021) concluded that both VR and control groups resulted in statistically significant improvements in ROM, target accuracy, dexterity, and fluency post-intervention and 8-week follow-up in children with Manual Ability Classification System (MACS) levels I to IV, including CP, pediatric stroke, and sustained traumatic brain injury; the VR group also showed more significant increases in UL dexterity post-intervention compared to the control group that received conventional OT in those with severe motor impairments (Choi et al., 2021). Lastly, El-Shamy and El-Banna (2020) found that the experimental group that received both Wii training and their usual care showed significant improvements in terms of their spasticity, grip strength, and hand function compared to the control group for children with hemiplegic CP. Overall the results of these studies display that the use of V&AR provide strong evidence in UE strength and ROM to support occupational performance in children with CP.

Level II Studies

One level II retrospective study showed significant improvements in all Quality of Upper Extremity Skills Test (QUEST) domains when using wearable Smart gloves (SG), which detected UL movement, gave real-time feedback, and included the ability to adjust the difficulty level (Chang et al., 2020). Overall, the results of this level II article offer moderate evidence for the use of V&AR in improving UE strength and ROM in children with CP.

Level III Studies

One level III study found that 14 out of 19 participants showed a positive increase in at least one body function measure: balance, gait symmetry, UL strength, higher-quality movements, active wrist extension, grip strength, and gross manual dexterity (MacIntosh et al., 2020). This study concluded that V&AR has statistically significant results when used with conventional rehabilitation therapy (MacIntosh et al., 2020). Robert et al. (2021) completed a non-randomized clinical trial study and found both statistically and clinically significant improvements in Assisting Hand Assessment (AHA) scores for bimanual performance during post-intervention and 6 month follow-up for children with hemiplegic CP following the augmented Pediatric Constraint Induced Movement Therapy (P-CIMT); while Melbourne Assessment of Unilateral Hand Function (MUUL) scores for unilateral performance showed statistically significant results post-intervention and 6-month follow up compared to baseline, the mean differences were not clinically significant (Roberts et al., 2021). Lastly, a repeated measures design study found statistically significant improvements in Jebsen-Taylor Hand Function Test (JHFT) results, along with gross grip and pinch forces, that were in favor of the Leap Motion Based Exergame Therapy (LMBET) for children with spastic CP (Yildirim et al., 2021). While both Structured

Neurodevelopmental Therapy-Based Hand Rehabilitation (SNDTBHR) and LMBET showed significant improvements in hand functions, LMBET presented with more statistically significant results, concluding that LMBET can be used as an alternative to NDT-based UE treatments (Yildirim et al., 2021). In conclusion, these studies show good evidence for V&AR on UE strength and ROM, but the studies are limited by their weak level of evidence due to lack of control group and randomization. Further research needs to be conducted in order to strengthen the argument for V&AR interventions.

Theme 2: Cognitive Rehabilitation

V&AR interventions were used to increase cognitive skills by addressing cognitive and executive functioning deficits faced by children with CP. Cognitive impairments are often associated with immature brain damage of CP (Yildirim et al., 2021). Examples of cognitive impairments in CP include altered information processing and motor-executive functions, decreased attention and executive functions, memory and learning disorders, and language impairment (Aran et al., 2020). Cognition and perception play a role in functional recovery and independence by helping process, store, and integrate information to successfully and independently interact with the environment. Of the studies reviewed for this RSR, there were two level I studies and one level III study that focused on the effects of V&AR on cognitive functions to increase occupational performance in children with CP.

Level 1 Studies

A level I RCT study showed more improvements in the VR group in areas of praxis, visuomotor construction, spatial perception, and executive functions in children with hemiplegic CP compared to the control group that received traditional OT (Aran et al., 2020); the authors concluded that VR provides good support and is recommended in therapy sessions when dealing with cognitive rehabilitation (Aran et al., 2020). Metin et al. (2013) also found that Hacettepe Psychological Adaptation Scores increased in the study group, which received both VR therapy and neurophysiological, conventional, and OT treatments; the study demonstrated that the use of VR has potential benefits in the realm of psychological adaptation (Metin et al., 2013). It relates to cognitive rehabilitation because psychological adaptation targets the ability to make changes according to different environmental contexts; levels of cognition affect psychological adaptation (Metin et al., 2013). Overall the results of these two level I studies display that the V&AR therapy has strong evidence in cognitive rehabilitation to support occupational performance in children with CP.

Level III Studies

One level III repeated measures design study found that LMBET resulted in statistically significant increases in cognitive function in children with spastic CP based on the Wisconsin Card Sorting Test (WCST) results (Yildirim et al., 2021). The results of this level III study demonstrate the benefits of V&AR on cognitive function to enhance occupational performance in children with CP. While the study shows good evidence for V&AR on cognitive rehabilitation in children with CP, it is limited by its weak level of evidence due to lack of control group and randomization. Further research needs to be conducted in order to offer more credibility.

Theme 3: Activities of Daily Living (ADL) Skills

V&AR interventions were used to address ADLs by incorporating real-life activities that children use on a daily basis. This RSR used areas of play, social interaction, dressing, and eating to find evidence for ADL skills. Of the studies reviewed for this RSR, there were three level I studies, one level II study, and two level III studies that focused on ADL skills to increase occupational performance in children with CP.

Level I Studies

One article looked at VR gaming interventions in children with unilateral spastic CP and concluded that these interventions have the potential to improve aspects of ADLs (Şahin et al., 2020). Similarly, Uysal and Baltaci (2016) found that both Nintendo Wii and control groups had statistically significant improvements post-intervention in areas of self-care, mobility and total Pediatric Evaluation of Disability Inventory (PEDI) scores compared to pre-intervention for children with spastic hemiplegic CP. The authors concluded that while NW cannot replace traditional physiotherapy, it would be an effective addition due to its contribution to

occupational performance, daily living activities, and functional balance (Uysal & Baltaci, 2016). Another level 1 RCT study found that ADL performance in children with severe motor impairments (i.e., CP, pediatric stroke, and sustained traumatic brain injury) had more significant improvements than the control group when utilizing the Pediatric Evaluation of Disability Inventory Computer Adaptive Test (PEDI-CAT) outcome measure (Choi et al., 2021). The authors noted that both groups had statistically significant improvements in the social-cognitive domain (Choi et al., 2021). All three studies indicated that V&AR is beneficial when used in conjunction with traditional rehabilitation therapy. Overall, the results of these three level I articles display strong evidence for V&AR in improving ADL skills and occupational performance in children with CP. However, there is a need for more research on the effects of V&AR as its own intervention method.

Level II Studies

One level II retrospective study showed that VR-based therapy and conventional OT resulted in improvements in ADLs for children with CP and caregiver burden when utilizing the PEDI outcome measure (Chang et al., 2020). Overall, the results of this article indicate moderate evidence for V&AR in enhancing ADL performance in children with CP.

Level III Studies

A level III study found that combined interventions of solution focused counseling (SFC) style coaching and high-quality biofeedback has potential to align with traditional therapy for home-based rehabilitation (MacIntosh et al., 2020); the authors found moderate effects in body function, motivation, and activity and participation measures (MacIntosh et al., 2020). Another level III study showed that the augmented Pediatric Constraint Induced Movement Therapy (P-CIMT) resulted in both statistically and clinically significant increases in occupational performance, as measured by the Canadian Occupational Performance Measure (COPM), during post-intervention and 6-month among participants with hemiplegic CP (Roberts et al., 2021). Overall the results of these level III articles show that the use of V&AR, including SFC and augmented P-CIMT, can be beneficial in facilitating ADL and occupational performance in children with CP. However, there is weak level of evidence due to their study designs (i.e., one group, non-randomized, pre- and post-tests).

Implications for Occupational Therapy Practice

The data collected in this RSR show moderate strength of evidence supporting V&AR as a potential intervention that improves motor skills, cognitive and executive functioning, and ADL performance, ultimately enhancing occupational performance in children with CP. Of the 20 studies evaluated, 17 showed moderate to strong motor rehabilitation outcomes following V&AR interventions. Through real-time feedback and repetition, V&AR was found to increase balance and UE strength and ROM. In terms of cognitive rehabilitation, several studies showed strong evidence to support the effects of V&AR on praxis, visuomotor construction, spatial perception, and executive function in children with hemiplegic CP. Lastly, there was strong evidence to support V&AR in conjunction with conventional therapy to improve ADL skills and occupational performance.

The main goal of OT is to help individuals engage in their daily activities and participate in their roles and routines. Motor rehabilitation, including motor learning and motor control, is within the scope of OT practice to assist with functional mobility, balance, and postural control. Cognitive rehabilitation also aims to increase functional capacity and independence by engaging in cognitive flexibility, executive functioning, attention control, psychological adaptation, and information processing. These domains of cognitive functions all impact a child's ability to interact with the environment. OTs can utilize this RSR to help children with CP gain their functional independence and reduce barriers in occupational participation due to their symptoms.

Through client-centered and holistic care, OTs must look at the child as a whole and incorporate games that the child finds most interesting. Reflecting these gaming choices can support client autonomy and encourage active participation. Client factors, including personal interests, values, beliefs, and spirituality, all impact motivation and occupational performance; personal and environmental supports and barriers should also be regarded when deciding the implementation of different types of V&AR interventions and adaptations

based on the child's interests and needs in order to ensure nonmaleficence and beneficence. V&AR allows OTs to address real life activities through virtual means in areas such as ADLs, play, and social participation. Technology has been integrated into healthcare through its increased popularity, accessibility, and advancements. Due to the wide range of CP symptoms, V&AR therapy may be substantially effective for one person and completely ineffective for another. It is imperative to evaluate all OT domains for each individual to ensure proper translation into practice and provide individualized interventions based on the child's needs.

Limitations

Although the relevance of V&AR interventions in improving ADL function in children with CP is supported, there are limitations within the literature. Of the 20 articles evaluated, varying levels of evidence were present, including 14 Level I, one Level II, and five Level III articles. The six non-Level I articles pose a limitation due to lack of control group, assessor blinding, and randomization, thus introducing potential risk for biases. Limitations also include small sample size, variability in CP types, and short study duration, which decreases generalizability and relevance of V&AR interventions to all children with CP. Lastly, individual studies with minor reporting errors or language translations result in minor errors in data, such as discrepancy of demographic data and results. Ultimately, these limitations decrease the study reliability and validity. Future studies must include qualitative data to depict participants' motivation, participation, and overall satisfaction in combination with the quantitative data already provided.

Conclusions

Moderate evidence supporting the use of V&AR therapy in increasing occupational performance for children with CP were found in all themes: motor rehabilitation, cognitive rehabilitation, and ADLs. The inclusion of research with weaker levels of evidence decreased overall strength. Additional research on the impact of V&AR therapy for children with CP is required to consider motivational aspects of V&AR when compared to conventional rehabilitative therapy. The gap between strictly the impact of V&AR on occupational performance and impact due to increased motivation from V&AR therapy must be distinguished to truly evaluate the role of V&AR in rehabilitation. Further research should be completed utilizing methods regarded as higher levels of evidence, such as RCTs. Additionally, studies including larger sample sizes and measuring the long-term effects of V&AR therapy on children with CP are necessary to evaluate the magnitude of impact on occupational performance.

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Appendix A

Table 1: Evidence Table for Interventions within the CP population

Author/Year	Level of Evidence/Study Design/Participants/Inclusion Criteria	Intervention and Control Group	Outcome Measures	Results
Virtual and Augmented Reality				
Şahin, S., Köse, B., Aran, O. T., Bahadır Ağce, Z., & Kayıhan, H. (2020). https://doi.org/10.1089/g4h.2019.0020	**Level of Evidence:** Level I **Study Design:** single blind, RCT **N**=60 ● 37 Males ● 23 Females **Child Age Range**: 7-16 yrs **Intervention:** n=30 **Control**: n=30 **Inclusion Criteria** ● Between ages 7-16 ● Cerebral palsy diagnosis ● Scored over 24 on the Mini-Mental State Examination for children ● Classification in levels 1-2 of the Manual Ability Classification System ● Classification in levels 1-3 of the Gross Motor Function Classification System ● Able to follow verbal instructions	**Intervention:** Received a VR intervention and traditional occupational therapy intervention. The VR intervention utilized five different VR games: air challenge, boxing trainer, wall breaker, jet run, and super kick. Each game was used equally and played during a single session. **Control:** The control group only received traditional occupational therapy intervention. The occupational therapists used activities to increase motor skills and daily activities.	**Outcome Measures** ● Bruininks-Oseretsky Test of Motor Proficiency (BOTMP-SF) ● The Functional Independence Measure for Children (WeeFIM) Outcome measures were completed by both groups during pre and post interventions.	**Results:** Although the total motor function and independence improved in both groups, the study group saw greater improvements. The comparison group also saw significantly higher improvements in gross and fine motor functions. This study was adequately powered and statistically significant due to a p-value of <0.05 and over 50 people taking part in the study. The analysis methods were appropriate for what was being tested. Because there are a lot of outcomes and variables being tested, quite a few analysis methods were used in the assessment of the results. Analysis methods were completed using the IBM Statistical Package for the Social Sciences (SPSS) version 22.0, Mann-Whitney U and chi-squared tests, Cohen's d, and Wilcoxon signed-rank test. Statistics were accurately reported in the article, both in table and written format. The results from this study were precise and clinically significant, as determined by the effect sizes. The effect size of the study group when tested with the BOTMP-SF scale was 1.70 total. The effect size of the study group when tested with the WeeFIM scale was 0.66 total. The effect size of the control group when tested with the BOTMP-SF scale was 0.44 total. The effect size of the control group when tested with the WeeFIM scale was 0.14 total. Using Cohen's d

				to calculate the magnitude of difference between assessments, it can be concluded that the study group made larger improvements in the variables being tested than the control group. This study demonstrated that VR gaming interventions do have the potential to improve motor functioning in children with unilateral spastic cerebral palsy to increase the ability to perform activities of daily living.
Aran, O. T., Şahin, S., Köse, B., Ağce, Z. B., & Kayihan, H. (2020). https://doi.org/10.1097/MRR.0000000000000378	**Level of Evidence:** Level I **Study Design:** single-blind RCT **N**=90 ● 47 Males ● 43 Females **Child Age Range:** 7-12 yrs **Intervention:** n=45 **Control:** n=45 **Inclusion Criteria:** ● Being between the ages of 7 and 12 ● Having a classified level 1 or 2 in the Gross Motor Function Classification System ● A classified level of a 1, 2, or 3 on the Manual Ability Classification System for Children with CP ● The ability to follow and accept verbal instructions.	**Intervention:** The intervention group combined VR interventions and traditional occupational therapy into 1 session. Traditional occupational therapy was administered the same way as the control group. There were a total of 4 different games that were utilized for this study: Jet Run, Boxing trainer, Air challenge, and Superkick. The various skills addressed during games included: visual-spatial processing skills, praxis, perception, reaction time, spatial awareness, and cognitive time management. **Control:** The control group received only traditional occupational therapy. During these sessions, neurodevelopmental therapy was the main focus. This type of therapy aimed to promote use of extremities and to improve motor and cognitive skills. It was used to enhance the independence in activities of daily living.	**Outcome Measures** ● Dynamic Occupational Therapy Cognitive Assessment (DOTCA-Ch) Outcome measures were completed by both groups during pre and post interventions.	**Results**: Prior to the intervention, both groups were deemed statistically identical in terms of age, sex, hemiparetic side, and pre-intervention assessment scores. Both DOTCA-Ch scores were also below cut-off scores before the interventions took place. When comparing the control and intervention groups, the study group revealed a larger increase ($P<0.05$) in all subtests being measured during the study. The study group revealed statistically significant improvements ($P<0.001$) in cognitive function than the control group. Comparisons of the changes over time in cognitive function within and between the groups were shown in Table 3. The degree of impact on praxis was strong (Cohen's $d>0.80$), while the degree of impact on some subscales in the DOTCA-Ch was moderate (0.30-0.80). Overall, the degrees of impact were smaller in the control group than they were in the study group. Overall, there were more improvements among the VR group in areas of praxis, visuomotor construction, spatial perception, and executive function than the control group for the HCP participants.
Jha, K. K.,	**Level of Evidence:** Level I	**Intervention:** The children that were	**Outcome Measures**	**Results**: There were 63 children with CP that

Karunanithi, G. B., Sahana, A., & Karthikbabu, S. (2021). https://doi.org/10.1080/08990220.2021.1876016	**Study Design:** double arm design with observer-blinded RCT **N**=38 ● 23 Males ● 15 Females **Child Age Range:** 6-12 yrs **Intervention:** n=19 **Control:** n=19 **Inclusion Criteria:** ● Were between the ages of 6 and 12 ● Cerebral palsy diagnosis ● Had the ability to understand simple verbal instructions ● A Gross Motor Functional Classification System (GMFCS) level 2 or 3, ● A Manual Ability Classification System (MACS) level 1 or 2.	included in the intervention group received both Kinet-based virtual reality gaming and balance-specific physiotherapy. It is noted in the study that the intervention group received the same physiotherapy activities as the control group. The 5 games used for this study were: super saver, soccer, volleyball, 20000 leaks, and space pop. All of these games had different rules which were explained to the children by the therapist, but they all targeted the child's postural stability of standing and movement control. The children were given their performance score after they completed the allotted time of virtual reality gaming training. **Control:** The control group of this study underwent physiotherapy interventions only. The interventions used were aimed at increasing balance and mobility training. Some of the balance training activities that were performed during the sessions include: reaching out at an object beyond arm's length, supervised sit to stand activities, standing on one leg, and kicking a ball. Some of the mobility training activities performed include: stepping forward, backward, sideways, walking overground, maneuvering through obstacle courses, and climbing a staircase. Muscle activity and stretching exercises for the lower extremity were also performed.	● Positive Behavior Supports (PBS) ● The-Kids-Mini-BESTest ● Gross Motor Function Measure (GMFM-88) ● The Functional Independence Measure for Children (WeeFIM) Outcome measures were completed at baseline, 6-weeks post-training, and 2 months follow-up.	were screened for the study. After going through the inclusion/exclusion criteria, 38 were allowed to participate. The mean age of children in the experimental group was 8.94 and the mean age of children in the control group was 8.72. There were 33 children that were classified as a level 2 GMFCS and 5 children that were classified as a level 3 GMFCS. There were 29 children with mild spasticity and 9 children with a score of 2 on the modified Ashworth scale. Using the measure ANOVA, all outcomes were found to be statistically significant ($p<0.001$). The PBS measure was also statistically significant across all outcomes ($p<0.001$). The experimental group showed a significant confidence interval (95%) using the PBS measure post-training and during the 2 month follow-up. The Kids-Mini-BESTest also showed improvements across the duration of the study ($p<0.001$). The children that were a part of the experimental group showed significant improvements in the Kids-Mini-BESTest after training and during the 2 month follow-up ($p<0.001$). The GMFM-88 showed significant changes ($p<0.001$) and showed that the experimental group was clinically meaningful post-training and during the follow-up. The WeeFIM showed improvements across time, but not between groups. The WeeFIM also showed a medium effect size for the experimental group post-training and during the follow-up ($p<0.001$), whereas the control group had a small effect size ($p<0.05$).
Tarakci, E.,	**Level of Evidence:** Level I	**Intervention:** The intervention group	**Outcome Measures**	**Results**: There were a total of 109 participants

Arman, N., Tarakci, D., & Kasapcopur, O. (2020). https://doi.org/10.1016/j.jht.2019.03.012	**Study Design:** Randomized parallel group trial RCT **N**=92 ● 36 Males ● 59 Females **Diagnosis** ● Juvenile idiopathic arthritis (JIA) ○ n=43 ● Cerebral Palsy (CP) ○ n=30 ● Brachial plexus birth injury (BPBI) ○ n=19 **Child Age Range:** 5-17 yrs **Intervention:** n=42 **Control:** n=50 **Inclusion Criteria:** ● Diagnosis of JIA, CP, or BPBI ● Between ages 5-17 ● At least one affected distal joint in the upper extremity ● An upper extremity spasticity score of 0, 1, or 1b according to the Modified Ashworth Scale ● Getting diagnosed 6 months before the study started ● Can read and write in the	utilized 2 games ("Fizyosoft CatchAPet" and "Fizyosoft Leapball") to improve joint range of motion, muscle strength, coordination, and fine motor functions. **"Leapball"**: focused on the development of grasping and motor skills, dexterity and coordination of digits, improved ability to flex/extend hand, and improvement of movement speed, muscle strength, and motor control. The aim of this game is to grasp a virtual ball and throw it into the same colored bucket. **"CatchAPet"**: the aim of this game is to touch rabbits that are coming out of holes, using repetitive wrist flexion/extension movements. These games were introduced in 4 stages: (1) The therapist introduces the game to the participants and informs the child how to play the game (2) The child was given the opportunity to practice using the games. (3) The therapist made sure the child was playing the game correctly and not using compensatory movements. (4) The game was adjusted based on the individual needs of the child. **Control:** The control group participated in conventional rehabilitation only. The purpose of this intervention was to increase functional leisure and self-care tasks with the upper extremity. The tasks	● Duruoz Hand Index (DHI) ● Jebson Taylor Hand Function Test (JTHFT) ● Childhood Health Assessment Questionnaire (CHAQ) ● Nine-Hole Peg Test ● Grip/Pinch Strength Outcomes measures were completed before intervention and 8 weeks after.	enrolled in the study. After being put through the inclusion/exclusion criteria, the following were deemed ineligible: 2 were excluded due to transportation problems, 4 refused to participate in the treatment, and 11 were not included in the analysis due to personal reasons. Therefore, there were 92 participants that actually completed the 8 week rehabilitation program. All groups within the study were deemed similar in terms of demographic and clinical data. All patients were randomized into 2 groups: group 1 (intervention/LMCBT group) and group 2 (control/CT group). The 3 types of conditions looked at include: cerebral palsy (CP), juvenile idiopathic arthritis (JIA), and brachial plexus birth injury (BPBI). Cohen's d was used to measure the effect sizes of each group. The CP population showed more improvement in the intervention group than the control group. The outcome scores for group 1 (LMCBT group) ranged from 0.10-0.77. The outcome scores for group 2 (CT group) ranged from 0.09-0.70. Effect sizes in group 1 were reported as medium for all games except for 9HPT and hand grip. In the JIA population, the outcome scores ranged from 0.31-2.65 for group 1 and 0.12-1.66 for group 2. For the BPBI population, the outcome scores ranged from 0-0.44 for group 1 and 0.08-0.62 for group 2. The effect sizes in this population were too small for significant improvement to be hypothesized.

	Turkish language.	used during therapy included: grasp and release activities to improve the ability to flex and extend the hand and increase the range of motion at all joints. In order to achieve these goals the following equipment was used: velcro cylinders, skill cubes, exercise bands, therapeutic putties, and objects with different shapes.		
Tarakci, D., Ersoz Huseyinsinoglu, B., Tarakci, E., & Razak Ozdincler, A. (2016). https://doi.org/10.1111/ped.12942	**Level of Evidence:** Level I **Study Design:** RCT **N**=30 ● 19 Males ● 11 Females **Child Age Range:** 5-18 yrs **Intervention:** n=15 **Control:** n=15 **Inclusion Criteria:** ● Diagnosis of CP (diplegic, hemiplegic, dyskinetic type) ● Between ages of 5-18 ● Gross Motor Function Classification System (GMFCS) level 1, level 2, or level 3 ● No history of epilepsy ● No botulinum toxin A treatment for the lower extremity within the past 6 months ● Spasticity less than 2 on the Modified Ashworth	**Intervention:** Participants that were a part of the intervention group participated in balance-based video games. The group received 30 minutes of a NDT approach and 20 minutes of a Wii-Fit balance-based video game program. The exercise program using the Wii balance board consisted of 4 games: Slalom skiing, walking on rope, tilt table-balance board, and heading a soccer ball. The purpose of these games were to work on trunk control, weight transfer, postural control, dynamic balance, and body awareness. **Control:** Participants that were a part of the control group participated in conventional balance training. The group received 30 minutes of a NDT approach and 20 minutes of a conventional balance training program. The exercises used for this group included: exercises on balance boards, mat activities, activities on trampoline, weight-shifting exercises, and walking activities. The purpose of these games were to work on trunk control, weight transfer, postural control, dynamic balance, and body	**Outcome Measures** ● Functional Forward Reach Test (FFRT) ● Functional Sideways Reach Test (FSRT) ● The Functional Independence Measure for Children (Wee-FIM) ● Sit to Stand Test (STST) Outcome measures were completed before and after the 12 week intervention.	**Results**: There were a total of 38 participants that were eligible for this study. After going through the inclusion and exclusion criteria, 30 patients completed the study. There were 4 participants that dropped from the control group and 4 participants that dropped from the WiiG group. Significant differences were not detected for mean age and GMFCS scores between the two groups. There were also no statistically significant differences in either primary and secondary outcome measures. The changes found between the primary and secondary outcome measures were all significant and favored the intervention (WiiG) group. The p values for the intervention group were more statistically significant than those in the control group. The TGGT performance-based balance test saw a significant decrease in completion time between the two groups, with a more significant difference in the WiiG group. The 10mWT and 10SCT also saw a significant decrease in completion time between the two groups, with a more significant difference in the WiiG group. This is likely due to the fact that the WiiG group had more opportunities to work on their center of gravity within limits of stability due to the utilization of different types of games. Although there were significant improvements seen in both groups after treatment, increases in the WiiG group in all

	Scale in any joint ● Enough mental ability to be able to adapt to exercise.	awareness.		outcome measures were statistically significant compared to the control group.
77 Chang, H., Ku, K. H., Park, Y., Park, J. B., Cho, E. J., Seo, J. H., Kim, C. D., & O, S. H. (2020). 10.3390/healthcare8040391	**Level of Evidence:** Level II **Study Design:** non-blinded retrospective study **N**= 17 ● 12 Males ● 5 Females **Child Age Range:** **SG Group:** 6.08 ± 1.77 yrs **COT Group**: 4.88 ± 1.15 **Intervention:** n=10 **Control:** n=7 ***Inclusion Criteria:** ● "Children" ● Diagnosis of cerebral palsy ● Regular participation in rehabilitation program at Samsung Changwon Hospital ● Gross Motor Function Classification System (GMFCS) level I-IV ● Manual Ability Classification System (MACS) level I-IV *inclusion criteria of retrospective studies are just demographic	**Intervention:** Received both VR-based therapy and conventional OT. This group received VR-therapy for 20 min, and COT for 10 min each therapy session. Focuses of this group include range of motion (ROM), stretching exercise, and RAPAEL SmartKids. RAPAEL SmartKids is a rehabilitation training tool with sensors for children with neurological disorders. It comes with a wearable Smart glove (SG), which detects upper limb movement, gives real-time feedback, and includes the ability to adjust the difficulty level. RAPAEL allows children to engage in video games that mimic ADLs and IADLs such as fishing, cooking, cleaning, and more. Intervention took place 30min/treatment/2x/week for 8 weeks. **Control:** Received only conventional OT for 30 min/session which focused on range of motion (ROM) exercise, stretching, and ADL training. Intervention took place 30min/session/2x/week for 8 weeks.	**Outcome Measures** ● Quality of Upper Extremity Functions (QUEST) ● Pediatric Evaluation of Disability Inventory (PEDI) Outcome measures were completed by both groups during pre and post interventions.	**Results** QUEST: Within groups: The SG group showed significant improvement in dissociated movement (p=0.027), weight bearing (p=0.001), protective extension (p=0.012), and total QUEST scores (p=0.005) while the COT group showed significant change in the total QUEST score Between groups: Statistically significant differences (p<0.05) between groups consisted of grasp (p=0.017), weight bearing (p=0.07), protective sensation (p=0.004), and total QUEST scores (p=0.001). PEDI: With-in groups: PEDI scores increased in five PEDI domains within the SG group. Under the functional skills dimension, domains of self-care (p=0.017), transfer (p=0.028), social function (p= 0.018) and under the caregiver assistance dimension, domains of self-care (p=0.031) and transfer (p=0.022). No significant increases were found in the COT group. Between groups: Statistically significant difference (p<0.05) between the COT and SG group were in the transfer domain (p=0.035) under the caregiver assistance dimension.

	characteristics of participants			
368 Machado, F. S., Antunes, P. P., De Moura Souza, J., Santos, A. C. D., Levandowski, D. C., & De Oliveira, A. A. (2017). https://doi.org/10.1080/00222895.2016.1191422	**Level of Evidence:** Level III **Study Design:** quasiexperimental pretest posttest study **N**= 28 ● 15 Males ● 13 Females **Child Age Range:** 3-12 yrs **Intervention:** n=28 **Control:** n=0 **Inclusion Criteria:** ● Diagnosis of cerebral palsy ● Between ages 3-12 ● Classification of level I, II, or III on the Gross Motor Function Classification System (GMFCS) ● Upon a medical chart review, did NOT have moderate to severe intellectual disability, uncorrected visual or hearing impairments, hyperactivity, and other syndromes ● Absence of bone malformations ● No severe reductions in muscle length	**Intervention:** Parents completed a questionnaire to answer questions about their child's health and treatment history. Children participated in a rehabilitation program with two Xbox 360 Kinect games (Balance Beam and Star Hop). Children were individually given time to familiarize themselves with the game, rest between the two activities, and freely play each of the games. The intervention was facilitated by a physiotherapist and was done a total of 40min/session/2x/week for two months. Oral instructions were given (no motor demonstration). Balance Beam: Participants were asked to imagine they were holding a tray and trying to balance falling items while stepping to collect starts on the ground in Balance Beam. Balance Beam focused on upper limb, balance, coordination, and walking Star Hop: participants were required to walk on virtual mat that depicted stars and bombs. While walking, they were required to avoid the bomb. This game focused on walking, balance, and coordination. **Control:** N/A	**Outcome Measures** ● Gross Motor Function Measure (GMFM) Outcome measures were completed by both groups during pre and post interventions.	**Results** Total GMFM scores increased significantly after Xbox 360 Kinect intervention indicating improvements in gross motor function (mean change in total GMFM scores = 4.5%). Dimensions B (sitting), C (crawling and kneeling), D (standing), and E (walking, running, and jumping) showed statistically significant changes pre/post intervention, standing being the highest (p<0.001). Standing was most likely the highest as the games were mostly performed in the standing position regardless of wheelchair status. Those who scored a level III in the GMFCS scale showed greater gain in motor function than the other participants. There were no significant differences between groups regardless of type of paresis and age.
417 Sajan, J. E., John, J. A.,	**Level of Evidence:** Level I	**Intervention:** Received both conventional therapy and interactive	**Outcome Measures**	**Results** Upper limb functions were significantly

Grace, P., Sabu, S., & Tharion, G. (2017). https://doi.org/10.1080/17518423.2016.1252970	**Study Design:** randomized, controlled, assessor-blinded study (parallel-group design) **N**= 18 ● N/A Males ● N/A Females **Child Age Range:** 5-20 yrs **Intervention:** n=9 children **Control:** n=9 children **Inclusion Criteria:** ● Were between the ages of 5 and 20 ● Cerebral palsy diagnosis ● Had enough sitting or standing balance, can hold the remote, and had sufficient cognitive skills to follow directions to play Wii ● Parent's informed consent and child asset	video gaming (IVG). Conventional therapy consisted of physiotherapy sessions (focusing on strength, balance, and graded mobility) and occupational therapy sessions (focusing on upper limb function, balance, and visual perception). One random conventional therapy session per day was replaced by IVG interventions. IVG intervention required participants to utilize their affected upper limb to follow directions to play boxing and tennis Wii games at level 1 difficulty (20 min/each sport +5 min break in-between). Wii remotes were decreased in motion sensitivity. Intervention took place 36 hours/week, for 3 weeks. **Control:** Received only conventional therapy (physiotherapy and occupational therapy). Intervention took place 36 hours/week, for 3 weeks.	● Static Posturography ● Balance: Pediatric Beg's balance scale (PBS) ● Box and Block test (BBT) ● Quality of Upper Extremity Skills Test (QUEST) ● Test for Visual-Perceptual Skills, third edition (TVPS-3) ● Walking speed and distance Outcome measures were completed by both groups during pre and post interventions.	improved in the intervention group ($p = 0.039$) in contrast to the control group ($p = 0.109$). Other outcome measures showed significance but were not statistically significant. Upper limb functions, especially grasp improved significantly in the IVG group. Improvements in upper limb functions but not in balance shows the benefit of IVG therapy in short period of time (3 weeks)
608 Metin, B. Ö., Dogan, M., Çuhadroğlu, F. Ç., Nakipoğlu, G. F. Y., Köse, B. G., & Özgirgin, N. (2013). https://doi.org/10.4274/npa.y6046	**Level of Evidence:** Level I **Study Design:** prospective RCT **N**= 41 ● 28 Males ● 13 Females **Child Age Range:** 5-15 yrs **Intervention:** n=21 **Control:** n=20 **Inclusion Criteria:**	**Intervention:** Received both neurophysiological, conventional, occupational therapy treatment AND VR-therapy were implemented for this group Neurophysiological/conventional/occupational therapy: There is no description on what this conventional therapy implies. Occupational therapy was administered by an occupational therapist. Occurred 5 days a week for 4 weeks.	**Outcome Measures** ● Hacettepe Psychological Adaptation Scale (HPAS) Outcome measures were completed by both groups during pre and post interventions.	**Results** ● No statistically significant difference between groups in terms of age and gender, CP type according to tonus disorder (spastic, athetoid, mixed type), body part involved (diplegic, quadriplegic, triplegic, hemiplegic), HPAS introversion, extraversion, symptom, and total score levels before intervention. ● Significant increase in scores in the study group

	• Between 5-15 years old • Diagnosis of CP • Enrolled in a rehabilitation program between April 2009-September 2009 • No visual or auditory deficits, could be cooperated with, motivated • With adequate cognitive function, sitting balance • No upper extremity contracture and severe spasticity	VR-based therapy: The Eye Toy Play system VR- system via a Sony Play Station 2 Eye Toy system was utilized for this intervention. This system included a camera, a TV screen, the game disc, and the Play Station 2. Children observed themselves on the screen as they participated in games that required them to move their bodies. This was administered for 4 weeks at Ankara Physical Therapy and Rehabilitation Education and Research Hospital. Occurred 60min/session/3x/week for 4 weeks **Control:** Received ONLY neurophysiological/conventional/occupational therapy was implemented for this group Neurophysiological/conventional/occupational therapy: There is no description on what this conventional therapy implies. Occupational therapy was administered by an occupational therapist. Occurred 5 days a week for 4 weeks.		• The changes in scores of the HPAS were much higher and statistically significant in the study group, whereas it was not in the control group.
886 Hsieh, H. (2020). Preliminary Study of the Effect of Training With a Gaming Balance Board on	**Level of Evidence:** Level I **Study Design:** pretest/posttest RCT **N**= 56 • 32* Males • 15* Females	**Intervention:** Received both regular school physiotherapy and gaming with balance board Regular school physiotherapy: Consists of gait training, posture training, strength training. Occurred	**Outcome Measures** • Zebris FDM System • Pediatric Balance Scale (PBS) Outcome measures were completed by both groups	**Result**s • The experimental group decreased in postural sway and improved on functional balance tests. There were significant changes in the CoP kinematics (p=0.001) after rehabilitation using the adapted balance board. The PBS-dynamic score (all

Balance Control in Children With Cerebral Palsy. https://doi.org/10.1097/phm.0000000000001300	*Number of male and female participants does not add up to total participants due to discrepancy within the study. **Child Age Range:** 6-10 yrs **Intervention:** n=28 **Control:** n=28 **Inclusion Criteria:** ● Clinical diagnosis of CP ● Gross Motor Function Classification System (GMFCS) category level I-III ● Ability to perform active ankle dorsiflexion ● Ability to walk with or without assistive device ● Ability to follow rules of simple games	once a week for 12 weeks. Balance Board: Played PC games while standing and using foot to manipulate gaming balance board as a mouse. The balance board was connected to a computer to substitute the controls from the left button. The 45 min session was broken down into PC games, break, and PC games again. This mouse required the child to manipulate the balance board with one foot. The games were from www.gamesmomo.com . Occurred 45min/session/3x/week for 12 weeks. **Control:** Received regular school physiotherapy and gaming with computer mouse. Regular school physiotherapy: Consists of gait training, posture training, strength training. Occurred once a week for 12 weeks. Computer Mouse: Played PC games by manipulating mouse via hand in standing position for 45 min with 5 min break after 20min for a total of 45min/session/3x/week. The games were from www.gamesmomo.com . Occurred 45min/session/3x/week for 12 weeks.	during pre and post interventions.	three scores of static, dynamic, and total score) also improved balance control significantly in the experimental group. In comparison to the control group, the experimental group had improved CoP postural sway and better performance.
MacIntosh, A., Desailly, E., Vignais, N.,	**Level of Evidence:** Level III **Study Design:** pre/post test, 1	**Intervention:** Participants after baseline, practice and used the ICP activity system at home. 1 time per	**Outcome Measures** ● Solution Focused	**Results:** Feasibility Success Criteria was met for response rate (greater than or equal to 10%) and

Vigneron, V., & Biddiss, E. (2020). https://doi.org/10.1371/journal.pone.0234767	group **N**= 19 ● 9 Males ● 10 Females **Child Age Range:** 8-18 yrs **Intervention:** n=19 **Control:** n=19 (intervention group at baseline) **Inclusion Criteria:** ● Between the ages 8-18 ● Diagnosis of Cerebral Palsy, present with mixed tone/only mild dystonia ● Normal or corrected-to-normal vision/hearing ● Ability to understand/follow instructions for the task ● Between levels I-III on the Manual Abilities Classification System. ● Passive wrist extension at least 10 degrees more than normal active wrist extension ● Goals of improving their hand/wrist function	week they were assessed by researchers of 60 minutes where game play was recorded, wrist extension/grip strength was measured, and check in conversations were held using the SFC guidelines, EARS, and during the first and last visit the SEAS was used. Check-ins were used throughout intervention to gauge satisfaction, motivations, progress, modify goals, and tweak game difficulty if needed. **Control:** (Group at baseline): Phase A took place in the clinic using Solution-focused Coaching style conversation and checklist to assess participants motivation, self identified practice schedule, and how their intervention would connect to their desired ADLs. Goals established using the COPM. For 1-2 baseline sessions participants learned the ICP activity system controls and gestures.	Coaching style conversation (participant focused) ● Canadian Occupational Performance Measure (COPM) ● Self-Reported Experiences of Activity Settings (SEAS) ● Active Wrist Extension- Open Fingers (AWEO) ● Grip Strength ● Gross Manual Dexterity (B&B) ● Functional Bimanual Performance (AHA) Outcome measures were completed pre and post intervention.	study completion (greater than or equal to 80%). In other words, 19/62 participants were recruited (31%) and 3/19 participants completed all assessments (84%). Only 14/19 participants met their goal criteria meaning this success criteria was only partially met. Criteria was set for 0 practice restrictions due to technical issues however 6/36 participants reported technical issues that restricted game play, so the criteria was not met. Based on post-hoc analyses there was small to no relationship between practice time and functional change scores. This intervention approach seems feasible with modifications and there were some moderate effects in body function, motivation, and activity/participation measures. The combined intervention of SFC style coaching and high-quality biofeedback might align with traditional therapy as a way of engaging youth in rehabilitation at home however definite RCT in further studies is needed to show the true effectiveness of this intervention.
Avcil, E., Tarakci, D., Arman, N., & Tarakci, E. (2021). https://doi.org/10	**Level of Evidence:** Level I **Study Design:** randomized controlled single blind study **N**= 30	**Intervention:** Wii and LMC games were used to target elbow and shoulder functions and remote-control sound and vibrations were provided for feedback. The Nintendo Wii Fit sports package: specifically bilateral boxing games	**Outcome Measures** ● Minnesota Manual Dexterity Test (MMDT) ● Childhood Health Assessment	**Results:** Baseline: differences in dominant side between groups and scores of CHAQ for rising, walking, reaching, and total were statistically different $p<0.05$

.1007/s13760-020-01400-8	• 17 Males • 13 Females **Child Age Range:** 6 - 15 yrs **Intervention:** n=15 **Control:** n=15 **Inclusion Criteria:** • Diagnosis of CP according to health records with spasticity in the upper limb lower than 3 according to the MMAS • Ability to cooperate with exercise and measurement	and tennis games were performed. LMC was used to develop Fizyosoft games such as "CatchAPet" and "Leapball". The "CatchAPet" game's objective was to use repetitive wrist flexion/extension to touch rabbits coming out of holes. The "Leapball" game required grasp and extension with all fingers of one hand to catch and throw a virtual ball. The levels of these games could be adjusted in terms of speed, repetition, number/size of ball/hole. **Control:** NDT based upper extremity rehabilitation was used to promote normal movements of the upper extremity with the end goal of improving these movements in activities such as dressing and eating. Activities in this intervention group included velcro cylinders, skill cubes, exercise bands, screw sets, therapeutic putty, and triple-coordination tools. These interventions were progressed by changing time, complexity, materials, and number of repetitions. ** Intervention and Control was done in the ambulatory clinic in Dilbade Special Education and Rehabilitation Center for 8 weeks. Each session was 1 hour long, 3 times a week.	Questionnaire (CHAQ) • Fine motor ability via a self-report questionnaire that assessed ability in the kitchen, during dressing, while performing personal hygiene, office tasks, and other general items • Grip/Pinch using dynamometer At baseline: • Gross Motor Function Classification System (GMFCS) • Manual Abilities Classification System (MACS)	Outcome: Statistically significant changes in all MMDT scores following treatment in both groups ($p < 0.05$). Intergroup comparison, unilateral sub test scores were significant in favor of group 1 ($p<0.05$). Grip strength scores following treatment showed significant changes in both groups ($p<0.05$) and were similar for changes in grip parameters. Many sub scores of the CHAQ and DHI showed significant changed in both groups after treatment ($p<0.05$). The control group did statistically favor changes in CHAQ-eating after treatment ($p<0.05$). Overall: Manual Dexterity changes: favor VGBT using Nintendo Wii and LMC games over NDT. Effects of both interventions on grip strength and functional mobility are similar in terms of benefit. The present study found both upper extremity rehabilitation programs to be effective for patients with CP. VGBT using Nintendo Wii and LMC games did have slightly superior effects on manual dexterity than the NDT based intervention. Authors additionally do conclude that long term effects of Nintendo Wii and LMC games using VGBT need to be studied further.
Malick, W. H., Butt, R., Awan, W. A., Ashfaq,	**Level of Evidence:** Level I **Study Design:** Randomized	**Intervention:** **3 groups each received intervention in a quiet room at the National Institute of	**Outcome Measures** • ROM using goniometer	**Results:** UE ROM in most joints and strength of most muscles significantly improved for all groups

M., & Mahmood, Q. (2022). https://doi.org/10.1089/g4h.2021.0128	controlled single blind study **N**= 30 ● 18 Males ● 12 Females **Child Age Range:** 6-12 yrs **Intervention:** 3 groups with 10 participants in each **Control:** N/A **Inclusion Criteria:** ● Children ages 6 to 12 years old with SHCP classified as level 1 or 2 on the Gross Motor Functional Classification System, independent, and ambulant. ● Participants had to be able to understand instructions and cooperate during the assessment and intervention. ● Children also could only score a 1 or 2 on the Modified Ashworth Scale for UE muscles ● Needed to be considered generally healthy without any other neurological/orthopedic diagnosis (confirmed with Dr. and parents).	Rehabilitation Medicine in Islamabad Pakistan. The day before the intervention the group received a 5-minute trial session to learn the game. Each intervention session lasted 15 minutes and participants had 3 sessions per week for 8 weeks totalling 24 sessions. Group 1: Balance It Participants stood 4 feet from a screen and were able to see their image in real time. In each new session participants picked up at the level they got to previously. The Balance It AR game had 15 levels, level 1-5: balance falling object from a plank on the screen by lifting UE to hold with hands, level 6-10: balance falling object while moving to opposite side of screen to put object in a basket by tilting the plank, level 11-15: balance 2 objects at the same time and put objects in a basket by tilting the plank. Group 2: Bubble Pop Participants stood 4 feet from a screen and were able to see their image in real time. In each new session participants picked up at the level they got to previously. The Bubble pop game consisted of 30 levels and required participants to use UE to reach in different directions, use their hands to pop bubbles on the screen, and move their body to avoid objects that would deduct game score.	● Muscle Strength: active resistance manual muscle testing following guidelines of Daniels and Worthington Outcome measures were completed pre and post intervention.	($p<0.5$). Elbow extension ROM significantly improved for the balance It group as compared to the Scoop'd group ($p<0.5$). This study concluded that the ROM of most UE joints as well as muscle strength improved in children with SHCP after augmented reality intervention. However, to be implemented into OT practice future studies should be done with larger sample sizes and with a control group for more generalizability across populations outside of CP. This study was a randomized clinical trial providing strong evidence supporting the use of augmented reality for CP populations with suggestions for games to add variation and challenge to increase UE ROM and muscle strength.

		Group 3: Scoop'd Participants stood 4 feet from a screen and were able to see their image in real time. In each new session participants picked up at the level they got to previously. The Scoop'd AR game had 30 levels and required participants to hold a cone shaped basket (ice-cream cone) to catch ice-cream scoops falling from one spot at a time from the top of the screen. As levels went on speed and time. Intervals of falling scoops changed as well as the color of ice-cream. At the halfway point (level 15) a weight was added to the basket. Like the Bubble pop game objects that would deduct points should be avoided. **Control:** no control group		
Kachmar, O., Kushnir, A., Fedchyshyn, B., Cristiano, J., O'Flaherty, J., Helland, K., Johnson, G., & Puig, D. (2021). https://doi.org/10.3233/PRM-190666	**Level of Evidence:** Level III **Study Design:** pre and post quasi-experimental exploratory design with 2 groups **N**= 25 ● 15 Males ● 10 Females **Child Age Range:** 5 to 18 yrs **Intervention:** n=13 **Control:** n=12 **Inclusion Criteria:** ● 5 to 18 years old	**Intervention:** Participants used personalized balance games from the Gamification for Better Life (GABLE) online serious gaming platform. These games targeted motor skills and visual-motor coordination. To complete this a standard Nintendo Wii Balance Board connected to a personal computer using Bluetooth was utilized. Games included Paddle Waddle, Woos wonderful World Adventure, and Hungry Woo. **Control:** Participants played Nintendo Wii games using the handheld remote. Games such as	**Outcome Measures** ● Trunk Control Measurement Scale (TCMS) ● Timed Up and Go Test (TUG) ● Center of Pressure Path Length (COP-PL) ● Dynamic Balance Test (DBT) Outcome measures were completed pre and post intervention.	**Results:** TCMS scores in the experimental group increased by 4.5 points (SD=3.5, $p<0.05$) DBT scores in the experimental group increased by 0.88 points (IQR = 1.03, $p<0.05$). TCMS and DBT scores did not change significantly in control group. TUG and COP-PL scores were not significantly changed in either group. This study concluded statistically significant improvements in children with CP after 2 weeks of intervention with the personalized balance games according to the TCMS and DBT scores. This data and fixing its limitations can be used for future studies such as an RCT to increase balance in CP children through the use of

	• diagnosed with CP (level I-III on the GMFCS). • No uncontrolled seizures or intellectual disabilities or uncooperative behavior • Be able to comply with assessment instructions and computer game	tennis, bowling, and golf were played using Wii Sports and Wii Sports Resort. *both groups took place at the International Clinic of Rehabilitation for 2 weeks. Participants in the intervention and control groups completed study for 8-9 game sessions for 15-20 minutes totaling 150-160 minutes.		personalized computer games.
Gatica-Rojas, V., Méndez-Rebolledo, G., Guzman-Muñoz, E., Soto-Poblete, A., Cartes-Velásquez, R., Elgueta-Cancino, E., & Cofré Lizama, L. E. (2017). https://doi.org/10.23736/S1973-9087.16.04447-6	**Level of Evidence:** Level I **Study Design:** Randomized controlled single blind study, two arm matched-pairs, parallele-groups, clinical trial **N**= 32 • 19 Males • 13 Females **Child Age Range:** 7 to 14 yrs **Intervention:** n=16 **Control:** n=16 **Inclusion Criteria:** • Children ages 7 to 14 (mean age was 10 years and 5 months) • Diagnosis of spastic hemiplegia or spastic diplegia CP • Had to have a level I or II of GMFCS or GMFCS-ER (participants were predominantly level II)	**Intervention:** Those in the Wii therapy group trained using the Wii fit plus with the balance board for 30 minutes, first two series = snowboard penguin slide and super hula hoop games, last series = yoga game. If participants couldn't do the first 2 series they would do games such as Run Plus and Heading Football. **Control:** Sessions for participants in the SPT intervention group lasted 40 minutes each and included various types of stretching, flexibility exercises, strengthening activities, and balance exercises. *both groups completed the study in an outpatient rehabilitation center in the city of Talca over a 6 week period and an additional 4 weeks of 2 follow up assessments. Participants completed 18 intervention sessions at a frequency of 3 sessions per week.	**Outcome Measures:** • CoP sway • Standard deviation of the CoP in mediolateral direction (SDML), Standard Deviation of the CoP in the anteroposterior direction, Velocity of the CoP in the media-lateral direction (VML), and velocity of the CoP in the anteroposterior direction (VAP) Outcome measures were completed during the duration of the intervention and post intervention.	**Results:** Wii therapy showed significant reduction of CoP sway ($p=0.02$) and SDap in eyes-open condition ($p=0.01$). The effects seem to disappear after 2-4 weeks, post hoc analysis showing that only children with SHE benefited from Wii Therapy. The authors of this research study concluded that Wii therapy overall was better than SPT in terms of seeing improved standing balance in only the SHE CP population. The effectiveness of Wii therapy for CP children long term is not supported based on waning effects 2-4 weeks after intervention ended.

	• No history of epilepsy, botulinum, previous surgeries in the lower limbs (past 18 months), and no vision or hearing problems			
Choi, J. Y., Yi, S., Ao, L., Tang, X., Xu, X., Shim, D., Yoo, B., Park, E. S., & Rha, D. (2021). https://doi.org/10.1111/dmcn.14762	**Level of Evidence:** Level I **Study Design:** International multicenter, single-blind, and randomized controlled trial **N**= 78 • 38 Males • 40 Females **Child Age Range:** 3-18 yrs **Intervention:** n=40 **Control:** n=38 **Inclusion Criteria:** • Between 3-18 years old • Diagnosis of Cerebral palsy or other acquired brain injuries at least 12 months after onset • Classified under levels I-IV of the Manual Ability Classification System (MACS) • Classified under levels 4-7 of the House Functional Classification System	**Intervention:** Received virtual reality (VR) intervention and conventional occupational therapy (OT) session for 30 minutes each 5 days/week (20 hours total) for 4 weeks. VR training used the RAPAEL Smart Kids, which utilizes a band-like wrist to attach two inertial measurement unit sensors on the dorsal hand and distal forearm. When the child wears the device, the avatar mirrors the child's upper limb movement on the computer screen. The VR system included games that incorporated ADL performance (cooking, eating, and pouring water) and promoted range of motions (wrist flexion/extension, wrist radial/ulnar deviation, and forearm pronation/supination). Conventional OT involved stretching, strengthening, and task-oriented training for 10 minutes each. **Control:** Received 2 sessions of conventional OT 1 hour/day, 5 days/week (20 hours total) for 4 weeks. Sessions involved stretching, strengthening, and task-oriented training for 10 minutes each.	**Outcome Measures** • Melbourne Assessment of Unilateral Upper Limb Function-2 (MA-2) • Upper Limb Physician's Rating Scale (ULPRS) • Pediatric Evaluation of Disability Inventory Computer Adaptive Test (PEDI-CAT) • Computerized three-dimensional motion analysis Outcomes were measured at baseline (pretest), after the 4-week intervention (posttest 1), and after the 8-week follow-up (posttest 2).	**Results:** Both VR and control groups had statistically significant improvements post-intervention compared to baseline. For MA-2, both groups had statistically significant improvements (p<0.01) in ROM, accuracy, dexterity, and fluency after intervention and during 8-week follow-up. However, VR group showed more significant improvements (p<0.01) in upper-limb dexterity post-intervention compared to control group. In ULPRS, both groups presented statistically significant improvements in segmental movement patterns in the affected limb (p<0.01), but there were no statistically significant differences between the two groups. In the PEDI-CAT, the domain of performance of ADLs significantly improved in the VR group than the control group (p<0.01); both groups had statistically significant improvements in the social-cognitive domain (p<0.01), but there were no statistically significant differences between the two. Overall, children with more severe motor impairments (MACS levels III and IV) presented significant functional improvements in ROM and accuracy domains in MA-2, total score in ULPRS, and performance of ADLs domain in PEDI-CAT compared to children with fewer motor impairments (MACS levels I and II). Lastly, the computerized three-dimensional motion analysis on 36 participants concluded that the VR group (n=19) demonstrated significant improvements in forearm supination during phase 1 (p=0.02)

				compared to the control group (*n*=17).
Uysal, S. A., & Baltaci, G. (2016). https://doi.org/10.1089/g4h.2015.0102	**Level of Evidence:** Level I **Study Design:** Single-Blind Study RCT **N**= 24 ● 10 Males ● 14 Females **Child Age Range:** 6-14 yrs **Intervention:** n=12 **Control:** n=12 **Inclusion Criteria:** ● Between 6-14 years old ● Cerebral palsy diagnosis ● Classified as levels I-II on the Gross Motor Function Classification System (GMFCS) ● Classified as levels I-III on the Manual Ability Classification System (MACS) ● Able to follow verbal instructions ● Children and their families all agreed to participate and signed consent form	**Intervention**: Received both their routine physiotherapy (PT) program and the NW training for 2x/week for 12 weeks. Participants completed a 30-minute NW training session, which included Wii basketball, Wii tennis, and Wii boxing for 10 minutes per game. The level of difficulty of each game increased every 4 weeks. Participants used their hemiparetic hand to hold the Wii remote. The physiotherapist supervised and instructed the participants to use their hemiparetic hand and to shift body weight equally while performing the games. Participants also completed their routine traditional PT program for 45 minutes, which followed principles of neurodevelopmental treatment. The program incorporated postural reactions and balance exercises that were individually designed based on the child's needs by the physiotherapist. **Control**: Received their routine traditional physiotherapy (PT) program 2x/week for 45 minutes per session for 12 weeks. The program was based on principles of neurodevelopmental treatment, such as postural reactions and balance exercises. It was designed by the physiotherapist based on the child's individual needs	Outcome Measures ● Canadian Occupational Performance Measure (COPM) ● Pediatric Evaluation of Disability Inventory (PEDI) ● Pediatric Balance Scale (PBS) Outcomes were measured during baseline assessments and evaluations before the training program started and during second assessments in the last week of the program when the interventions ended.	**Results:** Both the intervention and control groups had statistically significant improvements post-intervention for self-care, mobility, and total PEDI scores ($p<0.05$) from the PEDI compared to pre-intervention. The NW group showed statistically significant improvements in PBS for functional balance and COPM performance ($p<0.05$) post-intervention as well. When comparing the differences among the intervention and control groups, there was a statistically significant difference only for PBS ($p<0.05$). The study concluded that while NW cannot replace traditional physiotherapy treatment, it would be an effective addition to it due to its contribution to occupational performance, daily living activities, and functional balance. NW served as a fun play-based activity that encouraged active participation and motivation among participants during training sessions.
94: Yildirim, Y.,	**Level of Evidence:** Level III	**Intervention**: Included 3 phases over	**Outcome Measures**	**Results:** The study found statistically

Budak, M., Tarakci, D., & Algun, Z. C. (2021). https://doi.org/10.1089/g4h.2020.0182	**Study Design:** One group, nonrandomized, repeated measures designed study **N**= 20 ● 9 Males ● 11 Females **Child Age Range:** 8-15 yrs **Intervention:** n=20 **Control:** N/A **Inclusion Criteria:** ● Between 8-15 years old ● Cerebral palsy diagnosis ● Mental status of "normal" or "mild mental retarded" ● 0, 1, or 1+ on the Modified Ashworth Scale for spasticity ● Levels 1-3 on the Communication Function Classification System (CFCS) ● Accepted to participate in treatment after reading consent form	a total of 12 weeks: Baseline (T0): participants were first evaluated. 1st treatment period (T1): Participants completed structured neurodevelopmental therapy-based hand rehabilitation (SNDTBHR) 2 sessions/week for 6 weeks (12 sessions total). SNDTBHR protocol included NDT-oriented exercises and SNDTBHR for 20 minutes each. NDT-oriented exercises included balance, strengthening, walking, and gross motor exercises, while SNDTBHR exercises consisted of placing pegs in same colored areas, removing ropes through the bead, removing sticks using pinch grip, picking soft objects using pinch grip, and placing shapes in correct spots. 2nd treatment period (T2): Participants continued to receive 20-minutes of NDT-oriented exercises with 20-minutes of Leap Motion Based Exergame Therapy (LMBET), 2 sessions/week for 12 weeks. LMBET games helped increase joint ROM, muscle strength, coordination, and fine motor in the hand and wrist. Fizyosoft CatchAPet and Fizyosoft Leapball games were included. With Catch A Pet, participants had to touch the mole that came out in one of the five different holes in a certain order to repeat wrist flexion and extension and increase game scores with shortened reaction time. With Leap Ball, participants had to grasp and	● Jebsen-Taylor hand function test (JTHF) ● Manual Ability Classification System (MACS) ● Gross Motor Function Classification System (GMFCS) ● Wisconsin Card Sorting Test (WCST) ● Gross grip strength Outcomes were administered at baseline (T0), 6 weeks (T1), and 12 weeks (T2).	significant differences between the three measurements (T0, T1, & T2) in JHFT, gross grip and pinch forces, and WCST results. For JHFT, participants showed statistically significant results among the three measurements in all sub-categories, such as writing, turning cards, picking up small objects, stacking checkers, simulated feeding, moving light and heavy objects (P</=0.05); WCST had significant differences in some sub-categories, including categories completed, perseverative errors, non-perseverative errors, and total errors (P</=0.05). These statistically significant improvements were in favor of LMBET for all sub-categories of JHFT, grip strength, and WCST results compared to SNDTBHR (P<0.017). The authors elaborated how even if the effects of the first treatment (T1) continued throughout the study, there were greater immediate effects of the LMBET than the SNDTBHR when comparing the magnitude of differences between T1 and T2 measurements. However, the study did not find statistically significant differences among the three measurements in both MACS and GMFCS scores for hand skills and gross motor levels (P>0.05).

		throw the ball into the same-colored box. The purpose was to use correct grip movement patterns, match colors, and prevent complications. **Control:** N/A		
El-Shamy, S. M., & El-Banna, M. F. (2020). https://doi.org/10.1080/09593985.2018.1479810	**Level of Evidence:** Level I **Study Design:** Prospective, single-blind RCT **N**= 40 ● 26 Males ● 14 Females **Child Age Range:** 8-12 yrs **Intervention:** n=20 **Control:** n=20 **Inclusion Criteria:** ● Between 8-12 years old ● Spastic hemiplegia Cerebral palsy diagnosis ● Levels I-III on the Manual Ability Classification System (MACS) ● No history of musculoskeletal disorders ● Normal or corrected hearing and vision ● No prior experience with Wii ● Able to understand and follow simple directions	**Intervention:** Received both Wii training and usual care. Wii training given 40 minutes/day, 3x/week for 12 weeks. Participants were reflected in the virtual environment by avatars, and their movements were transferred through the Wii remote. The Wii consisted of multiplayer modes and different difficulty levels. Four Wii games were included in the training: 1) tennis, 2) boxing, 3) bowling, and 4) basketball. They practiced each game for 10 minutes and played the game for 30 minutes, resulting in 40 minutes total for each session. Games were presented in a random order, and the level of difficulty of the games were set by the physical therapist (PT) after assessing each child's needs and abilities. Participants were also trained in sitting or standing, depending on their ability. PT supervised each child when participating in games to ensure safety; participants were also instructed to stop the game at any point if they experienced discomfort or fatigue. They also received their usual care for 1-hour/day, 3x/week for 12 weeks. Usual care included passive stretching of the elbow and wrist flexors, weight-bearing exercises for the upper extremities,	**Outcome Measures** ● Peabody Developmental Motor Scales, Second Edition (PDMS-2) ● Modified Ashworth scale ● Grip Strength ● Pinch Strength Outcomes were measured at baseline and post-intervention.	**Results:** Compared to the control group, the Wii group showed significant improvements in spasticity, grip strength, and hand function. Spasticity among participants in the Wii group decreased by 0.4 out of 4.0 with a 95% CI (0.1-0.8) compared to those in the control group. While the amount was small, it was a statistically significant result. Moreover, power grip strength increased by 1.6 kg with a 95% CI (0.7-2.5), and pinch grip strength increased by 1.2 kg with a 95% CI (0.8-1.6) among participants in the Wii group compared to the control group. This increase in strength for both power and pinch grip were statistically significant with an overall 20% increase. Hand function, as reported by the PDMS-2, also improved by 6 points with 95% CI (5-7) compared to the control group. This was about a 16% increase, which is a clinically worthwhile improvement.

		and protective extensor thrust. It also had strengthening exercises for the antagonists of the spastic muscles (elbow and wrist extensors) by using different toys and motivation to facilitate performance. Exercises for hand skills consisted of basic reach and grasp, carry and release, in-hand manipulation, and bilateral hand use. Participants sat on a chair when performing these exercises while the PT was at the side for guidance and assistance. **Control:** Received usual care for 1-hour/day, 3x/week for 12 weeks. Usual care included passive stretching of the elbow and wrist flexors, weight-bearing exercises for the upper extremities, and protective extensor thrust. It also had strengthening exercises for the antagonists of the spastic muscles (elbow and wrist extensors) by using different toys and motivation to facilitate performance. Exercises for hand skills consisted of basic reach and grasp, carry and release, in-hand manipulation, and bilateral hand use. Participants sat on a chair when performing these exercises while the PT was at the side for guidance and assistance.		
Roberts, H., Shierk, A., Clegg, N. J., Baldwin, D., Smith, L., Yeatts, P., & Delgado,	**Level of Evidence:** Level III **Study Design:** One group, non-randomized **N**= 31	**Intervention**: The augmented Pediatric Constraint Induced Movement Therapy (P-CIMT) camp was completed 6 hours/day (Monday-Friday 9am-3pm) for 2 weeks of each summer from	**Outcome Measures** ● Assisting Hand Assessment (AHA) ● Melbourne Assessment of	**Results:** The study found that participants showed statistically and clinically significant improvements in AHA scores for bimanual performance (p<0.001) during post-intervention and 6-month follow up (p<0.001). Participants also showed statistically and clinically

M. R. (2021). https://doi.org/10.1080/01942638.2020.1812790	• 16 Males • 15 Females **Child Age Range:** 5-15 yrs **Intervention:** n=31 **Control:** N/A **Inclusion Criteria:** • Between 5-15 years old • Hemiplegic Cerebral palsy (hCP) diagnosis • Levels I-III on Manual Ability Classifircation Scale (MACS) • Able to attend camp every day • Speak fluent English to follow one-step directions	2014-2018. Participants wore a constraint for 5.5 hours and used the Hocoma Armeo Spring Pediatric, a device that uses exoskeleton and VR games, for 30 minutes to facilitate bimanual performance. Constraint involved a long arm ulnar gutter splint that was applied at the beginning of camp and removed during toileting and at the end of camp by the occupational therapist (OT) or trained interventionist. No constraint was worn on the last day of camp to use newly acquired unilateral skills into bimanual performance. The Hocoma Armeo Spring Pediatric gave the just-right challenge to participants by focusing on specific movement patterns and UE ROM while playing VR games (shoulder flexion & extension, shoulder ab & adduction, elbow flexion & extension, pronation & supination, and grip strength). All participants worked with the interventionist to choose games of their choice. Based on the P-CIMT camp manual, participants adhered to the camp daily schedule. Different gross and fine motor activities were given. Gross Motor Outside Activities involved 1) upper arm movement and shoulder, 2) reaching (elbow extension), and 3) socialization through free play on the playground for 15 minutes per activity. Fine Motor Stations were also 15 minutes per station and included: 1) hand craft, 2) sensation, 3) stabilizes/holds,	Uni-lateral Hand Function (MUUL) • Canadian Occupational Performance Measure (COPM) • 4-point Likert Scale on motivation, engagement, enjoyment, and frustration related to experience while using Hocomo Armeo Spring Pediatric training (tested on 4 kids) AHA, MUUL and COPM were measured at baseline, post-intervention, and 6 months following the intervention. The Likert Scale was rated by the first author and second occupational therapist via observations. They were documented on Tuesdays and Thursdays each week of camp.	significant results in both the COPM Performance and Satisfaction scores ($p<0.001$) post-intervention, and these scores remained the same at 6 months follow up. While MUUL scores for unilateral performance were statistically significant post-intervention and 6-month follow up ($p</=0.001$) compared to baseline, the mean differences were not clinically significant. Thus, participants demonstrated statistically significant improvements in all outcome measures and clinically significant results in at least one.

		4) grasp/release, 5) grasp release, 6) manipulates, 7) finger movements and thumb opposition/grip and pinch strength, 8) supination and wrist extension, and 9) choice of favorite station or preparation for talent show. These activities were delivered in small groups with supervision. They also engaged in group activities, such as board games or work bins. Token systems were also used for kids to collect “pirate coins” to win prizes at the end of each camp day. They completed 50 hours of unilateral and 10 hours of bimanual tasks. **Control:** N/A		