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**Task-specific training for bicycle-riding goals in ambulant children with cerebral palsy:  
a randomized controlled trial**

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**AIM** To determine whether a task-specific physiotherapist-led training approach is more effective than a non-specific parent-led home programme for attaining bicycle-riding goals in ambulant children with cerebral palsy (CP).

**METHOD** Sixty-two ambulant children with CP aged 6 to 15 years (33 males, 29 females, mean age 9y 6mo) with bicycle-riding goals participated in this multi-centre, assessor-blind, parallel-group, superiority randomized controlled trial. Children in the task-specific group participated in a physiotherapist-led, group-based, intensive training programme. Children in the parent-led home group were provided with a practice schedule, generic written information, and telephone support. Both programmes involved a 1-week training period. The primary outcome was goal attainment at 1 week after training measured using the Goal Attainment Scale. Secondary outcomes included bicycle skills, participation in bicycle riding, functional skills, self-perception, physical activity, and health-related quality of life at 1 week and 3 months after training.

**RESULTS** Children in the task-specific training group had greater odds of goal attainment than those in the parent-led home programme at 1 week after intervention (odds ratio [OR] 10.4, 95% confidence interval [CI] 2.8–38.6), with the evidence for superiority retained at 3 months (OR 4.0, 95% CI 1.3–12.5).

**INTERPRETATION** The task-specific physiotherapist-led training approach was more effective for attaining bicycle-riding goals than a non-specific parent-led home programme in ambulant children with CP.

#### **PUBLICATION DATA**

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#### **ABBREVIATIONS**

GAS	Goal Attainment Scale
ICF	International Classification of Functioning, Disability and Health
SPP-A	Self-Perception Profile for Adolescents
SPP-C	Self-Perception Profile for Children

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Task-Specific Bicycle Training in CP *Rachel A M Toovey et al.*

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**What this paper adds**

- Task-specific physiotherapist-led training programmes are superior to non-specific parent-led programmes for attaining bicycle-riding goals for ambulant children with cerebral palsy.
- This superiority is evident at 1 week after training and is retained at 3 months.
- Low-dose high-density task-specific training programme can lead to attainment of goals including learning to ride a bicycle.
- An evidence-based approach including dosage and task-specific progression now exists for clinicians working with children with cerebral palsy who have bicycle riding goals.

[Main text]

Cerebral palsy (CP) is an umbrella term for a group of disorders of movement, posture, and/or motor function that are permanent but not unchanging and caused by non-progressive disturbances that occurred in the developing fetal or infant brain.<sup>1</sup> It is the most common physical disability of childhood in Australia, with a rate of 1.5 cases per 1000 live births.<sup>1</sup> Effective means of engaging children with CP in physical activities are required to reduce the risk of poor health outcomes in adulthood, including increased risk of chronic disease.<sup>2,3</sup> Training directed towards goals that are meaningful and engaging for children with CP is supported by strong evidence for improved motor activities, function, and self-care.<sup>2</sup> The International Classification of Functioning, Disability and Health (ICF) provides a framework

to consider activity limitations and participation restrictions when setting these goals and to measure the impact of training beyond body structures and function.<sup>4</sup>

Riding a bicycle is a popular activity for Australian children<sup>5</sup> and can be a goal for children with CP.<sup>6</sup> It is a potential means of engaging this population in a physical activity that is functional and can be social.<sup>7</sup> However, we have previously reported that a lower proportion of ambulant children with CP can ride than their typically developing peers during childhood, and those who could ride learnt later.<sup>6</sup> The reasons for this probably go beyond the motor impairments inherent to CP. For example, physiotherapists and occupational therapists are routinely involved in training new motor skills in children with CP;<sup>8</sup> however, a paucity of evidence to guide therapists and families in how to train bicycle skills exists. While a recent systematic review suggests cycling training can improve strength, balance, and gross motor function in this population,<sup>9</sup> all but one<sup>10</sup> of the nine included studies involved stationary cycling and none focused on bicycle-riding goals.

Task-specific training is a rehabilitation approach in which individuals actively practice the goal or task they wish to achieve.<sup>11,12</sup> It is grounded in motor learning and dynamic-systems theory and involves repetitive practice of context-specific tasks.<sup>13,14</sup> The evidence for task-specific training for improved upper limb function in children with CP<sup>15,16</sup> is strong. However, evidence for task-specific training of gross motor skills for improving activity and participation-related outcomes in ambulant children with CP is lacking owing to limitations in study design and underpowered samples.<sup>17</sup> While no uniform approach to training bicycle riding in this population is apparent, task-specific training and using goals to evaluate effectiveness are predominant practices reported by Australian therapists.<sup>18</sup> This clinical uptake of task-specific training is promising; however, so far, no randomized controlled trial has been conducted to determine the effectiveness of this approach.

Thus, the primary research question for this study was the following: is a task-specific physiotherapist-led group training approach (experimental intervention) more effective than a non-specific parent-led individual home programme (comparison intervention) for attaining bicycle-riding goals in ambulant children with CP? For brevity, the experiment intervention will be termed the 'task-specific training programme/group' and the comparison intervention will be termed 'the parent-led home programme/group' throughout this paper. Our hypothesis was that the task-specific training programme would be more effective at 1 week after intervention than the non-specific parent-led home programme. The secondary aims were to explore the effects of the task-specific training programme compared with the parent-led home programme on bicycle skills, participation in bicycle riding, functional skills, physical

activity, self-perception, and health-related quality of life at 1 week and 3 months after training.

## **METHOD**

### **Design**

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This assessor-blinded, parallel-group, 1:1 randomized controlled superiority trial was conducted across two sites of the Victorian Paediatric Rehabilitation Service: the Monash Children's Hospital (Monash) and Royal Children's Hospitals, Melbourne, Australia. The study was prospectively registered with the US National Institutes of Health (NCT03003026) and the protocol has been published.<sup>19</sup> Ethics approval was granted by the Royal Children's Hospital Human Research Ethics Committee.

The randomizations were computer-generated using block randomization with variable block sizes (2, 4, or 6) stratified by site by an independent statistician. Allocation was concealed using sequentially numbered opaque envelopes. Randomization was conducted by a study investigator not involved in any outcome assessment in the week before the training period. Outcome assessors were blind to allocation but blinding participating families or treating clinicians was not possible. Families and clinicians were informed of participant allocation by telephone and/or e-mail.

### **Participants**

Participants were identified and recruited through the Victorian Cerebral Palsy Register and the two sites of the Victorian Paediatric Rehabilitation Service. Invitation to participate was also advertised via the website and e-newsletter of the nationally funded Centre of Research Excellence in Cerebral Palsy. Eligible participants were children with CP aged 6 to 15 years old (inclusive) who were independently ambulant (Gross Motor Function Classification System [GMFCS] levels I or II), had goals related to bicycle riding, could access a bicycle and helmet, and lived in the state of Victoria, Australia. Recruitment materials advertised the study as open to eligible participants who had goals related to riding a bicycle including activity- and participation-related goals. Activity goals could include learning to ride a bicycle for the first time or improving bicycle skills. Medical clearance and a parent or caregiver able to participate were also required, and both the children and parents were required to understand English. Exclusion criteria were a moderate-severe intellectual impairment, dual diagnosis with another developmental disability or condition that may have impacted their ability to participate safely, botulinum neurotoxin A injection(s), or

musculoskeletal (or other major) surgery in the 6 months before randomization. An outcome assessor obtained informed consent from eligible participants at baseline assessment ( $T_0$ ) before collecting participants' characteristics and baseline data (Fig. S1, online supporting information).

## **Interventions**

Both the task-specific and parent-led home training groups involved a 1-week intervention period during school holidays. The training programmes are described in detail in the protocol paper and are summarized below.<sup>19</sup> The task-specific programme was delivered by five physiotherapists and two allied health assistants. In the 3 months before the first intervention period, each clinician undertook a total of 8 hours training for both programmes. Training of clinicians was led by the primary author and included a manual.

### **Task-specific training group**

Children in the task-specific group participated in a bicycle skills training programme conducted for up to 2 hours a day over 3 consecutive days at an outdoor park adjacent to each site. Thirty minutes of daily home practice was prescribed for the 4 remaining days. Each programme was led by a physiotherapist, supported by an allied health assistant and delivered to a group of three to five children. At least one parent or caregiver attended the programme per child. This motor learning-based programme involved task analysis and child-led problem solving to inform modification of the task and environment while progressing through increasingly challenging bicycle skills. Each child's programme was individualized to goals set at baseline. While the focus was on practice of whole skills, adaptive part-practice was used to enable progression. New tasks were scaffolded so participants could achieve at least some skills: for example, by removing pedals, the therapist stabilizing the bicycle, or changing the gradient/surface of the practice environment. As skill competence developed, the task and/or environment continued to be modified so the activity was challenging enough to require new learning towards attainment of bicycle-riding goals. Clinicians were trained to enable repetitive, progressive, and variable practice with the amount and type of feedback guided by the participant. Clinicians coached parents on task-specific and safe practice in home and community environments. A Consensus in Exercise Reporting Template<sup>20</sup> has been completed to describe the programme in greater detail (Table S1, online supporting information).

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### Parent-led home group

Current bicycle skills training practices by therapists in Australia lack uniformity, meaning ‘standard’ or ‘usual’ care is difficult to specify.<sup>18</sup> Before this study it was found that many of the ambulant children with CP in Victoria who had learnt to ride did so in informal settings with their parents.<sup>6</sup> Thus, the comparison group involved a parent-led home programme. Families allocated to this group received written information on bicycle riding including safety considerations, bicycle and helmet fitting, and suggested practice location. Parents were encouraged to work towards their child’s bicycle-riding goals for 30 to 45 minutes each day of the intervention period, but no specific training methods were detailed. They also received a telephone call from a physiotherapist trained in providing general support but not task-specific guidance.

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### Outcome measures

Outcomes were assessed at 1 week ( $T_1$ ) and 3 months ( $T_2$ ) after the intervention period by one of two physiotherapists trained in measurement procedures and blind to group allocation.

### Primary outcome

The primary outcome, goal attainment, was measured using the Goal Attainment Scale (GAS). The GAS is a criterion-referenced tool that is valid and reliable in children with CP.<sup>21</sup> Two or three goals specific to bicycle riding were set in collaboration between the child, family, and assessor at baseline using proposed criteria for appraising GAS in rehabilitation research.<sup>22</sup> Six levels of attainment were determined for each goal (examples in Table 1).<sup>23</sup> The primary outcome was defined as attainment of at least one goal to an expected, or greater than expected, level at  $T_1$ . This binary interpretation is consistent with recommendations for using the GAS in paediatric rehabilitation as it allows appropriate statistical analysis and has been shown to identify clinically meaningful improvements.<sup>23,24</sup> The GAS T score was calculated as a secondary interpretation of goal attainment at both timepoints.<sup>21</sup>

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### Secondary outcomes

Secondary outcomes were goal attainment at  $T_2$ , bicycle skills, participation in bicycle riding, functional skills, physical activity, self-perception, and health-related quality of life. Secondary outcomes were collected at baseline ( $T_0$ ) and measured at  $T_1$  and  $T_2$ , except physical activity, which was assessed at  $T_0$  and  $T_2$  only. Outcome selection was informed by the ICF<sup>4</sup> and the family of participation-related constructs for childhood disability

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framework<sup>25</sup> to generate a holistic picture of the impact of the interventions on bicycle-riding activity competence and participation-related factors. Bicycle skills and functional skills sit within the ‘activity’ domain of the ICF and the ‘activity competence’ construct of the family of participation-related constructs. Participation in bicycle riding and physical activity sit within the ‘participation’ domain and construct of each framework. Self-perception relates to the ‘personal factors’ domain and ‘sense of self’ construct, while it has been proposed that quality of life encompasses all domains of the ICF.<sup>26</sup>

Bicycle skills were assessed using the Cycling Skills Checklist<sup>27</sup> (score out of 100) and two cycling items of the Dutch Pediatric Evaluation of Disability Inventory:<sup>28</sup> whether the child ‘can ride 50m independently but can have help to start’ and/or ‘can ride 100m without help to start’.

Participation in bicycle riding was assessed by parent-recorded time practising (hours per day or per week) and level of involvement (scale 1–5 from minimally involved to very involved) in bicycle riding in home/community settings.

Functional skills were measured using the scaled scores for the four domains of the parent-completed Pediatric Evaluation of Disability Inventory - Computer Adapted Test:<sup>29</sup> daily activities, mobility, social/cognitive, and responsibility.

Physical activity was assessed using the Physical Activity Questionnaire for Children score<sup>30</sup> and active time as measured by an Activ8 triaxial accelerometer (A8005 Professional Activity Monitor, Activ8, Valkenswaard, the Netherlands). Each child and parent completed the Physical Activity Questionnaire for Children together. The Activ8 was fitted to the lateral upper third of the non-affected or preferred thigh using waterproof tape or a leg strap. While the Activ8 is a valid and reliable measurement tool for physical activity in CP, it may not differentiate running from cycling well.<sup>31</sup> Thus, combined active time was utilized and was defined as the average time standing, walking, running, and cycling in hours per day conditional upon at least 15 seconds of included minutes being recorded as active. Participants were asked to wear accelerometers for 7 days and data were included in analyses if at least 3 days involving at least 10 hours’ wear time per day was available, consistent with published literature.<sup>31–33</sup>

Depending on a participant’s age, self-perception was assessed using the Self-Perception Profile for Young Children (SPP-YC),<sup>34</sup> Children (SPP-C),<sup>35</sup> or Adolescents (SPP-A).<sup>36</sup> Related domains from each age-group profile were combined to determine a mean domain score (1 [low competence] to 4 [high competence]) for each group. Combined domains included cognitive (cognitive [SPP-YC] and scholastic [SPP-C/A] competence),

social (peer acceptance [SPP-YC] and social competence [SPP-C/A]), physical (physical [SPP-YC] and athletic competence [SPP-C/A]), while global self-worth domain was only measured in children aged 8 years and over (SPP-C/A). Self-perceived bicycle riding competence was measured using the cycling item of the Pictorial Scale of Movement Skill Competence (score 1 or 2, low competence; 3 or 4, high competence).<sup>37,38</sup>

Health-related quality of life was measured using the Child Health Utility - Nine Domains utility score (0–1).<sup>39</sup> Quality of life and self-perception measures were completed through interview with each child.

### **Adverse events**

Adverse events were defined as any untoward medical occurrence related to the interventions during the training period. Adverse events were collected by trial clinicians via the training log and telephone calls for task-specific programme group and via telephone calls for the parent-led home group.

### **Compliance measures**

Clinicians completed attendance logs for the 3-day programme within the task-specific group and documented adherence to the parent-led home group protocol as reported by parents by telephone. Families in both groups completed diaries documenting time practising bicycle skills in home or community environments, and any other physiotherapy or occupational therapy received, each day during the intervention period and each week during the follow up period.

### **Statistical analysis**

The study was powered to find a between-group difference of 50% (from 25% in the parent-led home programme to 75% in the task-specific training group) in the proportion of children reaching goal attainment. A sample of 60 children (30 in each group) was required to identify a 50% difference in proportions of goal attainment with 80% power (on the basis of a two-sided test with a 5% level of significance), assuming an intraclass correlation of 0.1 between individuals within a task-specific training group,<sup>19</sup> and an average cluster size of 5 across 12 clusters while accounting for 10% loss to follow up.

Stata 14 statistical software (StataCorp LLC, College Station Texas, USA) was used for analysis. The analysis of all outcomes was conducted using an intention-to-treat analysis via mixed effects model. Models included: fixed effects for randomized group (task-specific

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or parent-led) and site (as used in the randomization process), and a random effect to allow for clustering among participants trained at the same time in the task-specific training group. Participants in the parent-led home group were analysed as a single cluster.

For binary outcomes, we report the proportion with each outcome separately in the two treatment groups, with groups compared by odds ratios (OR) estimated using logistic regression and reported with 95% confidence intervals (CI) and *p*-values. For the primary outcome, we conducted a pre-specified subgroup analysis by GMFCS level (I vs II) and sensitivity analyses where we defined the outcome of goal attainment as attaining at least one goal to (1) somewhat more and (2) much more than expected on the GAS.

Continuous outcomes are reported as the mean and standard deviation by group, with group comparisons presented as a mean difference estimated by linear regression reported with 95% CI and *p*-values.

Data summaries suggested that some of the baseline variables were associated with missingness in the primary outcome (i.e. data were missing at random); thus multiple imputation was used to handle missing data in line with the pre-specified statistical analysis plan. Multiple imputation was conducted using chained equations by treatment group.<sup>40</sup> Complete baseline variables that correlated with the primary outcome were used as auxiliary variables with separate imputation models for outcomes expected to be highly correlated (owing to convergence problems when all outcomes were imputed simultaneously). All analyses were repeated using a complete case analysis and for the per-protocol population as outlined in the published protocol.<sup>19</sup> Throughout this manuscript *p*-values are interpreted on a continuous scale representing the strength of evidence against the null hypothesis of no association, with smaller *p*-values representing stronger evidence.

## RESULTS

### Flow of participants through the study

Sixty-two of the 109 children screened for eligibility were randomly assigned to the task-specific group (*n*=31) or the parent-led home group (*n*=31). Figure S1 shows the flow of participants through the study. Recruitment was open from November 2016 to November 2017 and data were collected from December 2016 to April 2018. Demographics and baseline outcomes were similar between the groups except for level of bicycle riding skill (cycling skills score, Dutch Pediatric Evaluation of Disability Inventory cycling items) and self-perceived bicycle riding competency, which were higher in the parent-led home group

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(Table 2). Primary outcome data were obtained from 90% ( $n=56$ ) of participants, and 73% ( $n=45$ ) of participants were included in the 3-month follow-up assessment.

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## Effects of the intervention

### Primary outcome: goal attainment

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There was evidence that participants in the task-specific group had greater odds of goal attainment at 1 week than those in the home programme (OR 10.4, 95% CI 2.8–38.6,  $p=0.001$ ). This finding was consistent for the GMFCS level I and II subgroups and in the sensitivity analysis of the primary outcome (Fig. 1). There was also evidence for superior outcomes in the task-specific programme group for goal attainment at 3 months (OR 4.0, 95% CI 1.3–12.5,  $p=0.02$ ) and for GAS T scores at both time points ( $T_1$  mean difference 13.4, 95% CI 8.5–18.2,  $p<0.001$ ;  $T_2$  mean difference 13.1, 95% CI 5.4–20.7,  $p=0.001$ ). See Table S2 (online supporting information) for results from the complete case and per-protocol analyses for goal attainment outcomes which reflect results of the primary analyses.

### Bicycle-riding-related secondary outcomes

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At baseline, one participant in the task-specific group and eight participants in the parent-led group were able to ride 50m independently (could have help to start). After the intervention, an additional 12 participants in the task-specific group and three participants in the home-based programme were able to achieve this level of bicycle skill. However, little difference in bicycle skills was found between the groups at either time point (Table 3). There was some evidence of greater odds of high self-perceived bicycle-riding competence in the task-specific programme at  $T_1$  but not at  $T_2$  (Table 3). For participation in bicycle riding, there was some evidence for better outcomes in the task-specific group for involvement at  $T_2$ , but not at  $T_1$ , and little evidence for a difference for time practising bicycle riding in home/community settings at either timepoint (Table 3). The results from the secondary analyses for these outcomes are reported in Table S3 (online supporting information) with results reflecting those from the primary analysis.

### Other secondary outcomes

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There was little evidence of a group difference in outcomes related to functional skills, physical activity, and self-perception or quality of life outcomes in the intention-to-treat analysis (Table 4). The results from the complete case and per-protocol analysis for these outcomes are reported in Table S4 (online supporting information). Within these analyses,

effects favoured the parent-led home programme for the daily activities domain of the Pediatric Evaluation of Disability Inventory - Computer Adapted Test at  $T_2$  on both types of secondary analysis. Between-group differences favoured the task-specific programme at both time points for the SPP domain of global self-worth (self-perception) on both types of secondary analysis, and at 3 months on complete-case analysis only for the social/cognitive domain of the Pediatric Evaluation of Disability Inventory - Computer Adapted Test (functional skills) and physical activity when measured by the Physical Activity Questionnaire for Children (Table S4).

#### **Compliance with the interventions and adverse events**

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Eighty-eight per cent ( $n=27$ ) of children in both groups participated in their allocated programme (Fig. S1). Twenty-four participants allocated to the task-specific programme attended for all 6 hours of the centre-based component and completed a median of 19.4 minutes (interquartile range 10.0–46.9) of home practice per day for the remaining 4 days of the intervention period. In the parent-led home group, the median amount of practice per day during the intervention period was 17.1 minutes (interquartile range 11.1–26.8,  $n=25$ ) and clinicians could contact 26 out of 31 families by telephone. Three task-specific group participants and two parent-led home group participants attended other therapy during the intervention period (range 20–120min). This additional therapy did not involve cycling so these participants remained in the per-protocol analyses.

No adverse events were reported in either group. A few anticipated events (e.g. minor fall from bicycle) were reported in the task-specific group, as reported in item 12 of Table S1.

#### **DISCUSSION**

To our knowledge, this is the first randomized controlled trial to focus on training bicycle riding in children with CP. We found that a novel physiotherapist-led task-specific programme was superior compared with a parent-led, non-specific home programme for the attainment of bicycle-riding goals in ambulant children with CP at 1 week, supporting our hypothesis. The evidence for greater odds of goal attainment in the task-specific training group remained at 3 months. The evidence for the positive effects favouring the task-specific programme was consistent across pre-determined subgroup and sensitivity analyses of goal attainment.

Secondary outcome results provided some evidence that the task-specific training programme may benefit children beyond attainment of their bicycle-riding goals; however,

this was largely on secondary analyses only. Interestingly, there was also some evidence of effects favouring the home programme on daily activities, consistent with other studies in a similar population where home programmes have been effective for this outcome.<sup>41,42</sup> However, this was also only on secondary analyses. Given participant goals primarily targeted bicycle skills, we were surprised to find a lack of evidence for between-group differences in bicycle skills after the intervention despite large within-group improvements in the task-specific programme. However, this could be due to the higher level of bicycle skills in the parent-led home training group at baseline. The lack of evidence for a treatment effect in the intention-to-treat analysis for physical activity outcomes was not surprising given the intervention did not target physical activity behaviour.

The strengths of this trial were that it involved an adequate sample, concealed allocation, blinded outcome assessment, and used multiple imputation for missing data. Good participant compliance, successful embedding of the task-specific programme across two sites, and a lack of adverse events provide evidence to support the feasibility and safety of the programme. At up to 8 hours high-density training over a week, the task-specific programme in the current trial was low dose compared with other motor learning-based approaches for children with CP, such as hand–arm bilateral intensive therapy including lower extremity, which involves 90 hours over 10 days.<sup>43</sup> While this latter therapy addresses participant goals across a range of activities, the task-specific programme in the current study focused specifically on bicycle-related goals. The positive effects of the task-specific training programme found in our study suggest that short bursts of high-density training can be effective for children with goals related to specific complex motor skills. This is consistent with evidence from bicycle skills programmes delivered in a week or less in other populations including children with Down syndrome and autism spectrum disorder.<sup>44,45</sup>

This study was not without limitations. Attempts were made to dose-match training time; however, on average, participants in the home programme group did not achieve the recommended practice time of 30 to 45 minutes per day during the intervention period. This raises a question around the extent to which effects were mediated by training dose.<sup>19</sup> However, it may indicate that relatively independent practice of a new and complex skill is challenging for many families, in contrast to the supportive physiotherapy-led task-specific training programme. In any case, this study aimed to address whether the task-specific programme was more effective than a pragmatic comparison—it did not seek to determine which programme components were the active ingredients. Moreover, within this study it was not possible to disentangle the effect of the key components of the intervention (task-specific,

physiotherapist-led, and group-based) or comparison (parent-led, non-specific, home-based, individual) programmes.

The 95% confidence intervals for treatment effect in the subgroup analysis of goal attainment by GMFCS level were very wide and included the no difference result (Fig. 1). This was probably due to the smaller number of participants within each subgroup. However, the results across all goal attainment outcomes (Fig. 1) consistently favoured the task-specific programme. There was also a reasonably large amount of missing data, in particular for the outcomes related to physical activity. Although we used multiple imputation to account for missing data – a well-documented means of improving precision where data are missing – there is mixed evidence whether it is appropriate to use where more than 40% of data are missing such as for the physical-activity-related outcomes in this study.<sup>40</sup> Further, when considering clinical implications of randomized controlled trial findings, care needs to be taken with interpreting mean group differences, especially in heterogeneous populations such as those with CP.<sup>46</sup> A specialized programme may not be necessary for all: some participants achieved their goals at home with their parents. So, while this study demonstrated evidence of superiority of the task-based intervention across the study as a whole, it would be worth exploring the heterogeneity of the effectiveness of this intervention across subgroups in future studies.

This study was limited to 3 months follow-up and to children classified in GMFCS levels I or II. The limitation in insufficient observation timeline may be the reason for no difference between the two groups in some secondary outcomes. Future work should explore longer-term involvement in community cycling and enablers of this. A recently published trial that tested the efficacy of functional electrical stimulation and adapted cycling in children classified in GMFCS levels II to IV helps address the knowledge gap across the spectrum of CP.<sup>47</sup> In the context of the focus on goals in paediatric rehabilitation<sup>48</sup> and the goal-directed disability insurance funding model in Australia,<sup>49</sup> findings have the potential to translate well into clinical practice. To optimize knowledge translation, it will also be important to direct efforts to school and community settings.

In summary, we have shown that a task-specific physiotherapist-led group training programme is superior to a non-specific parent-led home individual programme for attaining bicycle-riding goals in ambulant children with CP in the short term. It may also lead to additional short-term self-perception of bicycle-riding competence and medium-term participation-related benefits. Specific evidence-based guidance is now available to clinicians working with children with CP who have bicycle-riding goals. This is important in the

context of rehabilitation increasingly being directed towards the individual's activity and participation goals. Future work should explore supporting ongoing participation in cycling and identify conditions that support goal attainment so interventions can be targeted to individuals and findings can be translated across settings.

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## SUPPORTING INFORMATION

The following additional material may be found online:

**Table S1:** Consensus on Exercise Reporting Template (CERT).

**Table S2:** Goal attainment outcomes – complete case and per-protocol populations.

**Table S3:** Bike riding related secondary outcomes – complete case and per-protocol populations.

**Table S4:** Other related secondary outcomes – complete case and per-protocol populations.

**Figure S1:** Design and participant flow through the study.

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**Table 1:** Goal Attainment Scale examples

Score	Predicted	Activity-related example	Participation-related
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attainment at $T_1$		example	
-3	Deterioration	Can ride bicycle in straight line on flat grassy surface 50m with assistance at seat and handlebars from two people	Rides a bicycle to school once every 4mo
-2	Much less than expected (equal to start)	Can ride bicycle in straight line on flat grassy surface 50m with assistance at seat and handlebars from one person	Rides a bicycle to school once every 2mo
-1	Less than expected	Can ride bicycle in straight line on flat grassy surface 50m with assistance at seat from one person	Rides a bicycle to school once every month
0	Expected	Can ride bicycle in straight line on flat grassy surface 50m with close supervision	Rides a bicycle to school once every fortnight
+1	More than expected	Can ride bicycle in straight line on flat grassy surface 50m with distant supervision	Rides a bicycle to school once every week
+2	Much more than expected	Can ride bicycle in straight line on flat grassy surface 50m independently	Rides a bicycle to school twice a week

**Table 2:** Characteristics of participants at baseline

	Task-specific programme, $n=31$	Parent-led home programme, $n=31$
Site		
Monash Children's Hospital	18 (58)	19 (61)
The Royal Children's Hospital	13 (42)	12 (39)
Age, mean (SD), y:mo	9:11 (2:8)	9:1 (2:4)
Sex		
Male	16 (52)	17 (55)
GMFCS level		

I	17 (55)	18 (58)
II	14 (45)	13 (42)
MACS level		
I or II	28 (90)	30 (97)
III	3 (10)	1 (3)
Distribution		
Unilateral	16 (52)	15 (48)
Bilateral	15 (48)	16 (52)
Predominant motor type		
Spastic	25 (81)	24 (78)
Dyskinetic	2 (6)	1 (3)
Ataxic	1 (3)	1 (3)
Hypotonic	3 (10)	5 (16)
Mild intellectual impairment (IQ >70)	5 (16)	3 (10)
Low social risk (score 0 or 1)	18 (58)	22 (71)
Previous bicycle-related experience		
Bicycle with training wheels	21 (68)	23 (74)
Balance bicycle	3 (10)	4 (13)
Upright trike	11 (36)	17 (55)
Recumbent trike	4 (13)	0 (0)
Mean time (SD) spent practising bicycle skills in last month, h	0.2 (0.3)	0.3 (0.5)
Family interest in bicycle riding		
Not at all/not really interested	2 (6)	2 (6)
Somewhat interested	9 (29)	6 (19)
Interested/really interested	20 (65)	23 (75)
Parent-rated importance of child attaining bicycle-riding goals		
Not at all/not really important	0 (0)	0 (0)
Somewhat important	2 (6)	2 (6)
Important/really important	29 (94)	29 (94)
Parent self-perceived bicycle-riding competence		
Not at all/not really competent	2 (6)	2 (6)

Somewhat competent	2 (6)	5 (16)
Competent/really competent	27 (88)	24 (78)
Cycling skills checklist score, mean (SD)	38.9 (11.9), <i>n</i> =29	50.0 (23.9)
PEDI-NL cycling items		
Can ride 50m without training wheels, may have help to start	1 (3)	8 (26)
Can ride 100m without training wheels, no help <sup>a</sup>	0 (0)	5 (16)
PEDI-CAT domain scaled score, mean (SD)		
Daily activities	55.8 (3.1)	56.4 (2.85)
Mobility	64.6 (2.6)	64.6 (2.3)
Social/cognitive	67.5 (4.1), <i>n</i> =28	67.5 (3.5)
Responsibility	50.3 (5.6), <i>n</i> =28	49.8 (4.9)
Active <sup>b</sup> time per day, mean (SD), h	3.3 (1.2), <i>n</i> =26	3.7 (1.3), <i>n</i> =24
PAQ-C score, mean (SD)	2.5 (0.7), <i>n</i> =25	2.5 (0.5), <i>n</i> =25
SPP domain score, mean (SD)		
Cognitive/scholastic competence	2.9 (0.8)	2.9 (0.7)
Peer acceptance <sup>c</sup> /social competence	3.0 (0.7)	3.0 (0.7)
Physical <sup>c</sup> /athletic competence	2.6 (0.9)	2.5 (0.8)
Global self-worth, mean (SD) <sup>d</sup>	3.3 (0.5), <i>n</i> =22	3.2 (0.5), <i>n</i> =17
High self-perceived riding competence (score 3–4) on Pictorial Scale of Movement Skill Competence	5 (16)	11 (37), <i>n</i> =30
CHU-9D HRQoL utility score, mean (SD)	0.88 (0.1)	0.92 (0.1)

Data are *n* (%) unless otherwise stated. <sup>a</sup>All had also achieved 'Can ride 50m without training wheels, may have help to start'. <sup>b</sup>Active defined as walking, running, or cycling. <sup>c</sup>For children aged 6 or 7 years. <sup>d</sup>For children aged 8 to 15 years only. SD, standard deviation; GMFCS, Gross Motor Function Classification System; MACS, Manual Ability Classification System; ICF, International Classification of Function, Disability and Health; PEDI-NL, Dutch Pediatric Evaluation of Disability Inventory; PEDI-CAT, Pediatric Evaluation of Disability Inventory – Computer Adaptive Test; PAQ-C, Physical Activity Questionnaire for Children; SPP, Self-Perception Profile; CHU-9D, Child Health Utility - Nine Domains; HRQoL, health-related quality of life.

**Table 3:** Bicycle riding related secondary outcomes: intention-to-treat analysis

Outcome	1wk ( $T_1$ )		3mo ( $T_2$ )	
	Mean difference (95% CI)	$p$	Mean difference (95% CI)	$p$
<b>Participation in bicycle riding</b>				
Average involvement in home practice	0.3 (-0.3 to 1.0)	0.3	0.8 (0.1–1.6)	0.03
Home bicycle skills practice, h <sup>a</sup>	0.1 (-0.1 to 0.4)	0.4	0.1 (-0.1 to 0.3)	0.4
<b>Bicycle skills</b>				
Cycling skills checklist score	5.5 (-2.5 to 13.6)	0.2	8.0 (-1.0 to 16.9)	0.08
	OR (95% CI)	$p$	OR (95% CI)	$p$
<b>PEDI-NL cycling items achieved</b>				
Rides 50m no training wheels, help to start	1.3 (0.4–3.7)	0.7	1.1 (0.4–3.1)	0.9
Rides 100m no training wheels, no help <sup>b</sup>	0.6 (0.2–2.0)	0.4	1.1 (0.4–3.6)	0.8
High self-perceived bicycle competence	4.0 (1.1–15.4)	0.04	2.6 (0.7–9.5)	0.2

<sup>a</sup>Hours per day ( $T_1$ )/per week ( $T_2$ ). <sup>b</sup>All had also achieved riding 50m without training wheels but could have help to start. CI, confidence interval; OR, odds ratio; PEDI-NL, Dutch Pediatric Evaluation Disability Inventory.

**Table 4:** Other secondary outcomes: intention-to-treat analysis

Outcome	1wk ( $T_1$ )		3mo ( $T_2$ )	
	Mean difference (95% CI)	$p$	Mean difference (95% CI)	$p$
<b>Functional skills</b>				
<b>PEDI-CAT scaled score</b>				
Daily activities	-0.7 (-2.7 to 1.2)	0.4	-1.2 (-2.7 to 0.4)	0.1
Mobility	0.6 (-0.4 to 1.7)	0.3	0.3 (-1.2 to 1.8)	0.7
Social/cognitive	0.3 (-1.4 to 2.2)	0.7	0.8 (-1.3 to 2.8)	0.5
Responsibility	-0.8 (-3.5 to 2.0)	0.6	-1.0 (-4.2 to 2.2)	0.5
<b>Physical activity</b>				
Active <sup>a</sup> time per day, h	—	—	-0.3 (-2.0 to 1.5)	0.8
PAQ-C score	—	—	0.3 (-0.3 to 0.9)	0.4
<b>Self-perception</b>				

SPP domain score				
Cognitive <sup>b</sup> /scholastic competence	0.1 (-0.2 to 0.4)	0.6	-0.05 (-0.4 to 0.3)	0.8
Peer acceptance <sup>b</sup> /social competence	0.1 (-0.2 to 0.5)	0.5	0.2 (-0.2 to 0.5)	0.4
Physical <sup>b</sup> /athletic competence	0.06 (-0.4 to 0.5)	0.8	0.2 (-0.3 to 0.6)	0.4
Global self-worth <sup>c</sup>	0.2 (-0.8 to 0.7)	0.9	0.1 (-0.8 to 1.0)	0.8
Health-related quality of life				
CHU-9D utility score	0.02 (0.03-0.05)	0.6	0.01 (-0.05 to 0.06)	0.8

<sup>a</sup>Active defined as walking, running, or cycling. <sup>b</sup>For children aged 6 or 7 years. <sup>c</sup>For children aged 8 to 15 years only. CI, confidence interval; PEDI-CAT, Pediatric Evaluation of Disability Inventory - Computer Adaptive Test; PAQ-C, Physical Activity Questionnaire for Children; SPP, Self-Perception Profile; CHU-9D, Child Health Utility - Nine Domains.

[Figure legend]

**Figure 1:** Forrest plot of goal attainment outcomes as odds ratios. GMFCS, Gross Motor Function Classification System; CI, confidence interval;  $T_1$ , 1 week after training period;  $T_2$ , 3 months after training period.

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