Title

Predictors of response to a participation-focused intervention for leisure-time physical activity in children with cerebral palsy

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Conflicts of Interest

The authors have no conflicts of interest to declare.

Trial Registration

Australian New Zealand Clinical Trials Registry ACTRN12615001064594

Abstract

Aim: To determine predictors of magnitude of change in response to a participation-focused physical activity (PA) intervention (ParticiPAte CP).

Method: We included 33 children aged 8-12 years with cerebral palsy (CP) with pre-post intervention data from a waitlist randomized trial. Hypothesized linear predictors of change in primary outcomes (Canadian Occupational Performance Measure [COPM] goal Performance and Satisfaction, Belief in Goal Self-competence Scale [BiGSS]) and minutes/day moderate to vigorous physical activity [MVPA]) were: age, Gross Motor Function Classification System, comorbid autism spectrum disorder (ASD), Goal Attainment Scaling T-Score, Problems in Schools Questionnaire, Physical Activity Climate Questionnaire, Motives for Physical Activities Measure – Revised, and Stage of Behaviour Change. Multivariable models were selected using the Bayesian Information Criterion.

Results: Overcoming barriers to participation, age, and comorbid ASD explained 49% of the variance in change in COPM Performance. Being motivated by interest/enjoyment and age explained 32% of the variance in change in COPM Satisfaction. Being motivated by PA competence or appearance (extrinsic motivation) explained 24% of the variance in change in BiGSS. Parental autonomy-supportiveness, overcoming barriers to participation, appearance motivation, and baseline MVPA explained 59% of the variance in change in MVPA.

Interpretation: These findings support a behaviour paradigm for conceptualising PA in children with CP.

What this paper adds

- Children who met their treatment goals had a greater increase in their physical activity participation
- Children who were more intrinsically motivated by physical activity at baseline also improved more
- Being older and having a comorbid diagnosis of ASD was associated with an attenuated effect of the therapy

Key words

Cerebral palsy, physical activity, participation intervention, motivation, self-efficacy, self-competence, self-determination theory, leisure, predictors of response.

Compared to typically developing children (TDC), children with cerebral palsy (CP) have restricted participation in physical activities (PAs) in the community and increased sedentary behaviour.^{1,2} According to national PA report cards, TDC also have low levels of PA and high levels of sedentary behaviour.³ In TDC, it is recognized that a variety of informational, behavioural, environmental and social support strategies may be needed to change PA health behaviours.⁴ In contrast, most interventions to promote PA participation or increase PA level in children with CP have only utilised strategies aimed to improve physical fitness or motor skills, without addressing contextual barriers.⁵ These approaches were based on the premise that the main barrier to PA participation in children with CP is the presence of physical impairments and accompanying activity limitations.⁵ Other barriers such as inaccessible facilities, limited access to assistive technology, reduced sports-specific skills, and reduced self-efficacy associated with prior negative experiences may be more influential or have stronger association with participation than has previously been understood.⁶⁻⁹

Despite these barriers, children with disabilities can and do successfully engage in physical activities and report positive, affirming experiences when these meet their psychological needs.^{10,11} Specifically, children will persist with activities when they feel they have choice, are well supported, and have the skills necessary to sustain involvement, experiences which resonate with the central tenets of Self-Determination Theory (SDT).¹⁰ SDT is a macro theory of human motivation based on empirical studies.¹² The three basic psychological needs posited by SDT are: autonomy (being able to act in a way congruent with one's sense of self and desires), competence (one's actions produce desired outcomes, self-efficacy), and relatedness (feelings of love and connection to others and society).^{12,13} Fulfilment of these psychological needs leads humans towards intrinsically motivated goal pursuit, personal growth and wellbeing.¹³ Cross-sectional and experimental studies based on SDT in adults consistently demonstrate a positive relationship between intrinsic types of

motivation and health-promoting PA behaviours, especially long-term participation in physical activities.¹⁴ In a large meta-analysis (n=15,984 participants) of the relationship between type of motivation and PA behaviours in children, intrinsic motivation was a clinically significant predictor of PA in both leisure time and physical education settings.¹⁵

ParticiPAte CP was a randomized waitlist-controlled clinical trial of a participation-focused intervention with the aim of enabling participation in physical activities for children with CP, underpinned by SDT.^{16, 17} The intervention was designed to support children and their families to overcome barriers to participation and support intrinsic motivation for physically active leisure. ParticiPAte CP led to significant, clinically-meaningful improvements in perceived performance of PA participation goals on the Canadian Occupational Performance Measure (COPM) compared to usual care, though there were no significant between-group differences in objectively-measured minutes/day moderate-vigorous physical activity (MVPA) or sedentary behaviour.¹⁷ Children who were not yet meeting national guidelines (≥ 60 minutes/day MVPA), however, increased their MVPA by about 6 minutes/day.

It is important to explore the mechanisms of action of complex interventions, and to identify characteristics that may predict a best response.¹⁸ As ParticiPAte CP was underpinned by SDT, we incorporated measures of motivational climate (autonomy-supportive vs. controlling), child motivational orientation (intrinsic vs. extrinsic), and readiness for behaviour change into the study design, in order to evaluate how these constructs may be related to outcomes.¹⁶

We hypothesized that: (i) participant characteristics including lower age,¹⁹⁻²¹ (ii) higher functional mobility (according to GMFCS level),²² (iii) ability to overcome barriers to participation during the intervention (as reflected by attainment of incremented goals), (iv) increased baseline parental autonomy-supportiveness (both parent- and child-reported), (v)

increased baseline child intrinsic motivation for PA, and (vi) increased baseline readiness for change in PA behaviour, would be associated with greater increases in performance and satisfaction on the COPM, confidence to persist with goal pursuit on the Belief in Goal Self-competence Scale (BiGSS), and minutes/day of MVPA. We also hypothesized that (vii) a comorbid diagnosis of Autism Spectrum Disorder (ASD) would be associated with reduced response to the intervention as children with ASD may have additional difficulties with social competency that may be an additional barrier to participation,²³ not targeted specifically within the ParticiPAte CP model. Furthermore, since children who did not meet recommendations for MVPA at baseline were more likely to have increased MVPA post-intervention,¹⁷ we hypothesized that (viii) baseline MVPA would also predict change in MVPA.

Methods

The parent ParticiPAte CP study was conducted in Brisbane Australia between October 2015 and April 2017.¹⁷ The trial is described in detail within the protocol¹⁶ and primary outcomes paper.¹⁷ The Children's Health Queensland Hospital and Health Service Ethics Committee (HREC/15/QRCH/162) and The University of Queensland Medical Research Ethics Committee (2015001609) approved the study and it was prospectively registered on the Australian New Zealand Clinical Trials Registry (ACTRN12615001064594). Appropriate written informed consent was obtained from caregivers on behalf of participants.

Design and Procedure

Thirty-seven children with CP at Gross Motor Function Classification System (GMFCS) levels I-III between 8-12 years of age living within 200km of South Brisbane,

Australia were recruited from population-based research and clinical registries. Children were excluded if they had: (i) an unstable medical condition which precluded safe community physical activity; (ii) orthopaedic and/or neurological surgery in the previous 6 months; (iii) moderate to profound intellectual disability ($IQ < 50^{24}$); (iv) moderate to severe communication impairment/disability (Communication Function Classification System²⁵, CFCS IV-V) or; (v) severe visual impairment/blindness (defined as 6/60 or lower when appropriately corrected in the better eye in the opinion of an ophthalmologist).

Participants and their families were randomly allocated to ParticiPate CP immediately (n=18) or to a waitlist usual care control group (n=19) who received the intervention after 16 weeks. Four children allocated to the waitlist group withdrew from the study before receiving the intervention. This resulted in a combined dataset of 33 children with outcome measures available both pre-intervention (baseline) and immediately post-intervention (8 weeks).

Intervention

ParticiPate CP was a highly-individualised intervention aimed to promote increased frequency of participation or involvement in self-selected physical activities. The physiotherapist visited the child for one hour, once a week for eight weeks in the child's home and/or community (total dose 8 hours direct intervention). The decision about where each session was conducted was driven by the goal content (e.g. what activity and where it would ideally be performed), the barriers, and strategies to be implemented to address these. Detailed information about the ParticiPate CP intervention is reported in the study protocol and primary outcomes paper.^{16, 17} Elements common to all participants included:

- individualised goal-setting;
- a clinical reasoning framework to identify and address modifiable barriers to selected PA participation goals;

- communication techniques consistent with Motivational Interviewing²⁶ to orient communications towards changing physical activity behaviour;
- use of strategies to promote participant autonomy, sense of competence and feelings of being supported in accordance with SDT (e.g. Motivational Interviewing, encouragement of positive self-talk, verbal persuasion about capability, activity modification to create a 'just right challenge' and increased likelihood of success etc.)¹⁶;
- activity-specific functional training utilizing motor learning techniques, and
- context/environment focused strategies (e.g. equipment prescription, site visits to observe the child's goal performance, work with others present there such as coaches to promote inclusive practices, or to modify the actual physical environment).

The physiotherapist was registered with at least 3 years paediatric experience and formal training in Motivational Interviewing. Modifiable barriers were defined as those that were within the physiotherapist's scope, clinical expertise/skillset and were able to be addressed in 8 weeks or less, including upon referral to another practitioner.

Outcomes

Participant characteristics

Participant age, sex, and comorbid diagnosis of ASD were reported by caregivers. Child GMFCS level was assessed by an experienced paediatric physiotherapist according to the GMFCS Expanded & Revised,²⁷ and confirmed with the child's treating medical professionals if required.

Outcome variables

The COPM is a patient-reported outcome measure whereby children and their caregivers rate their performance of, and satisfaction with, self-selected occupational performance goals on a scale of 1 (not very good/satisfied) to 10 (very good/satisfied).²⁸ In ParticiPAte CP, each child together with their primary caregiver and physiotherapist collaboratively set two to five goals relating to leisure-time physical activities that they wanted to achieve by the end of the intervention.^{16, 17} Each goal had to reflect either the frequency or involvement construct of participation.²⁹ Participants also rated their confidence to achieve each goal on the same scale of 1 (not very confident) to 10 (very confident), representing the child's goal self-competence (i.e. self-efficacy) according to the Belief in Goal Self-competence Scale (BiGSS).³⁰ As all children set more than one goal, the average score for each domain (performance, satisfaction and confidence) was calculated. Generally, children were encouraged to rate their own goal performance, satisfaction and confidence where possible. Parents provided proxy ratings for younger children and those with intellectual disability. If the caregiver disagreed with their child's rating, this was resolved by discussion until the child and caregiver agreed on one rating.

To determine sedentary time and MVPA at each timepoint, children wore an accelerometer (ActiGraph GT3X+, ActiGraph LLC, Pensacola, FL) around the waist at the right mid-axillary line for seven consecutive days at each assessment time point.^{16, 17} The device was initialised to sample at 30Hz. Data were downloaded and visually inspected with ActiLife version 6.13.3. A customized Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) macro was used to identify non-wear periods and to apply validated GMFCS-specific cut points to vertical axis counts per 15 second epoch.³¹ Epochs categorized at MVPA intensity were summed for each day, then divided by the number of valid wear days to determine average minutes/day MVPA.

Predictor variables

Goal Attainment Scaling (GAS) is a scoring method to quantify goal attainment.³² The psychometric properties of GAS are well-studied in paediatric populations including good inter-rater reliability (Cohen's kappa=0.65-0.92),³³ established content validity, and excellent sensitivity to change.³⁴ At the time of setting each GAS goals, five possible increments of attainment are described with roughly even levels of 'effort' between each: -2 (much less than expected), -1 (less than expected), 0 (expected), +1 (more than expected), and +2 (much more than expected).³² In ParticiPAte CP, GAS was used to set, increment and rate goal/s relating to any barriers faced to achievement of the child's broader COPM goal/s. For example, if one COPM goal was "to ride my bike at the park twice a week with my sister" and an identified barrier to this goal was inability to ride a two-wheel bike, the physiotherapist may have set and incremented a GAS goal related to progression in two-wheel bike skills relative to the child's current performance.¹⁶ Failure to prioritize the activity in daily routines is an example of an environmental or personal factors (caregiver) barrier in which case a GAS goal related to scheduling may have been incremented. GAS scores at post-intervention were transformed into T-scores (with an approximate mean of 50 and standard deviation [SD] of 10, higher scores indicating greater than expected performance) which enable use of parametric statistics.³² The first 19 participants' GAS goals were reviewed according to the GAS technical proficiency checklist by author CE in order to validate the process.³² The GAS goals were also summarized by goal type according to the International Classification of Functioning Disability and Health Framework (ICF).³⁵

The Physical Activity Climate Questionnaire (PACQ) is a 15-item questionnaire where a child responds to statements about the 'climate' for physical activity created by their parent/caregiver.³⁶ An average score is taken which ranges from 1 (controlling climate) to 7 (autonomy-supportive climate).³⁶ The PACQ has not been used in children with CP however

demonstrates moderate test-retest reliability in a 6-item version in 11-16 year old typically developing children ($\alpha=0.80-0.81$),³⁷ and acceptable discriminant, convergent and cross-cultural validity in a sample of typically developing children mean age 13 years.³⁶

In the Problems in Schools Questionnaire (PISQ), caregivers read a series of vignettes about a child's behaviour. They are presented with four possible responses to each behaviour from an adult (e.g. teacher or parent) and rate these responses from 1 (highly inappropriate) to 7 (highly appropriate).³⁸ The score reported is a weighted average with scores above zero representing a more autonomy-supportive parenting style and scores below zero representing a more controlling style.³⁸ The PISQ demonstrates fair test-retest reliability (subscale coefficients 0.77-0.82, total score 0.70), good internal consistency (subscale Cronbach's $\alpha=0.63-0.80$), and predicts change in intrinsic motivation of children over time taught by an autonomy-supportive vs controlling teacher.³⁸

In the child-report Motives for Physical Activities Measure – Revised (MPAM-R), children respond to 30 questions on a 7-point Likert-type scale (1=strongly disagree [not motivated by this], 7=strongly agree [very motivated by this]). This results in 5 subscale scores that are averages of questions corresponding to the child's motivation to participate in physical activities because of: (1) interest/enjoyment (fun), (2) competence, (3) social motivation, (4) appearance, or (5) fitness.³⁹ The first three motivation types are considered to be more intrinsic, and the last two extrinsic.³⁹ The MPAM-R has not been used in children with CP, but has demonstrated high internal consistency (Cronbach's $\alpha=0.78-0.92$) and predicts exercise adherence in adults,³⁹ and is responsive to a physical activity intervention in adolescents.⁴⁰

Baseline readiness for behaviour change according to the Transtheoretical model was collected to facilitate intervention tailoring.⁴¹ The Transtheoretical model of behaviour change describes five stages of readiness for health behaviour change: (1) pre-contemplation,

(2) contemplation, (3) preparation, (4) action or (5) maintenance.⁴¹ Caregivers rated their children's readiness for changing their physical activity behaviour at one of the five levels based on responses to a flowchart with dichotomous options.

Statistical analysis

Hypothesized predictor variables and participant characteristics were summarized by mean and standard deviation (SD) for continuous variables and counts and percentages for categorical variables (Table 1). There were missing data for some outcome variables (n given in Table 1) as some participants were too young or did not have the cognitive ability for the child-report measures, and/or the caregiver failed to return the questionnaire.¹⁷ A chi-square test was performed to test for an association between goal type and goal attainment level. This was a post-hoc test performed to determine whether the intervention had a differential effect according to goal type. Predictor variables were visually observed for distributional characteristics and the presence of outliers. For ordinal scales (COPM, BiGSS, PACQ, MPAM-R) we assumed for the purposes of statistical analyses that intervals within these scales were equal. Regression diagnostic plots showed that residuals did not deviate significantly from normality. Univariable linear regression was performed for all predictor variables. The best multivariable model for each outcome variable was selected using an iterative stepwise model selection procedure. The most appropriate model was identified as the model with the smallest Bayesian information criterion (BIC) statistic. If models with a different number of predictor variables had similar (within 1 unit) BIC values, the most parsimonious model was chosen. The BIC prevents overfitting in multivariable regression (when compared to, for example the R^2 statistic) by adding penalty terms for the number of predictors in the model and the sample size.⁴² Statistical analyses were conducted using Stata/SE v16.0 (StataCorp LLC, College Station, TX, USA).

Results

Participant characteristics are reported in Table I. Thirty-three children (16 males) with CP and mean age of 10 years (SD=1 year 6 months, range 8-12 years) received the ParticiPAte CP intervention in the clinical trial (n=16 males, GMFCS I=19, GMFCS II=8, GMFCS III=6). Three participants had a mild intellectual disability. Of 102 GAS goals (Table II), most were at the Activities level of the ICF (n=45, 44%), followed by Environment (n=35, 34%). Seventy-four percent (74%) of GAS goals had ‘expected’ or ‘greater than expected’ level of attainment post-intervention. There was a relationship between goal type and goal attainment, with a smaller proportion of Environment goals reaching the ‘expected’ or ‘greater than expected’ level of attainment ($X^2 [3]=22.44$, $p<0.001$, $n=102$).

COPM Performance

In univariable linear regression models, GAS T-score ($\beta=0.04$, $p=0.018$), and participant age ($\beta=-0.74$, $p<0.001$) had the strongest associations with improvement in COPM Performance (Supplementary Table I). The best fitting multivariable model according to BIC explained 49% of the variance in increase in COPM Performance scores pre-post intervention (Table III). It consisted of GAS T-score (10 unit [1SD] increase associated with additional +0.40 points increase in COPM Performance pre-post intervention, 95%CI 0.10 to 0.70, $p=0.017$), participant age (1 year increase associated with -0.57 points attenuated increase in COPM Performance pre-post intervention, 95% CI -0.96 to -0.19, $p=0.005$), and comorbid diagnosis of ASD (diagnosis associated with -1.57 points attenuated increase in COPM Performance pre-post intervention compared to no diagnosis, 95% CI -2.86 to -0.29, $p=0.018$).

COPM Satisfaction

In univariable linear regression models, MPAM-R Interest/enjoyment motivation ($\beta=1.24$, $p=0.025$) and participant age ($\beta=-0.63$, $p=0.040$) has the strongest associations with change in COPM Satisfaction (Supplementary Table II). MPAM-R Interest/enjoyment motivation (1 point increase associated with additional +1.20 points increase in COPM Satisfaction, 95%CI 0.19 to 2.20, $p=0.022$) and participant age (1 year increase associated with -0.63 points attenuated increase, 95%CI -1.28 to 0.02, $p=0.057$) were retained in the best fitting model according to BIC, explaining 32% of the variance in change in COPM Satisfaction scores pre-post intervention (Table III).

Belief in Goal Self-Competence Scale

In univariable linear models, only MPAM-R Competence motivation for physical activity ($\beta=-0.75$, $p=0.034$) was significantly associated with attenuated increase in BiGSS pre-post intervention (Supplementary Table III). The best fitting multivariable model according to BIC explained 24% of the variance in change in Belief in Goal Self-Competence scores pre-post intervention (Table III). It consisted of MPAM-R Competence motivation (1 point increase associated with -0.88 points attenuated increase in BiGSS pre-post intervention, 95%CI -1.62 to -0.15, $p=0.021$) and MPAM-R Appearance motivation (1 point increase associated with additional +0.33 points increase in BiGSS pre-post intervention, 95%CI -0.21 to 0.87, $p=0.216$). .

Minutes/day MVPA

In univariable linear models, baseline minutes/day of MVPA ($\beta=-0.36$, $p=0.045$) and PISQ Total weighted average ($\beta=-2.37$, $p=0.046$) were associated with change in minutes/day of MVPA pre-post intervention (Supplementary Table IV). The best fitting multivariable model

according to BIC explained 59% of the variance in change in minutes/day MVPA pre-post intervention (Table III). It included PISQ Total weighted average (1 point increase associated with -2.30 minutes attenuated increase in MVPA pre-post intervention, 95%CI -4.23 to -0.37, $p=0.023$), GAS T-score (10 point [1 SD] increase associated with additional +3.70 minutes increase in MVPA pre-post intervention, 95%CI 0.10 to 7.20, $p=0.043$), MPAM-R Appearance motivation (1 point increase associated with -3.53 minutes attenuated increase in MVPA pre-post intervention, 95%CI -6.90 to -0.16, $p=0.041$) and minutes/day MVPA at baseline (1 minute increase associated with -0.37 minutes attenuated increase in MVPA pre-post intervention, 95%CI -0.75 to 0.00, $p=0.053$).

The best one to five predictor variable models for all outcomes can be accessed in Supplementary tables V to VIII.

Discussion

This secondary pre-post analysis of the Participate-CP study provides preliminary evidence that motivational and behavioural determinants of health behaviour predict change in perceived participation and PA level following a participation-focused intervention in children with CP. This provides empirical support for relationships between PA and motivational/behavioural constructs in children with CP that have been reported in TDC.¹⁵ Findings support the hypothesized direction of relationships of COPM Performance/Satisfaction and Belief in Goal Self-Competence with age, comorbid ASD, GAS T-Score and MPAM-R Interest/enjoyment, but not MPAM-R Competence motivation. Our findings also support the hypothesized direction of relationship between min/day MVPA and GAS T-score, MPAM-R Appearance motivation and minutes/day MVPA at baseline, but not PISQ (parental autonomy-supportive parenting style). There was no evidence for

relationships between COPM Performance, COPM Satisfaction, BiGSS and min/day MVPA with GMFCS level, autonomy-supportive climate for PA (PACQ), or Stage of Behaviour Change.

Increasing age was associated with a decreased improvement in both COPM Performance (univariable and multivariable) and COPM Satisfaction (univariable, included in multivariable but not significant) following the intervention. This may reflect the additional barriers faced by children with CP as they get older and transition from less competitive to more competitive, rule-driven PA environments.⁴³ Large declines in participation in sports and physical activities following the transition from childhood to adolescence have been demonstrated in both TDC,⁴⁴ and children with CP.⁴⁵ The reasons for this decline are not clear though have been speculated to be associated with reduced parental control, increased self-consciousness, and increased adoption of sedentary pastimes,⁴⁴ and in children with CP, increasing environmental and contextual barriers.⁴⁵ The implications of this finding are: (i) that it is possibly easier to intervene to promote PA participation in younger children, and (ii) that additional tailoring may be required for adolescents, for example with a greater focus on environmental and contextual barriers.

An additional diagnosis of ASD was associated with a decreased change in COPM Performance following ParticiPAte CP compared to no diagnosis.²⁸ It is possible that the slightly reduced efficacy may be due to additional and/or different barriers to participation experienced by children with ASD (for example therapy support for social skills where the goals relate to participation in an activity with peers²³), or difference in motivational orientation. A study of n=100 adolescents participating in an inclusive physical education class demonstrated that adolescents with ASD (n=25) had lower self-determined motivation for PA compared to those without ASD.⁴⁶ Higher PA level in adolescents with ASD was associated with need for extrinsic motivation (structure/reward) rather than intrinsic

motivation, which is the expected relationship frequently demonstrated in typically developing populations.⁴⁶ This speaks to a need to tailor interventions specifically for individual motivational orientation, rather than assuming that all children will or should be intrinsically motivated to participate in PA. The prevalence of an additional diagnosis of ASD in children with CP is estimated to be between 2-30%⁴⁷ (18% in a recent register-based study⁴⁸), making this a critical consideration for future research. A protocol of a social skills group program for adolescents with CP and co-occurring difficulties with social competence has been published, however efficacy has not yet been reported.²³

There was a positive relationship between quantifiable goals (GAS T-score) and an increase in participant-reported COPM Performance and minutes/day MVPA pre-post intervention, which supports the proposed mechanism of action that addressing barriers to participation across ICF domains would lead to increased participation in PAs and increased MVPA.¹⁶ Most GAS goals were achieved regardless of type, however goals reflecting environmental variables (e.g. parental scheduling/prioritization of activity) were less frequently attained than expected. Many environmental barriers are not able to be incremented on the GAS, for example, obtaining a piece of equipment such as a tricycle typically has a dichotomous outcome (yes vs. no), is not possible to increment, and may have taken longer than the eight week period to obtain. The predominance of activity goals and apparent reduced success in attaining environment goals may therefore reflect the properties of GAS or the way the goals have been worded, rather than a failure to successfully address environmental barriers. In support of this, we have previously demonstrated that caregivers reported significantly increased behavioural and environmental facilitators and/or reduced barriers following ParticiPAte CP.¹⁷

Children who were more motivated to participate in physical activities because of interest or enjoyment (as measured on MPAM-R) had greater increases in COPM Satisfaction

with goal performance pre-post ParticiPAte CP. This supports our hypothesis that motivational determinants of PA behaviour are associated with response to a behaviour-oriented PA intervention. Children who are highly motivated by interest or enjoyment of physical activities to begin with may be more likely to participate in and enjoy a physical activity-oriented intervention, and have their enjoyment and satisfaction of physical activities reinforced through psychological needs satisfaction.⁴⁹ Furthermore, increasing MPAM-R Appearance motivation, which is an extrinsic type of motivation, predicted a decreased response to the intervention on minutes/day MVPA as expected. This is because ParticiPAte CP did not contain elements appealing to children who may have wanted to increase PA for reasons of changing their physical looks (i.e. look stronger or lose weight). It may be important to tailor interventions according to the motivational orientation of individual children and families to maximise the potential for success.⁵⁰ For example, children who have low relative interest/enjoyment motivation but high social motivation for PA may require early and deliberate introduction of exercise in a highly social context.

There was a negative relationship between baseline Competence motivation for PA on MPAM-R and change in BiGSS (goal self-competence) pre-post intervention, which was opposite to the hypothesized effect. Upon further examination, five of the six children who had both greater than average baseline MPAM-R Competence motivation, and a negative change score on the BiGSS, reported a baseline BiGSS score of 10 (the maximum possible on a scale of 1-10, mean=7.3 SD=2.0). This may demonstrate a ceiling effect of the BiGSS for children who are highly motivated by competence to engage in physical activities, or interpretation of BiGSS as 'hope' to achieve goals instead of confidence. Conversely, children with the lowest competence-related motivation on the MPAM-R at baseline demonstrated the greatest increases in their perceived self-competence on the BiGSS following the intervention. As perceived self-competence and competence-related motivation

may be linked to a child's prior experiences of success or failure (i.e. success leads to more internal locus of control and greater motivation to achieve further success, and vice versa),⁵¹ it is encouraging that children with lower competence-related motivation had greater increases in their perceived self-competence following ParticiPAte CP. Some children with physical disabilities report a number of negative past experiences from participation in physical activities.⁶ It is these children for whom ParticiPAte CP may provide a boost of positive experiences of physical activity which in turn may increase their confidence to try. This may act through provision of a 'just right challenge' in an autonomy-supportive therapy context that encourages children and youth to develop task-oriented mastery motivation⁵⁰ that is not contingent on external perceptions of success or failure in sport.⁵² This has recently been demonstrated in a practitioner-led sports group for children with CP functioning at GMFCS I-II.⁵³ Sports Stars Physiotherapists could carefully manage the difficulty level and progression of tasks and foster a positive social and motivational environment, leading to increased child confidence for PA participation.⁵⁴

Baseline MVPA was the most significant univariate predictor of change in min/day MVPA and was retained in the multivariate model (although no longer statistically significant). Higher MVPA at baseline predicted a reduced response to the intervention. This result is not surprising as MVPA was very high in ParticiPAte CP when compared to previous estimates in both children with CP and in TDC,¹⁷ however it was nearly identical to a non-overlapping sample of same-aged children with CP GMFCS I-III from a similar geographic area.⁵⁵ This comparative sample was drawn from a population-based longitudinal study, suggesting that the high MVPA in ParticiPAte CP did not result from sampling bias (and is reflective of the true MVPA level of this population). It may be difficult for children with CP who are already accumulating almost 60min/day MVPA to increase their PA given the increased energy cost of movement and increased risk of fatigue.⁵⁶ Instead, swapping

sedentary behaviour for light PA may be more feasible,⁵⁵ however studies are required that evaluate the effects of interventions aimed specifically at sedentary behaviours.

There was evidence of a negative relationship between increasing parental autonomy-supportive parenting style on the PISQ at baseline and change in minutes/day MVPA pre-post intervention. This is contrary to the hypothesized mechanism of effect that increased parental autonomy-supportiveness at baseline would predict increased response to the intervention. The items in the PISQ however reflect choices and scenarios unrelated to physical activity, and therefore may not reflect parenting decisions or practices around children's participation in sports and active recreation. In TDC, parental influence in the form of modelling and provision of resources is associated with increased PA.⁴ Future studies should explore parenting practices specific to PA in children with CP using a reliable questionnaire of PA parenting validated in the population of interest.^{57, 58}

Study Strengths and Limitations

One strength of the present study was the completion of pre-planned analyses of predictors of change in the primary outcomes.^{16, 17} This provides information about the mechanism of effect of ParticiPAte CP and facilitates both replication and improvement of this intervention. Consequently, we believe this is also the first study to demonstrate causal relationships between SDT constructs and response to a physical activity intervention in children with CP. .

This study had some potential limitations. Firstly, our study had a small sample size powered only for the primary analysis¹⁶ and must be replicated in a larger adequately powered sample, however the statistical approach used was robust to overfitting of the models. Secondly, to explore predictors of a 'best response' we had to use pre-post change score instead of dichotomizing responders vs. non-responders. This is because almost all

participants achieved a clinically significant response on the primary outcome (COPM). The results are therefore more difficult to interpret compared to logistic regression which results in odds ratios. Furthermore, whilst the constructs of SDT have been demonstrated empirically across cultures and contexts, the results may not be generalizable to children with CP living in dissimilar settings, and relate specifically to the ParticiPAte CP model of intervention. Additionally, the intervention was only 8 weeks in length and due to study design constraints behaviour change was only explored immediately post-intervention. Long term follow-up is required to explore sustained PA behaviour-change. Finally, we were not able to explore the relationship between movement competence and response to intervention as gross motor activity capacity was not measured.

Conclusions

Motivational determinants of physical activity behaviour aligning with SDT are associated with response to a participation-focused intervention in children with CP. Supporting the hypothesized mechanism of effect, increased goal attainment during the intervention and increased interest/enjoyment motivation for PA predicted a greater response to the intervention. In contrast to hypothesized effects, higher competence-related motivation for physical activities at baseline predicted a decreased response on both goal confidence (BiGSS) and min/day MVPA. This may be due a ceiling effect in measuring goal confidence, high average baseline MVPA, and the presence of the inverse relationship, i.e. that decreased competence-related motivation for PA at baseline predicted a greater increase in confidence (self-efficacy) to achieve participation goals and greater increase in min/day MVPA post-intervention. Participant characteristics including increased age, and presence of comorbid ASD diagnosis were associated with a decreased response to the intervention.

The implications of our findings are that clinicians must consider the motivational orientation of children with CP for PA, i.e. whether they are motivated to exercise for fun, to improve their capacity, for social participation, or because they need extrinsic rewards to do so. A tailored approach such as that used in ParticiPate CP must then be applied that optimises motivation, builds self-efficacy (especially for those with low confidence and negative PA experiences), and ensures that any modifiable barriers to participation are identified and effectively addressed. Clinicians may also consider how comorbid diagnoses such as ASD or older age introduce additional barriers that may need a multidisciplinary team approach to foster successful PA participation, or change motivational profile. An understanding of the content of ParticiPate CP is required to further refine the intervention and provide recommendation for specific behaviour change techniques, however it is clear that the adoption of a health behaviour paradigm for improving PA in children with CP may significantly advance the field.

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Table I: Study Participant Characteristics and Predictor Variables (n=33)

<i>Participant characteristics</i>	n	
Age, mean (SD)		10y0m (1y6m)
Sex, n (%)	33	
Male		16 (48)
Female		17 (52)
GMFCS, n (%)	33	
I		19 (58)
II		8 (24)
III		6 (18)
Comorbid ASD, n (%)	33	
No		25 (76)
Yes		8 (24)
<i>Outcome variables</i>		
Change in COPM Performance, mean (SD)	33	4.13 (2.00)
Change in COPM Satisfaction, mean (SD)	33	3.29 (2.56)
Change in BiGSS, mean (SD)	33	0.75 (2.09)
Change in minutes/day MVPA, mean (SD)	25	0.28 (15.73)
<i>Predictor variables</i>		
Baseline MVPA, mean (SD)	25	53.87 (17.54)
GAS T-Score, mean (SD)	33	56.97 (19.12)
PACQ, mean (SD)	25	6.02 (0.68)
PISQ, mean (SD)	27	0.91 (2.76)
MPAM-R Interest/enjoyment, mean (SD)	25	6.04 (1.02)
MPAM-R Competence, mean (SD)	25	5.34 (1.21)
MPAM-R Appearance, mean (SD)	24	2.62 (1.64)
MPAM-R Fitness, mean (SD)	24	4.64 (1.50)
MPAM-R Social, mean (SD)	25	4.66 (1.44)
Stage of Behaviour Change, n (%)	26	
Pre-contemplation		3 (9)
Contemplation		0
Preparation		11 (33)
Action		1 (3)
Maintenance		11 (33)
Missing		7 (21)

GMFCS, Gross Motor Function Classification System; MVPA, moderate-vigorous physical activity; GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire; PISQ, Problems in Schools Questionnaire; MPAM-R, Motives for Physical Activities Measure – Revised; ASD, Autism Spectrum Disorder

Note: COPM, BiGSS, PACQ and MPAM-R are assumed to be continuous for the purposes of statistical analyses

Table II: Goal Attainment Scaling Goal Characteristics				
		Level of goal attainment		
GAS Goal type	Sample frequency n(%)	Less than expected n(%)	Expected or greater n(%)	Chi square test
GAS Goal Type				
Body structures and functions	9 (9)	1 (4)	8 (11)	X ² (3)=22.44 <i>p</i> <0.001 n=102
Activities	45 (44)	7 (26)	38 (51)	
Environment	35 (34)	19 (70)	16 (21)	
Personal factors	13 (13)	0 (0)	13 (17)	
GAS, Goal Attainment Scaling				

Table III: Multivariate regression analysis results					
	Model r^2	β	95%CI		p
COPM Performance	0.49				
GAS T-score ^a		0.04	0.01	0.07	0.017
Age		-0.57	-0.96	-0.19	0.005
Comorbid ASD, n (%)					
No		0.00 (ref)			
Yes		-1.57	-2.86	-0.29	0.018
COPM Satisfaction	0.32				
MPAM-R					
Interest/enjoyment		1.20	0.19	2.20	0.022
Age		-0.63	-1.28	0.02	0.057
Belief in Goal Self-competence Scale	0.24				
MPAM-R Competence		-0.88	-1.62	-0.15	0.021
MPAM-R Appearance		0.33	-0.21	0.87	0.216
Minutes/day MVPA	0.59				
PISQ Total weighted average		-2.30	-4.23	-0.37	0.023
GAS T-score ^a		0.37	0.01	0.72	0.043
MPAM-R Appearance		-3.53	-6.90	-0.16	0.041
Baseline minutes/day MVPA		-0.37	-0.75	0.00	0.053

^a Values presented for GAS T-score in this table reflect 1 unit increase

COPM, Canadian Occupational Performance Measure; GAS, Goal Attainment Scaling; ASD, Autism Spectrum Disorder; ref, reference category; MPAM-R, Motives for Physical Activities Measure – Revised; MVPA, moderate-vigorous physical activity; PISQ, Problems in Schools Questionnaire

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Supplementary Table I: Univariate predictors of change in COPM Performance

	<i>r</i>	β	95%CI		<i>p</i>
GMFCS					
I		0.00 (ref)			
II		1.31	-0.33	2.95	0.114
III		-0.99	-2.82	0.83	0.274
GAS T-score	0.41	0.04	0.01	0.08	0.018
PACQ Total	-0.02	-0.05	-1.30	1.20	0.931
PISQ Total weighted average	-0.10	-0.08	-0.38	0.23	0.611
MPAM-R Interest/enjoyment	0.11	0.23	-0.63	1.08	0.590
MPAM-R Competence	-0.05	-0.09	-0.82	0.63	0.795
MPAM-R Appearance	0.22	0.27	-0.26	0.80	0.299
MPAM-R Fitness	0.20	0.26	-0.31	0.84	0.352
MPAM-R Social	0.24	0.34	-0.25	0.93	0.241
Age	-0.54	-0.74	-1.16	-0.32	<0.001
Stage of Behaviour Change					
Pre-contemplation		0.00 (ref)			
Preparation		-1.94	-4.61	0.73	0.146
Action		-2.78	-7.52	1.96	0.237
Maintenance		-1.07	-3.74	1.61	0.417
Comorbid ASD, n (%)					
No		0.00 (ref)			
Yes		-1.47	-3.06	0.12	0.069

GMFCS, Gross Motor Function Classification System; GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire; PISQ, Problems in Schools Questionnaire; MPAM-R, Motives for Physical Activities Measure – Revised; ASD, Autism Spectrum Disorder

Supplementary Table II: Univariate predictors of change in COPM Satisfaction

	<i>r</i>	β	95%CI		<i>p</i>
GMFCS					
I		0.00 (ref)			
II		-0.08	-2.34	2.18	0.944
III		-0.92	-3.43	1.59	0.460
GAS T-score	0.02	0.00	-0.05	0.05	0.914
PACQ Total	0.37	1.53	-0.11	3.18	0.066
PISQ Total weighted average	0.07	0.06	-0.32	0.45	0.733
MPAM-R Interest/enjoyment	0.45	1.24	0.17	2.30	0.025
MPAM-R Competence	0.10	0.22	-0.77	1.22	0.647
MPAM-R Appearance	0.18	0.31	-0.45	1.06	0.406
MPAM-R Fitness	0.22	0.42	-0.40	1.23	0.299
MPAM-R Social	0.26	0.50	-0.31	1.32	0.214
Age	-0.36	-0.63	-1.22	-0.03	0.040
Stage of Behaviour Change					
Pre-contemplation		0.00 (ref)			
Preparation		-1.92	-5.53	1.69	0.282
Action		-1.78	-8.18	4.62	0.570
Maintenance		-0.31	-3.92	3.30	0.861
Comorbid ASD, n (%)					
No		0.00 (ref)			
Yes		-0.87	-3.01	1.26	0.410

GMFCS, Gross Motor Function Classification System; GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire; PISQ, Problems in Schools Questionnaire; MPAM-R, Motives for Physical Activities Measure – Revised; ASD, Autism Spectrum Disorder

Supplementary Table III: Univariate predictors of change in Belief in Goal Self-Competence Scale

	<i>r</i>	β	95%CI		<i>p</i>
GMFCS					
I		0.00 (ref)			
II		0.26	-1.58	2.10	0.777
III		-0.57	-2.62	1.47	0.573
GAS T-score	0.04	0.00	-0.04	0.04	0.831
PACQ Total	-0.11	-0.37	-1.79	1.05	0.595
PISQ Total weighted average	-0.01	-0.01	-0.28	0.27	0.956
MPAM-R Interest/enjoyment	-0.22	-0.46	-1.35	0.42	0.288
MPAM-R Competence	-0.43	-0.75	-1.44	-0.06	0.034
MPAM-R Appearance	0.013	0.18	-0.41	0.76	0.537
MPAM-R Fitness	0.00	0.00	-0.64	0.64	0.993
MPAM-R Social	0.01	0.02	-0.62	0.66	0.945
Age	-0.05	-0.07	-0.59	0.45	0.777
Stage of Behaviour Change					
Pre-contemplation		0.00 (ref)			
Preparation		-1.58	-4.23	1.08	0.230
Action		-0.89	-5.59	3.82	0.699
Maintenance		-2.12	-4.77	0.54	0.112
Comorbid ASD, n (%)					
No		0.00 (ref)			
Yes		0.33	-1.43	2.08	0.707

GMFCS, Gross Motor Function Classification System; GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire; PISQ, Problems in Schools Questionnaire; MPAM-R, Motives for Physical Activities Measure – Revised; ASD, Autism Spectrum Disorder

Supplementary Table IV: Univariate predictors of change in Minutes/day of MVPA

	<i>r</i>	β	95%CI		<i>p</i>
GMFCS					
I		0.00 (ref)			
II		10.80	-5.51	27.11	0.183
III		-7.34	-23.64	8.97	0.361
Baseline minutes/day MVPA	-0.40	-0.36	-0.72	-0.01	0.045
GAS T-score	-0.19	-0.16	-0.53	0.21	0.373
PACQ Total	-0.21	-5.14	-16.37	6.09	0.350
PISQ Total weighted average	-0.44	-2.37	-4.69	-0.05	0.046
MPAM-R Interest/enjoyment	-0.41	-6.34	-13.35	0.66	0.073
MPAM-R Competence	-0.39	-4.72	-10.26	0.82	0.091
MPAM-R Appearance	-0.36	-3.31	-7.55	0.92	0.118
MPAM-R Fitness	-0.40	-3.81	-8.13	0.50	0.080
MPAM-R Social	-0.39	-4.03	-8.78	0.72	0.092
Age	0.08	0.76	-3.52	5.03	0.718
Stage of Behaviour Change					
Pre-contemplation		0.00 (ref)			
Preparation		-7.80	-30.45	14.85	0.477
Action		-15.96	-55.19	23.28	0.403
Maintenance		-16.99	-39.99	6.01	0.138
Comorbid ASD, n (%)					
No		0.00 (ref)			
Yes		12.40	-4.93	29.73	0.152

GMFCS, Gross Motor Function Classification System; MVPA, moderate-vigorous physical activity; GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire; PISQ, Problems in Schools Questionnaire; MPAM-R, Motives for Physical Activities Measure – Revised; ASD, Autism Spectrum Disorder

Supplementary Table V: Best one to five predictor variable models for the COPM Performance model. The best models are identified using the Bayesian information criterion value.

Variables	BIC					
1	87.15	GAS-Tscore				
2	87.35	Comorbid ASD	GAS-Tscore			
3^a	82.12	Comorbid ASD	GAS-Tscore	Age		
4	82.88	Comorbid ASD	GAS-Tscore	Age	MPAM-R Social	
5	82.98	Comorbid ASD	GAS-Tscore	Age	PISQ Total weighted average	MPAM-R Social

^a Selected model

COPM, Canadian Occupational Performance Measure; MVPA, GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire; PISQ, Problems in Schools Questionnaire; MPAM-R, Motives for Physical Activities Measure – Revised; ASD, Autism Spectrum Disorder

Supplementary Table VI: Best one to five predictor variable models for the COPM Satisfaction model. The best models are identified using the Bayesian information criterion value

Variables	BIC					
1	105.82	MPAM-R Interest/enjoyment				
2^a	104.27	Age	MPAM-R Interest/enjoyment			
3	106.23	Age	MPAM-R Interest/enjoyment	PACQ		
4	108.83	Age	MPAM-R Interest/enjoyment	PACQ	MPAM-R Social	
5	111.30	Age	MPAM-R Interest/enjoyment	PACQ	MPAM-R Competence	MPAM-R Social

^a Selected model

COPM, Canadian Occupational Performance Measure; MPAM-R, Motives for Physical Activities Measure – Revised; PACQ, Physical Activity Climate Questionnaire; GAS, Goal Attainment Scaling; PISQ, Problems in Schools Questionnaire

Supplementary Table VII: Best one to five predictor variable models for the BiGSS model. The best models are identified using the Bayesian information criterion value

Variables	BIC					
1	89.49	MPAM-R Competence				
2^a	86.92	MPAM-R Competence	MPAM-R Appearance			
3	87.66	MPAM-R Competence	GAS T-score	MPAM-R Appearance		
4	87.25	MPAM-R Competence	GAS T-score	Age	MPAM-R Appearance	
5	89.50	MPAM-R Competence	GAS T-score	Age	MPAM-R Appearance	PISQ Total weighted average

^a Selected model

BiGSS, Belief in Goal Self-competence Scale; MPAM-R, Motives for Physical Activities Measure – Revised; GAS, Goal Attainment Scaling; PISQ, Problems in Schools Questionnaire; PACQ, Physical Activity Climate Questionnaire

Supplementary Table VIII: Best one to five predictor variable models for the MVPA model. The best models are identified using the Bayesian information criterion value

Variables	BIC					
1	156.08	MPAM-R Appearance				
2	154.99	PISQ Total weighted average	MPAM-R Appearance			
3	154.93	PISQ Total weighted average	Baseline minutes/day MVPA	MPAM-R Competence		
4^a	153.30	PISQ Total weighted average	GAS T-Score	MPAM-R Appearance	Baseline minutes/day MVPA	
5	154.09	PISQ Total weighted average	GAS T-Score	MPAM-R Appearance	Baseline minutes/day MVPA	MPAM-R Competence

^a Selected model

MVPA, moderate-vigorous physical activity; MPAM-R, Motives for Physical Activities Measure – Revised; PISQ, Problems in Schools Questionnaire; GAS, Goal Attainment Scaling; PACQ, Physical Activity Climate Questionnaire