Evaluating a Therapeutic Powered Mobility Camp for Children with Severe Cerebral Palsy

Évaluation d'un camp thérapeutique de mobilité motorisée pour les enfants atteints de paralysie cérébrale grave

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Abstract

Background. Children and youth with severe cerebral palsy (CP) have limited independent mobility, which affects opportunities for overall development. **Purpose.** To examine the effectiveness of Power Fun, a therapeutic powered mobility summer camp. **Methods.** A quasi-experimental, repeated-measure design was used, with participants acting as their own control. Twenty-four participants with severe CP (aged 7–20 years) attended Power Fun for three weeks, five days/week. Assessments of powered mobility skills and functional mobility goals were conducted three weeks before the camp (T1), at baseline (T2), postintervention (T3), and at three-week follow-up (T4). **Findings.** An analysis of variance results indicated significant improvements in powered mobility skills ($F(1,22) = 56.61$, $p < 0.001$, $\eta_P^2 = 0.74$) and functional mobility goals ($F(1,58) = 80.17$, $p < 0.001$, $\eta_P^2 = 0.74$), with 70% of goals achieved postintervention. A descriptive analysis revealed three learning profiles. **Implications.** This study provides initial evidence supporting the effectiveness of Power Fun as an intervention promoting powered mobility for children with severe CP, across a range of abilities.

Abrégé

Description. Les enfants et les jeunes atteints de paralysie cérébrale (PC) grave présentent une mobilité limitée, ce qui affecte leurs possibilités de développement global. **But.** Examiner l'efficacité de *Power Fun*, un camp d'été thérapeutique de mobilité motorisée. **Méthodologie.** Un devis quasi-expérimental à mesures répétées où les participants agissaient comme leur propre contrôle a été utilisé. Vingt-quatre participants atteints de PC grave (âgés de 7 à 20 ans) ont participé au camp *Power Fun* pendant trois semaines, à raison de cinq jours par semaine. Des évaluations des compétences en matière de mobilité motorisée et des objectifs de mobilité fonctionnelle ont été réalisées trois semaines avant le camp (T1), au tout début (T2), après l'intervention (T3) et lors du suivi de trois semaines (T4). **Résultats.** Les résultats de l'ANOVA ont indiqué des améliorations significatives des compétences sur le plan de la mobilité motorisée (F(1,22) = 56,61, p < 0,001, $\eta_P^2 = 0,74$) et des objectifs de mobilité fonctionnelle (F(1,58) = 80,17, p < 0,001, $\eta_P^2 = 0,74$), avec 70 % des objectifs atteints après l'intervention. L'analyse descriptive a révélé trois profils d'apprentissage. **Conséquences.** Cette étude fournit des preuves initiales soutenant l'efficacité de *Power Fun* en tant qu'intervention promouvant la mobilité motorisée pour les enfants atteints de PC grave, en ce qui concerne une gamme variée de capacités.

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Introduction

Cerebral Palsy (CP) describes a group of movement and posture disorders caused by disturbances in the developing brain covering a wide variety of associated disturbances, such as communication, perception, or cognition (Rosenbaum et al., 2007), occurring in 2–3.5 cases per 1000 live births (Colver et al., 2014). The ability of children with CP to initiate movement can be rated by the five levels of the gross motor function classification scale (GMFCS), where children at levels IV and V need assistance in mobility (Rosenbaum et al., 2002). Self-generated locomotion has significance beyond movement from one location to another; it allows exploration and promotes development (Anderson et al., 2013). A powered mobility device can provide children with severe CP (GMFCS levels IV and V) opportunities for development, as well as participation (Anderson et al., 2013; Butler, 1986; Rosen et al., 2018); however, operating a power mobility device is a complex activity requiring a variety of physical and mental skills (Smith et al., 2020).

While children at GMFCS levels IV and V often need powered mobility for locomotion due to their gross motor abilities, they may be limited by their cognitive and visual function. Studies have shown that cognitive and visual skills influence driving abilities; children with CP have less driving proficiency than peers without brain involvement (Mockler et al., 2017) and spatial relations and problem-solving skills predicted 74% of the variance in driving skills for children with CP under six years old (Furumasu et al., 2004). This is salient as approximately half of the children with CP, especially those with lower gross motor abilities, present visual limitations and there is a correlation between intellectual disability and motor limitations (Baranello et al., 2020; Fluss & Lidzba, 2020; Salavati et al., 2014).

The pattern of comorbidities that interfere with the ability to learn powered mobility is also true for hand function. Predictive models show that children with limited manual abilities have difficulty mastering driving proficiency, especially those with difficulty controlling a joystick and/or propelling a manual wheelchair for short distances (Gefen et al., 2019b; Mockler et al., 2017). Children at GMFCS levels IV and V often have lower manual abilities as measured by the manual ability classification scale (MACS) (a five-level scale, in which levels three to five imply a consistent reduction of functional abilities (Eliasson et al., 2006); a study showed that 91% of children at GMFCS levels IV and V were at MACS III–V (Carnahan et al., 2007). Children with CP at GMFCS levels IV and V should be encouraged to learn powered mobility to access opportunities for development, despite the limitation of their manual, cognitive, and/or visual skills (Livingstone & Paleg, 2014; Rosen et al., 2018), but how should this be done if the skills are interdependent?

Research has shown that children with severe limitations can learn powered mobility skills (Bottos et al., 2001; Durkin, 2009; Kenyon et al., 2016; Nilsson, 2019). Many, however, are denied access to independent mobility due to their limited cognitive, physical or behavioral abilities rather than being provided with practice opportunities (Kenyon et al., 2018b; Nisbet, 2002). A systematic review of powered mobility training methods concluded that there is only moderate evidence to support teaching powered mobility, and recommended additional research regarding power mobility training methods for children (Kenyon et al., 2018a).

Power Fun is a therapeutic powered mobility summer camp for children with severe CP. The development of its protocol is described elsewhere (Rosenberg et al., 2019), but a summary appears below. The program has a theoretical basis, founded on (1) motor learning, approved as an intervention for CP (Novak et al., 2013)), (2) self-determination theory, which fosters engagement (D'Arrigo et al., 2020), and (3) the model of Human Activity Assistive Technology (Cook & Polgar, 2015), which explains the dynamics between a powered wheelchair, the user, and the activity.

The camp's central principles derive from Nilsson and Durkin's facilitating strategies (Nilsson & Durkin, 2014). These facilitating strategies, developed through a rigorous analytic grounded theory study, relate to the learning process for encouraging children with severe limitations to use powered mobility as a therapeutic tool (Nilsson, 2019). Examples include learner-led activities to create a partnership, empowering the student through a "just-right" challenge, and progressions of games, environment and feedback, to highlight their progress (see Supplementary Material for more details).

The model of a therapeutic summer camp was chosen, as this method has proven effective for other populations (Moola et al., 2014), including children with unilateral CP (Cohen-Holzer et al., 2017; 2020). A therapeutic summer camp can provide a supportive context encouraging play in natural environments, an important consideration when acquiring powered mobility skills (Kenyon et al., 2018a). In addition, this method enables intensive, repetitive, task-specific, salient learning through age-appropriate games and is therefore ideal to incorporate the principles of Power Fun.

The Power Fun protocol was evaluated in a feasibility study with five participants (Rosenberg et al., 2019) as a first step to test the novel intervention, prior to a full-scale study (Leon et al., 2011). Building on the positive results, the current study's overarching goal was to explore the intervention's effectiveness with a larger sample study. Specific objectives were to (1) examine the camp's effectivity in improving mobility skills and reaching functional mobility goals, (2) analyze which participants gain from the intervention through examining individual learning profiles, and (3) understand the participants' opinions about the intervention.

Method

Study Design

The research design incorporates two research strategies combining elements of multiple baseline case studies with quasi-experimental methods where each participant acts as

their own control, as recommended for research in this population (Damiano, 2014). The single-subject designs allow examining personal changes, as recommended in interventions studies of wheeled mobility (Kenyon et al., 2020). The quasi-experimental without a control group allows analysis of the group, while reducing the confounding factor of individual variability, as severe CP is a complex diagnosis, making it difficult to achieve two homogeneous groups (Bottos et al., 2001; Damiano, 2014). Data were collected and compared at four points in time: an initial no-treatment period of three weeks (T1), baseline (T2), postintervention (T3), and three weeks follow-up (T4).

Participants

The study comprised students from two self-contained special-education schools for physical disabilities in central Israel, which expressed interest in hosting the camp. Although the participants had received varied powered mobility training during the school year as part of their regular therapy program, they had yet to attain proficiency; therefore, prior powered mobility training was not an eligibility criterion. Inclusion criteria were: (a) diagnosis of CP; (b) GMFCS levels IV and V (Rosenbaum et al., 2002); (c) MACS III–V (Morris et al., 2007); (d) aged 6–21 years (the standard age range of local special-education schools); (e) motivation to attend the camp, and (f) signed parental consent. The exclusion criterion was comorbidities that could affect the stability of medical conditions, such as imminent surgery.

Therapists from each school used convenience sampling to select suitable participants who received a description of the summer camp in simple wording appropriate to their cognitive level. Their parents received written and verbal information about the camp and the research project, including the researchers' contact information for further questions, and were asked to sign and return informed consent forms.

Power analysis was based on Bottos et al. (2001), a study of 29 children with tetraplegic CP aged 3–8 years, which used the total power mobility program (PMP) score before and after the intervention. Cohen's d was calculated at 0.958. In determining sample size, a power analysis for pre- to postintervention with alpha = 0.05 yielded a desired sample of 17 participants; this was increased to cover potential dropouts.

Data Collection

Procedures. Following approval by the ethics committees of the Hebrew University Faculty of Medicine Institutional Review Board (license no. 11062017), the camp ran four times over three summers (2017–2019), at the two different special-education schools. Assessments were conducted at the four above-mentioned time points; T1 and T2 measurements aimed to address potential gains due to the regular therapy received during the school year. To reduce bias, an external assessor (an experienced occupational therapist) conducted all the assessments.

Each camp comprised six participants, taking place over a three-week period, and five days a week, in parallel with the regular school summer camp (campers ate and had recess with their classmates in the regular camp and were toileted by the class staff, but participated in the special Power Fun sessions). Each participant received a personally adapted power wheelchair for use throughout the camp (for details of adaptations, see Table 1). During the camp, modifications to wheelchairs were made as needed (such as the exact location of switches or joystick or addition of foam to lateral trunk supports). The intervention was conducted by an experienced occupational therapist (LR), with three to five assistants who received instruction about the intervention's theoretical basis and its practical principles prior to the camp, as well as feedback during the course of the camp to ensure protocol fidelity.

Each day, participants attended 2 h long sessions of developmentally appropriate games adapted to their mobility level (examples of games are provided in Supplemental Table 1). Ample space allowed freedom of movement in a setting

Table 1

Demographics and Characteristics of Participants (n = 24)

Demographics	n (%)
Gender—males	16 (66.7)
Diagnosis (from school file)	
CP spastic quadriparesis	15 (65.2)
CP hypotonic quadriparesis	2 (8.7)
CP dystonic quadriparesis	2 (8.7)
CP mixed quadriparesis	3 (13.0)
CP ataxia quadriparesis	1 (4.3)
Spastic diplegia	1 (4.3)
GMFCS level (from school file)	
IV	11 (45.8)
V	13 (54.2)
MACS level (from school file)	
III	5 (20.8)
IV	9 (37.5)
V	10 (41.7)
CFCS level (from school file)	
I	1 (4.2)
II	2 (8.3)
III	5 (20.8)
IV	10 (41.7)
V	6 (25)
Visual impairment/CVI (from school file)	12 (50)
Wheelchair control system	
Joystick	16 (66.7)
Switches (on the head array and/or tray)	6 (25)
Foot joystick	2 (8.3)
Wheelchair seating systems	
Only positioning belt	5 (20.8)
Lateral side supports + positioning belt	6 (25)
Full support + head rest + positioning belt	4 (16.7)
Full support, head rest, positioning belt + tilt	9 (37.5)

Note: All participants had bilateral CP. Diagnosis is according to school files. CP = cerebral palsy; GMFCS = gross motor function classification system; MACS = manual ability classification system; CFCS = communication function classification system; CVI = cerebral visual impairment.

which encouraged self-discovery, with feedback provided according to motor learning principles (Zwicker & Harris, 2009) and facilitating strategies (Nilsson & Durkin, 2014). Between sessions, participants returned to their regular class but remained seated in their powered wheelchair whenever possible; a few rested on mattresses, as this was their school routine, and some transferred to personal chairs to eat. They enjoyed recess along with peers who were not attending Power Fun, but with additional supervision (as little physical help as possible, and no instruction) in accordance with their powered mobility needs. Further details of the Power Fun protocol are available in Supplementary Material 1 or through contact with the first author.

Tools

Demographics and Clinical Characteristics. Demographics and clinical characteristics including age, gender, diagnosis, GMFCS, MACS, communication function classification system (CFCS) (Hidecker et al., 2011) and visual abilities (a dichotomous score indicating the presence of visual limitations or not) were collected from school files. Cognitive measurements for children with severely limited visual and/or manual and/or communication abilities are beyond the scope of this study, though all children had brain involvement (diagnosis of CP) and attended self-contained special-education schools.

Powered Mobility Skills. The primary measure used was the PMP (Furumasu et al., 1996), a 34-item checklist divided into three categories: basic mobility, integration of basic skills within a structured environment, and integration in an unstructured environment. Scores (0–5) reflect the physical and verbal assistance needed for each skill, with a higher score representing greater independence. To allow sensitivity to change despite a significant variation of starting levels, the sum total (0–170) rather than averages was used (Bottos et al., 2001). PMP has been used in research for children with CP up to the age of 18 years (Gefen et al., 2019a) and shows good-to-excellent interrater reliability (0.87) and excellent intrarater reliability (0.97) (Furumasu et al., 1996). It is the most frequently cited measure in pediatric powered mobility studies (Field & Livingstone, 2018), has been translated into Hebrew, and has good-to-excellent validity and intrarater reliability (intraclass correlation coefficients of 0.97–0.98) (Gefen et al., 2020).

The assessment of learning-powered mobility (ALP) (Nilsson & Durkin, 2014) captures the overall stage of learning-powered mobility through observation. It covers attention, understanding of tool use, interaction and communication, activity and movement, as well as expressions and emotions. The ALP uses an ordinal scale of 1–8 with 8 as the highest score and is suitable from age 12 months on (Nilsson, 2007; Nilsson & Durkin, 2014). The ALP and its Hebrew translation have good interrater reliability (0.83), and convergent validity with the PMP ($r_s = 0.89$) (Gefen et al., 2020).

Functional Mobility Goals. Participants chose two functional goals for the following two assessments. The goals were set by the participants themselves or with the help of a staff member who worked with them during the school year and understood them well. In the latter case, the proxy defined appropriate and meaningful goals and the child then chose two from the options.

The goal attainment scaling (GAS) (Kiresuk et al., 1968) is an individual, criterion-referenced technique for setting measurable and relevant goals. Its scale runs from −2 (much less than expected), −1 (somewhat less than expected), 0 (expected outcome level), 1 (somewhat more than expected) to 2 (much more than expected). The interrater reliability for pediatrics is 0.82, with reasonable construct validity and ecological validity (McDougall & Wright, 2009) and it is responsive to meaningful change in pediatric rehabilitation, including CP (Harpster et al., 2019).

The wheelchair outcome measure for young people (WhOM-YP) (Field et al., 2016) is a client-centered wheelchair intervention measure designed to identify desired outcomes at a participation level. It rates the importance of goals and satisfaction with their performance (0–10, respectively) through interviews with either the young person or a proxy (a staff member who worked with them intensively), using visual aids as necessary; a weighted satisfaction score was determined by multiplying importance and satisfaction. Its test–retest reliability (interclass correlation coefficient (ICC)) ranges from 0.63 to 0.94, and discriminant and concurrent validity have been established ($p < 0.0001$) (Field & Miller, 2020). The official Hebrew version was used.

Acceptability. Postintervention interviews allow for exploration of the intervention from the participants' point of view (May & Rugg, 2010; Pituch et al., 2019). Structured feedback interviews, mediated by a staff member who worked regularly with the participant during the school year, were conducted at T3 to allow participants to express what they enjoyed or disliked. They comprised six closed questions with three possible responses each, using pictorial aids (happy, neutral, and sad emoji or drawings), inspired by the WhOM-YP. Participants at CFCS levels IV and V could answer either by looking, pointing, using a speech-generating device or responding verbally, as in WhOM-YP interviews (Field & Miller, 2020). In addition, an open question about general feelings was included for those capable of verbal expression (see Supplemental Table 2).

Data Analysis

Descriptive statistics were used for participants' clinical characteristics, individual PMP scores over time as well as GAS, and ALP scores. As the combined data ($n = 24$) of the primary outcome measure showed normal distribution, with skewness and kurtosis scores between −1.96 and 1.96 on Kruskal–Wallis tests, parametric statistics were employed. Change over time (T1–T4) was calculated for PMP and WhOM-YP

Table 2
PMP, ALP, and WhOM-YP Scores Over Time

	T1 pre ($n = 23$) mean (SD)	T2 baseline ($n = 24$) mean (SD)	T1–T2 p	T3 postintervention ($n = 24$) mean (SD)	T2–T3 p	T4 follow-up ($n = 21$) mean (SD)	T3–T4 p
PMP	36 (44)	38 (47)	>0.05	90 (62)	<0.001	88 (67)	>0.05
ALP	3.5 (2.0)	3.6 (2.0)	>0.05	5.7 (1.9)	<0.001	5.8 (2.0)	>0.05
WhOM-YP	3.1 (1.9)	3.1 (1.7)	>0.05	7.9 (2.2)	<0.001	8.4 (1.5)	>0.05

Note: PMP = power mobility performance; ALP = assessment of learning-powered mobility; WhOM-YP = wheelchair outcome measure-young person.

by repeated-measures analysis of variance (ANOVA; Fox, 2016) using data from the 21 participants who completed the tests in all time points. Pearson correlation was performed between both MACS and CFCS and the final skill level (PMP T3), as well as the delta (PMP T3–T2). A Wilcoxon signed-rank test was conducted to analyze the differences between GMFCS levels (IV and V) and PMP score at T3, as well as between visual ability (presence of visual limitation or not) and PMP score T3. This test was also used to analyze the difference between GMFCS levels and the delta (PMP T3–T2) as well as visual ability with the delta (PMP T3–T2). The global α level was set at 0.05, with Bonferroni adjustment used for post hoc comparisons.

GAS raw scores were converted to *T*-scores using the following formula:

$$T = 50 + \frac{10 \sum (w_i x_i)}{\sqrt{(1 - r) \sum w_i^2 + r (\sum w_i)^2}}$$

where w_i represents the weight of each specific goal, x_i represents the outcome score at T3, and r represents the expected correlation of the scores, which is assumed to be 0.3. The *T*-scores are standardized, with a mean of 50 (standard deviation of 10); a *T*-score of 50 indicates achievement of the expected goal, with <50 below the expected level and >50 above the expected level (Ottenbacher & Cusick, 1993).

Findings

The current overall study comprised 24 participants with severe bilateral CP, ages range 7–20 years (average: 11 years 11 months [3 years 10 months]); their demographics and characteristics are presented in Table 1. Participants ($n = 5$) in the initial study were included, as the intervention was identical. In addition, the primary outcome measure used, PMP, showed no significant difference between any of the four summer camp groups (including the feasibility study) at all time points (T1: $\chi^2 = 4.10$ (3), $p = 0.25$, T2: $\chi^2 = 4.05$(3), $p = 0.26$, T3: $\chi^2 = 4.05$(3), $p = 0.26$, T4: $\chi^2 = 2.19$(3), $p = 0.53$). As a result, data from all four camps were analyzed together.

Overall, 22 participants completed the full 3-week intervention; one left unexpectedly after the first week (returning for T3 and T4) and was replaced by another who completed the final two weeks (thus missing T1, with T2 a week late). PMP analysis without these two participants showed the

same statistical trend as the whole sample ($F(1, 21) = 32.60$, $p < 0.001$, $\eta_p^2 = 0.765$), and as a result their data were included. Only 21 participated at follow-up, as one was sick and two had left the school. Average attendance ($n = 22$) was 13.81 ± 1.17 days out of the full 15, with absences due to illness or medical appointments, and one participant due to a family holiday.

Primary Outcome Measure

Table 2 presents the participants' scores at the four time points. A significant time effect (T1–T4) was evident in the PMP scores using repeated-measures analysis ($F(1,22) = 56.61$, $p < 0.001$, $\eta_p^2 = 0.74$; $n = 21$). A post hoc analysis showed no significant change T1–T2 ($p = 1.00$), confirming that participants' skills remained stable prior to the camp, significant improvement following the intervention between T2 and T3 ($p < 0.001$), and skills were maintained at follow-up, with no significant change evident from T3 to T4 ($p = 1.00$).

Individual PMP profiles show the gain over time, as seen in Figure 1; in general, participants' profiles confirmed the statistical trends. Three interesting subgroups were noted within the graph. The first was participants ($n = 8$) who, starting at a higher mobility level, achieved functional mobility independence and eligibility for a government-funded powered wheelchair (link to local government requirements). A second group ($n = 7$), participants with a low baseline score, exhibited no clinical
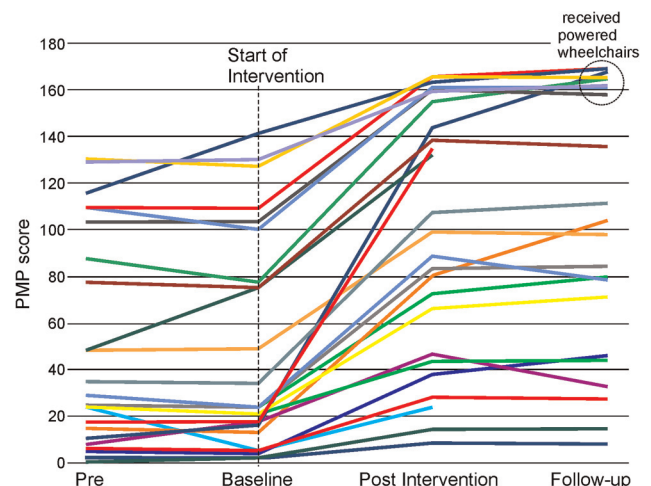

*Figure 1.* Power mobility program (PMP) individual scores over time.

Table 3
Example of Participants' Functional Mobility Goals

Participant	Goal 1	Goal 2
Jonny	Jonny will play a game in which he needs to reach a designated place (such as a treasure hunt or color tag) with mild assistance.	Jonny will move around the gym with supervision from a far (without physical or verbal assistance) for 10 min during recess.
Sarah	Sarah will drive to her teacher 3 m away who calls her name in a quiet room, with only verbal cueing.	Sarah will bring her hand to the joystick herself and drive for 5 min without touching people or objects in a quiet environment, with only verbal cueing.
Yoosef	Yoosef will drive to reach the iPad on his desk, including maneuvering and stopping when he touches a wall, with only verbal cueing.	Yoosef will leave the classroom and enter the music room across the hall, with only verbal cueing.
Jasmin	Jasmin will hang out with Dyna (a friend who is an independent wheelchair user) during recess, and keep up to her without physical help (verbal cues and/or close supervision).	Jasmin will go from her classroom to the secretary in the school office in 5 min with supervision from a far.
Vladi	Vladi will hang out with his friends in the schoolyard during recess with supervision from a far.	Vladi will drive from his classroom to the gym (including leaving the classroom, maneuvering halls and entering the gym) in 4 min with supervision from a far
Yael	Yael will drive with her friend Beth during recess in the schoolyard without supervision.	Yael will enter her classroom and maneuver to her table, sitting close, without supervision
Roberta	Roberta will drive around the school grounds with her friend Roz during recess without supervision (other than the staff member supervising the recess)	Roberta will go in and out of the larger lift, including turning, without touching the walls without cuing (with supervision as she is not allowed to take the lift herself).

Note: Pseudonyms have been used to protect the participants' identities.

improvement. The third group ($n = 9$), however, while starting at the same low baseline level, showed dramatic improvement following the camp; one participant even developed enough skill to be eligible for a government-funded powered wheelchair.

Significant correlation between participants' manual/communication abilities and PMP scores at T3 (MACS: $r = -0.046$, $p = 0.007$; CFCS: $r = -0.533$, $p = 0.021$) was evident, however, there was no clear correlation between their
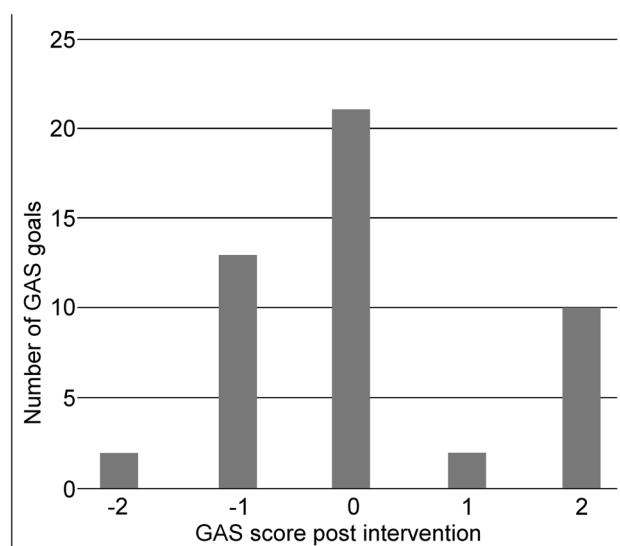
GAS - Goal Attainment Scaling

Figure 2. Frequency of goal attainment scaling (GAS) scores at postintervention.

abilities and the delta, or change from baseline to postintervention (MACS: $r = -0.082$, $p = 0.702$; CFCS: $r = -0.295$, $p = 0.161$). Similarly, while significant variation between gross motor levels IV and V with a PMP score at T3 (GMFCS: $z = -2.753$, $p = 0.006$) was seen, this was not evident for gross motor levels and the delta (GMFCS: $z = -1.827$, $p = 0.068$). For visual abilities, according to school files ($n = 12$ in each group, with and without visual limitation), no significant difference was seen at either T3 ($t = 1.3$, $p > 0.05$) or the delta (T3–T2) ($t = 1.612$, $p > 0.05$).

Secondary Outcome Measures

The ALP had a median of 3 at both T1 and T2 (interquartile range [IQR] T1: 3–6, T2: 3–5), rising to 6 at T3 (IQR 6–7) and remaining stable at T4 (median = 6, IQR 6–8). This shows that significant improvement was achieved as a result of the camp and retained at follow-up.

Functional mobility goals were established by each participant (examples can be seen in Table 3); the mean GAS T-score at T3 was 51.2, just above the achievement of the outcome goal. The frequency of the postintervention GAS score distribution for all goals is shown in Figure 2; overall, 70% of goals were achieved (score ≥ 0). At the individual level ($n = 24$), 13 participants (54%) succeeded in achieving both of their goals, seven (29%) achieved one of the two, and only four (17%) failed to achieve either of their two GAS goals.

A significant time effect ($n = 21$) was seen in WhOM-YP results from T1 to T4 ($F(1, 58) = 80.17$, $p < 0.001$, $\eta_p^2 = 0.74$). A post hoc analysis revealed no change between T1 and T2 ($p > 0.05$), but a significant change following the camp, from T2 to T3 ($p < 0.001$), with goals maintained at T4 ($p > 0.05$).

Structured feedback interviews were conducted in three of the four camps ($n = 19$). One camper was incapable of expressing a choice, and another consistently chose the last option, so both were excluded ($n = 17$). Overall, 88% enjoyed the camp (chose the happy emoji) and a similar percentage felt their driving had improved, while 73% of participants felt they had increased interaction with peers. When asked about other aspects of the camp (to gauge whether these aspects were motivating or distracting) 66% said the feedback was helpful, and 66% enjoyed the music accompanying the games. When asked which activity they enjoyed most, 71% chose "driving by myself," 23% the games, and only 6% the obstacle courses. All participants capable of verbal expression ($n = 9$) were very positive about their experiences. One, for example, said:

> Who wouldn't love driving a powered chair? It's the most fun! When you can move about, you aren't stuck in the same place all the time … I love it tons. (The group) is more interesting than being alone; it's sad to be alone. I enjoyed myself because it's fun to be able to move around.

Discussion

This research project provides preliminary support for Power Fun as a viable method to help children and youth with severe CP improve powered mobility skills and attain functional goals, though further investigation is warranted. Both primary (PMP) and secondary measures (ALP and WhOM-YP) revealed no change before the intervention, but showed improvement following the treatment, retained at follow-up. While previous studies have already shown the advantages of summer camps for children with CP at GMFCS levels I–III (Cohen-Holzer et al., 2017; Field & Miller, 2020), as far as we are aware this is the first study using a summer camp approach for a population with lesser abilities (GMFCS levels IV and V). The current results reinforce the effectiveness of an immersive intervention using repetition, intensity, and salience—necessary for motor learning (Kleim & Jones, 2008). As it is difficult to implement an intensive program during the regular school year, a summer camp is ideal.

The results of the primary outcome measure highlight the connection between abilities (GMFCS, MACS, and CFCS) and powered mobility skills (PMP at T3). This is in line with studies that have shown that infants, children, and adults with better manual and communication abilities (such as the ability to stop on demand) also show higher-powered mobility skills (Gefen et al., 2019b; Mockler et al., 2017; Smith et al., 2020). The current study did not find a connection between visual ability and powered mobility skills, which is not in line with Massengale et al. (2005). The divergent results may be explained by the different methods used to assess visual abilities and the populations examined. Massengale et al. (2005) used a variety of measures to analyze the specific visual limitation and this study used only a rough dichotomy; while they studied adults with up to 40 years of powered wheelchair experience, this study was limited to children and youth with no initial driving proficiency. What our study adds is that there is

no necessary connection between motor, communication, and visual abilities, and improvement in powered mobility skills after participation in the camp (delta PMP T2–T3); this suggests that even participants with severe disability have the potential to learn new skills. The result is in accord with a qualitative study by Livingstone et al. (2020) with preschoolers who also did not find trends relating to diagnosis, age or abilities. Power Fun is based on the belief that a child can develop powered mobility skills despite significant motor limitations (Livingstone & Paleg, 2014), rather than negating the use due to the limitations. This is in line with a study using shared-control technology to provide training for adults with cognitive limitations, and thus allow them to learn powered mobility (Smith et al., 2019). It also fits with Nilsson et al.'s findings that even individuals with severe cognitive limitations can learn powered mobility (Nilsson, 2019; Nilsson & Durkin, 2017). The current study strengthens research concluding that limited vision or cognition, behavioral issues and poor motor abilities should not prevent a child from learning to use a powered wheelchair (Rosen et al., 2018).

The three profiles which emerged from the individual PMP scores over time conform with the exploratory, operational, and functional learner groups proposed by Field and Livingstone (2018). Those at the low baseline level who did not improve significantly can be described as exploratory learners who may need assistance and supervision for extended periods, but nevertheless benefit from the experience of powered mobility. The second group, referred to as operational learners, progressed to only needing assistance at times. The last groups, which reached independent powered mobility and received personal devices, are functional learners, capable of driving safely in multiple environments (Field & Livingstone, 2018). While the last group who achieved independent mobility are obvious candidates for the intervention, the other two groups made important gains in functional goals and mobility skills, conforming with the current thinking that powered mobility can be both an end (providing mobility) as well as a means (allowing development) (Pituch et al., 2019). In addition, despite the fact that both exploratory and operational learners started at approximately the same level, one group nevertheless succeeded in advancing to the operational level, showing the difficulty of predicting which subjects will show significant improvement and at what rate of progress. This further reinforces the importance of providing learning opportunities for children at all levels (Livingstone & Paleg, 2014; Rosen et al., 2018).

Secondary measures of the GAS and the WhOM-YP demonstrated that personal participation goals were generally achieved. Setting personal, functional goals keeps the intervention relevant and engaging, and is an important component of motor learning (Bar-Haim et al., 2010) and self-determination theory (Ziviani, 2015). Our results are in line with research stressing powered mobility as a tool for children with physical limitations, to optimize participation and prevent passivity (Huang, 2018; Livingstone & Field, 2015; Livingstone & Paleg, 2014; Rosen et al., 2018). Our findings also concur with those of a study on adults, who also reported achievement

of personal goals after receiving powered wheelchair training (MacGillivray et al., 2018).

Many goals set by participants related to free movement, as appropriate to the majority's favorite activity, "driving by myself." This is in accord with a systematic review (Kenyon et al., 2018a) recommending training in environments that promote self-exploration, and also concurs with findings from a focus group of children with multiple, complex disabilities who said they loved exploring and doing things on their own (Durkin, 2009). Studies on very young children also showed similar results; a qualitative study highlighted the importance of child-led exploration (Livingstone et al., 2020) and a synthesis concluded that evidence supported conceptualizing powered mobility as "movement for movements sake" regardless of physical or cognitive abilities (Bray et al., 2020).

Participants' interviews raised interesting questions about the level of concentration needed for learning to use a powered wheelchair. Although 66% said they enjoyed the music played during the camp, this may have proved to distract the other third. Durkin (2009) found that the levels of attention increase as the levels of acquisition of powered mobility progress. In this study, many of those who answered that the music interfered showed a low PMP score at T3 (lower levels of powered mobility acquisition), but the numbers of this subgroup were too small to support similar conclusions. Feedback to participants during the camp was the most difficult aspect of the intervention to control; some staff tended to respond too much with general exclamations such as "great work." This may explain why only two-third of the participants responded that the feedback was helpful. Further research with a larger sample is required to better understand these findings.

Study Limitations and Future research

Although this study shows the viability of Power Fun in improving powered mobility skills and attaining functional goals, it nevertheless had a number of limitations, primarily the lack of a control group, although a repeated-measure design was implemented to address this. A second limitation was the absence of a standard cognitive abilities assessment. All available measures, even those which circumvent verbal abilities, require either adequate vision and/or manual abilities. Despite deliberation and consultation with experts, no appropriate assessment was found for the participants in the current study characterized by motor, vision and/or communication disabilities. The development of a suitable tool to address the variation in cognitive abilities in this population is vital.

Another limitation relates to slight differences in the feasibility study procedure when compared with that of the other three camps, although their data were statistically homogeneous. The feasibility study included (1) assessments conducted by the primary researcher (LR) and not an external assessor; (2) did not include personal interviews, although PMP, ALP, GAS, and WhOM-YP were used; and (3) T4 took place six weeks after the camp, rather than three weeks. While there may be a concern that data from the feasibility study could contaminate the full study, this is nevertheless permissible when a study uses validated tools and is primarily concerned with methodological aspects, especially when the sample is small (van Teijlingen & Hundley, 2002) and when the protocol changes are minimal and clearly explained (Leon et al., 2011).

A further limitation relates to the follow-up; three participants were absent, and some did not have access to the same powered wheelchair used during the camp (which may explain the slight drop in follow-up scores). In addition, there is a limitation relating to the two participants who only partially attended; their data were included as significant improvement was seen in the PMP using ANOVA, both with and without them. This also raises questions regarding the appropriate training dosage, in consideration of different learner groups; the first participant reached independence after only one week of Power Fun, while the second participant may have improved even further if she had attended the full intervention. Future studies should attempt to determine the optimal intervention period, according to the baseline characteristics. It may be the case that a briefer intervention will still prove effective for higher functioning participants, while a longer one would benefit the lower functioning ones.

Despite the fact that this study was conducted at two different special-education schools with diverse ethnic origins, further studies in other locations could extend the intervention's external validity. Although all participants were diagnosed with bilateral CP (GMFCS levels IV and V), their age range was relatively wide (7–18 years old). This had advantages and disadvantages; while validating the intervention protocol for a wider age range, it precluded any focus on the effects on specific age groups. Future studies should examine a broader population with different diagnoses, who also present with severe disabilities. In addition, ad-hoc, personal modifications were made to the wheelchairs as needed during the camp, such as changes to the exact location of the controller or foam added to stabilize posture. This is very common when working with children with severe limitations, even independent drivers, and it would have been unethical not to adapt the wheelchair, nevertheless, it may have been a source of variation.

The final limitation is that the same measures were used at four time points. Although the measures were created to be administered more than once, some of the improvement may have been due to learning from previous assessments.

Implications for Practice

Power Fun provides an evidence-based intervention for children and youth with severe CP to learn powered mobility. The three-week theoretically based summer camp uses participation in fun activities while driving personally adapted wheelchairs in adapted environments, to encourage powered mobility skills acquisition. Although carried out on a small population, the study showed that participants improved powered mobility skills significantly achieved functional goals and enjoyed themselves in the process. The current findings strengthen the conclusions of previous studies (Kenyon et al, 2017; Livingstone

& Paleg, 2014; Nilsson & Durkin, 2017; Rosen et al., 2018) that children and youth with severe limitations can benefit from the opportunity to learn powered mobility.

Conclusion

Improvement in independent mobility is especially important for nonmobile children, as it opens up opportunities for engaging in meaningful life experiences, which promote development (Anderson et al., 2013; Livingstone & Paleg, 2014; Rosen et al., 2018). Power Fun provides a promising evidence-based protocol for a therapeutic mobility camp catering for children and youth with severe CP learning to use powered mobility. To the best of our knowledge, this is the first intensive, short-term, conventional powered mobility intervention designed for this challenging population. The encouraging results strengthen evidence that even children and youth with severe physical limitations can learn new functional skills. Further research on the protocol, the population, and the skills involved in powered mobility is warranted.

Key Messages

- Children and adolescents with severe CP can improve powered mobility skills, following intensive intervention.
- Power Fun promoted most participants to reach functional mobility goals.
- Participants enjoyed participating in Power Fun.

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Supplemental Material

Supplemental material for this article is available online.

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