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**Acceptability of a progressive resistance training programme for ambulatory adolescents with spastic cerebral palsy in England: a qualitative study.**

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## **Abstract**

**Purpose:** The aim of this study was to explore the acceptability of a 10-week progressive resistance training programme from the perspective of ambulatory adolescents with CP and physiotherapists.

**Material and Methods:** Semi-structured interviews were conducted with 32 adolescents with spastic CP, aged 10-19 years in Gross Motor Function Classification System (GMFCS) levels I-III, and 13 physiotherapists. Adolescents had completed a 10-week progressive resistance training programme and physiotherapists had delivered the programme. The Framework Method was used to analyse data.

**Results:** The analysis identified four themes. *“It’s do-able”* described the acceptability of the programme structure, including the frequency of sessions and the duration of the programme. *“They were difficult but I did it”* described the acceptability of the exercises. *“It is completely different”*, explored the experience of using equipment to progress the programme and *“I wish I could do it on a permanent basis”* discussed continuing to participate in resistance training.

**Conclusions:** Findings suggest that resistance training is largely acceptable to adolescents and physiotherapists. Acceptability was enhanced by having a weekly supervised session and being able to adapt and progress the exercises to meet the individual’s ability. However, there are challenges to implementing progressive resistance training as part of routine practice.

**Clinical Trial Registration number:** ISRCTN90378161

## **Keywords**

cerebral palsy; resistance training; strength; acceptability; adolescent; qualitative

## **Implications for Rehabilitation**

- Progressive resistance training is largely acceptable to ambulatory adolescents with cerebral palsy and physiotherapists
- Adolescents’ ability to complete the exercises increased their confidence and motivated them to continue with the programme
- Adolescents valued being supervised by a physiotherapist and believed they needed a physiotherapist to progress the exercises and motivate them to perform to their maximum capacity
- Within the National Health Service (NHS), limited time and equipment may prevent implementation of resistance training for adolescents with CP in accordance with guidelines

- A short-term resistance training programme delivered by physiotherapists in the NHS may provide the foundation for continuing participation in resistance training in a community setting

## **Introduction**

Children and adolescents with cerebral palsy (CP) typically experience reduced muscle strength, which may contribute to impaired motor function [1]. Muscle strengthening is one of the most commonly used interventions by physiotherapists to improve or maintain lower limb function among ambulatory adolescents with CP [2]. Despite this, the evidence that exercise programmes improve the muscle strength or function of children and adolescents with CP is weak [3, 4]. Variations in the volume and intensity of training may contribute to variation in the effect of exercise programmes on strength between studies [4].

The National Strength and Conditioning Association (NSCA) identified guidelines for designing resistance training programmes to enhance muscle strength in youth [5]. These guidelines were used to develop exercise prescription guidelines for people with CP because of a lack of evidence regarding appropriate training parameters specifically for people with CP [6]. The NSCA guidelines state that young people should use a load that is sufficiently heavy to prevent them from completing more than 10-15 repetitions of an exercise for one to two sets. The guidelines also recommend short-term resistance training programmes should last 8-20 weeks. A position stand from the American College of Sports Medicine additionally recommends progressively increasing training volume and intensity throughout the programme to improve strength [7]. Many studies that have examined the effect of strength training for children and adolescents with CP have used an intensity and duration that is inadequate to improve muscle strength according to NSCA guidelines [6].

Although physiotherapists often aim to increase muscle strength in adolescents with CP, resistance training may not be successfully implemented or enhance clinical outcomes if it is not acceptable to both adolescents and physiotherapists [8]. Acceptability can be defined as “a multi-faceted construct that reflects the extent to which people delivering or receiving a healthcare intervention consider it to be appropriate, based on anticipated or experiential cognitive and emotional responses to the intervention” [8]. If adolescents do not find resistance training acceptable, they are less likely to adhere to and benefit from a programme. If physiotherapists do not find resistance training acceptable, they may not deliver it as it is intended, which could negatively influence effectiveness. Several constructs

contribute to the acceptability of an intervention, such as the perceived burden of participating in the intervention, the opportunity cost of participating in the intervention, and the participant's confidence that they can perform the behaviour required to participate in the intervention [9].

Two studies have previously explored the benefits of strength training from the perspective of young people with CP, adults with CP and parents [10, 11]. Adults enjoyed participating in strength training and reported experiencing benefits including increased physical activity, muscle strength and social interaction [11]. Some adults experienced negative effects of strength training such as fatigue and discomfort [11]. Young people and parents similarly reported improvements in strength and balance, physical activities, and participation in school, leisure and social activities [10]. Young people and parents also described how personal and environmental factors such as parental assistance, time management and equipment could act as barriers or facilitators to participation in strength training [10]. While these studies provide an essential understanding of the perceived benefits of strength training to people with CP, they did not focus on exploring the acceptability of strength training from the perspective of people with CP and physiotherapists.

This study aimed to explore the acceptability of a 10-week progressive resistance training programme from the perspective of ambulatory adolescents with spastic CP and physiotherapists. The programme was developed in line with NSCA guidelines for youth resistance training [12], with training intensity and volume being progressively increased over the duration of the programme.

## **Methods**

### *Design*

This qualitative descriptive study was embedded in a randomised controlled trial. Qualitative descriptive studies are a useful approach to provide a comprehensive summary of an event in everyday terms, staying closer to the surface of the data than approaches based on specific methodological frameworks [13]. The randomised controlled trial, Strength Training for Adolescents with cerebral palsy (STAR trial), was a multi-centre trial comparing a 10-week progressive resistance training programme of the ankle plantarflexors to usual care [3]. The trial was approved by Brunel University London's College of Health and Life Sciences Research Ethics Committee and the Surrey Borders Research Ethics Committee (ref: 15/LO/0843). Trial registration number was ISRCTN90378161.

### *Participants*

Adolescents with a diagnosis of spastic CP, aged 10-19 years, ability to walk independently with or without a mobility aid (i.e., Gross Motor Function Classification System [GMFCS] levels I-III), and an

ability to activate the ankle plantarflexors, as determined by palpation, were included in the STAR trial. Adolescents who received orthopaedic surgery of the lower limbs in the past 12 months, botulinum toxin type A injections or serial casting in the past 6 months, or who had insufficient cognition to comply with assessment procedures and the training programme, were excluded. Adolescents were recruited to the trial from eight National Health Service (NHS) trusts in England, a special education needs school, a University, a primary care organisation, national organisations for people with disabilities, and by word of mouth. An NHS trust is an organisational unit within the NHS generally serving either a geographical area or a specialised function (e.g., a hospital trust, a mental health trust). Gatekeepers at the recruiting organisations shared information with adolescents who met the eligibility criteria. The research team confirmed eligibility during an initial conversation with each participant and/or parent prior to scheduling the baseline assessment. Sixty-four participants were randomly allocated to the resistance training or usual care control group after baseline assessments.

When invited to participate in the RCT, adolescents and their parent/guardian were provided with an information leaflet that stated they would be asked to take part in an interview upon completion of the programme. Additionally, seventeen physiotherapists and one physiotherapy assistant who delivered the programme were invited to take part in an interview on completion of the programme at their site and provided with an information leaflet. Written informed consent was provided by adolescents aged  $\geq 16$  years and physiotherapists, and by parents/guardians of adolescents  $< 16$  years. Written informed assent was provided by participants under 16 years.

### *Intervention*

A brief description of the progressive resistance training programme is provided here as the programme is described in detail elsewhere [3, 12]. The programme was delivered by one or two physiotherapists to participants in groups of up to three across a variety of settings, i.e., therapy centres, hospitals, a University, and schools. Physiotherapists attended a one-hour training session where they were provided with information about the theoretical underpinning of the programme and were shown how to practically prescribe and progress the exercises. The trial manager attended the first supervised session and additional sessions to provide support if requested by the therapist.

Adolescents completed 10 supervised and 20 home sessions over 10 weeks. The programme was progressed from 4 sets of 12 repetitions at 12 repetition-maximum (RM) to 8 sets of 6 repetitions at 6 RM (Table 1). Participants performed one or more exercises that targeted the ankle plantarflexors to achieve the prescribed number of sets and intensity for a given week. Resistance was added to the exercise using

body weight, free weights on a leg press or hack squat machine, weighted vests, ankle weights or resistance band, depending on the individual's baseline level of strength. During each session, physiotherapists prescribed at least one exercise to complete at home and provided participants with written instructions and photographs outlining the exercise(s) to be performed.

#### *Data collection*

Data were collected through semi-structured interviews. Interviews with adolescents were face-to-face and scheduled to coincide with their attendance at Brunel University London for their 10 week assessment (i.e., immediately post-intervention). However, they were offered the opportunity to take part in the interview at an alternative place of convenience for them if preferred. Interviews with physiotherapists and the physiotherapy assistant were conducted by telephone or face-to-face at a time and place convenient to them. All interviews were conducted by one researcher (GL) who is also a physiotherapist. A topic guide developed from the aims of the study was discussed with the research team, which included an experienced qualitative researcher and expert paediatric physiotherapist and was piloted prior to use. Interview topic guides are included in appendices. Participants were asked to describe their experience of taking part in or delivering the programme. Prompts, when required, included their perceptions of the specific exercises, positive or challenging aspects of the programme, and potential to continue the programme. Interviews were audio-recorded and transcribed verbatim. Participant names were replaced with pseudonyms.

#### *Analysis*

Data were analysed using the Framework Method by two researchers (GL, JR). The two researchers had some prior experience of conducting qualitative research and a professional background in physiotherapy. This paper specifically reports aspects of the participants' experience relating to the acceptability of the programme.

The Framework Method involves seven stages: transcription, familiarisation, coding, developing an analytical framework, applying the framework, charting, and interpretation [14]. Two researchers (GL, JR) familiarised themselves with data by reading the transcripts, before independently completing line-by-line coding on a sample of transcripts. Both a deductive and inductive approach to line-by-line coding was taken. Specific areas relating to acceptability were identified a priori, i.e, the structure of the programme in terms of duration, number and duration of sessions, and acceptability of the exercises. Codes were also generated inductively through a process of "open-coding" [14]. Following this, the researchers and a third experienced qualitative researcher and experienced physiotherapist specialising

in neurorehabilitation (CK) discussed and agreed on a set of codes, and grouped codes into broader, clearly defined, categories to form the analytical framework. One researcher (GL) applied the framework to all transcripts (labelling phase) before charting the data. Finally, the two researchers discussed their interpretation of data with each other and members of the wider research team before developing broader themes (interpretation phase). Processes used throughout the analysis to enhance trustworthiness included the two researchers iteratively engaging with the data, noting and discussing ideas during the analysis, revisiting codes and recoding data, and discussing their interpretation with members of the wider research team [15]. In recognition of the interviewer's involvement in the delivery of the intervention and her professional background as a physiotherapist, GL engaged in reflexive discussions with the CK and JR who also challenged any assumptions and drew out considerations of any negative case analyses.

## **Results**

Of the 33 adolescents who completed the programme, 32 participated in an interview. One adolescent did not return for the 10-week assessment and we were unable to schedule an interview at an alternative time. Twelve physiotherapists and one physiotherapy assistant participated in interviews. Five physiotherapists refused to participate in interviews because they had insufficient time. However, we interviewed at least one therapist from each site at which the intervention was delivered. We will hereafter refer to the physiotherapy assistant and physiotherapists as "therapists". All interviews with adolescents were completed face-to-face. Interviews with therapists were completed either face-to-face (n =11) or by telephone (n = 2). The mean duration of interviews with adolescents was 15 minutes (range 8 minutes to 41 minutes). The mean duration of interviews with therapists was 25 minutes (range 10 minutes to 40 minutes).

Characteristics of adolescents are presented in Table 2. Therapists (all female) were from 6 NHS trusts. Adolescents attended supervised sessions in 8 different locations across England: 5 NHS trust therapy centres/hospitals, a University, and two schools. Supervised sessions were predominantly held after school hours in the evening. Two participants attended supervised sessions during school hours. At some sites, the timing of the supervised session changed weekly based on participants' preference. Among the 32 adolescents, median attendance at supervised sessions was 80% and median percentage of home sessions completed was 77.5% (Table 2).

- Table 2 -

### *Summary of themes*

The analysis identified four themes, which described participants' perceptions of the acceptability of the programme. The first "*It's do-able*" describes the acceptability of the programme structure, including the frequency of sessions and the duration of the programme. "*They were difficult but I did it*" describes the acceptability of the exercises. The third theme, "*It is completely different*", explores the experience of using equipment to progress the programme and the fourth, "*I wish I could do it on a permanent basis*" discusses continuing to participate in resistance training, beyond the trial. We outline each theme below. Additional supporting quotes for each theme are provided in supplemental table.

### **"It's do-able"; acceptability of the programme structure**

Having one supervised session per week was important to both therapists and adolescents. Adolescents valued the experience and knowledge of the physiotherapists and wanted reassurance that they were performing the exercises correctly. They also thought they needed a physiotherapist to continuously progress the exercise for them and to motivate them to perform the exercise to their maximum capacity.

*"...it's just that I think maybe the class... you have someone like watching you and making sure you're doing it right. At home you don't really know if you're doing it right and you could be doing it wrong and then..."; Adam, 15 years, GMFCS level I*

The therapists thought that the supervised session was important for building a relationship with the adolescent, monitoring progress and motivating the adolescent.

*"I think it's nice that they were sort of seeing, seeing us regularly, having contact.....rather than just being sent away with programmes and get on with it..." Paula, therapist*

One supervised session per week was an acceptable frequency, largely because therapists were flexible with the time that the supervised session was held. They also often held after school to increase participation in the programme. Acceptability was also enhanced by the therapists consulting adolescents and parents before choosing the day and time of the session. Adolescents liked the structure of having one supervised session at the same time each week, which helped them to develop a routine.

Although holding the supervised session after school increased participation in the programme, adolescents and therapists thought it was tiring. It was particularly tiring when adolescents were participating in physical education in school or other sports on the same day. Fatigue may have contributed to the variable attendance at the supervised session; only 18% of participants attended all

sessions. Other reasons for non-attendance reported by adolescents and therapists included conflict with other after school activities, family commitments, illness and the distance some adolescents had to travel to the session.

For these reasons, adolescents also did not think it would be possible to attend more than one supervised session per week. When adolescents did not attend the supervised session, therapists tried to advise the parents on how to progress the exercise at home but were not always confident that the programme was being followed correctly without face-to-face supervision.

*“I think it absolutely needed to happen to have that check in once a week; I don’t think you could ask them to manage for any longer than that really.”; Kim, therapist*

The home exercise sessions were on the whole well received, with adolescents appreciating the flexibility of being able to perform the two home sessions at a time that suited them.

*“It was just sort of fitting them in between, at the end of the day or in the morning, or I’d normally do them on days where I’d got nothing on .....you found the days because you had free days anyway, so it was all right to squeeze it in.”; Conor, 18 years, GMFCS level II*

However, there were challenges to completing the exercises at home. Some adolescents struggled to find space to complete the exercises while other household members were there. Others needed support from someone to use the equipment and some lacked motivation.

*“It was good, but it was sort of like I just didn’t want to do it at home. Because I didn’t feel like it at home, I just sort of like wanted to sit down and do nothing to be honest.”; Louis, 10 years GMFCS level I*

Therapists reported that compliance with home exercises was variable, and perceived that compliance depended on either the adolescent’s internal motivation, parents’ engagement with the programme, or both.

Most adolescents reported that 10 weeks was an appropriate duration for the programme. Many said they would like the programme to be longer than 10 weeks. This desire for a longer programme was linked to the improvements they believed they had made over 10 weeks. They also found the programme came to an abrupt end, which they were not prepared for.

*"I personally would have liked more, liked a bit more time to be part of it. Yes. If it was my decision. [I would make it longer] I thought there wasn't really a gradual stop to it, it was all very instantaneous."; Frank, 10 years, GMFCS level I*

In contrast, some adolescents thought that 10 weeks was just right and that the programme would become boring if it was longer.

Therapists' views about the acceptability of a 10-week programme were more mixed than adolescents'. All worked in the NHS where they reported it was unusual to deliver a programme for as long as 10 weeks. They appreciated being able to monitor the adolescents' performance over 10 weeks and build a relationship with the adolescent. They also viewed the continuous contact as important for keeping the adolescent motivated and progressing the exercises appropriately.

*"I think the 10 weeks of consistency is quite rare in clinical practice so that was a real treat. And you would think by the very nature of the fact that they all increased their weights that there was some progression, so that was, yes, nice to be able to do that; felt like a luxury."; Lily, therapist*

Additionally, while many perceived that 10 weeks was a long time at the start of the programme, they commented that it went by very quickly in retrospect. However, some therapists perceived a decline in motivation among adolescents over 10 weeks, with adolescents needing more encouragement to participate in the programme.

In one site, several therapists shared the delivery of the programme because one therapist was not able to commit to delivering the programme in the evening, outside of working hours, for 10 weeks. While this enabled the programme to be delivered, therapists noted some potential negative impacts of changing therapist, such as limiting their ability to build a rapport with the adolescent and potential variations in how the programme was delivered between therapists.

*"I think just making it really clear what you've done over the week and sort of adding a little comment so, if a child is bending their knee then make sure that that's being observed next time because otherwise you do get differences...and stuff. Yeah I think that's the main thing just having that continuity"; Olivia, therapist*

**"They were difficult, but I did it": acceptability of the exercises**

The exercises were largely acceptable to both adolescents and therapists. Adolescents reported the exercises were challenging but possible to complete. The simplicity of the exercises and potential for therapists to adapt them, by changing positions and varying the level of support to each individual's ability, enabled the majority of adolescents to successfully perform them. Therapists' ability to adjust the amount of resistance added to the exercises ensured adolescents were constantly challenged within their capability.

*"I think that on the whole they were at the right balance because of the way you could adjust the weight so you would end up doing what you were capable of doing and not more which was good, which was positive."; Matt, 16 years, GMFCS level I*

*"What was nice with this is actually you have the time and actually if it wasn't working you stopped it you started again, you stopped it you started again. It was very individual and prescriptive which was nice"; Gill, therapist*

Adolescents' ability to complete the exercises, and rise to the challenge, increased their confidence and motivated them to continue with the programme. Repetition of the exercise in the supervised session also gave adolescents the confidence to perform the exercises independently at home.

*"Yes I'm pretty comfortable doing it. The only ones that I got in the home programme were ones that I could already do. That had been checked already that I could do at home."; Maria, 18 years, GMFCS level III*

Although repetitiveness and simplicity had benefits, therapists were concerned that they would become boring.

*"I think their repetition allowed them to build the strength..... So calf raises was quite a nice exercise to give to children to practice by themselves at home. Quite straightforward.....it is quite, I think, easy to do. I'm not sure if the participants liked them, this exercise, perhaps they could comment, "It was boring," but no-one told me that..."; Marian, therapist*

While young people were primarily focused on adding more weight to the exercise, therapists reported a tension between increasing the weight and ensuring that the adolescent performed the exercise with good technique. This was a particular challenge when different therapists delivered the programme because they had different opinions about what constituted adequate technique. Some therapists focused on ensuring technique was excellent before increasing weight, whereas others increased weight even if technique was not perfect.

*'The only thing I'd say is really that understanding of what is a good heel raise, so what level is acceptable. I think I'm quite picky maybe so what some people might say, "Yes that was fine," I might want to go, "No that's not."'; Gill, therapist*

Finally, therapists reported that they were not always able to adequately adapt the exercises to enable adolescents to perform them. In particular, children who had poor selective motor control or very limited range of movement were not able to perform the exercises. Therapists noted it may be particularly challenging to target the ankle plantarflexors in this group because it required a combination of balance, co-ordination and selective motor control.

### **"It is completely different": experience of using equipment**

Adolescents and therapists reported that the use of equipment to increase the intensity of the exercises was novel and it differentiated the programme from previous exercise programmes that they had received or delivered. Importantly, the concept of working at a high intensity and progressively increasing the intensity of the exercises to challenge adolescents was novel.

*"It is completely different...just because we only do a few groups and it was not really with weights. If it is, it's really light ankle weights, like up like 2 kilograms, something like that, and we tend to do various exercises, whereas this was just the one exercise and mainly weights. Yeah, we definitely don't push them to fatigue like it was for this group." Millie, therapist*

The equipment was simply a means of enabling this progression. Adolescents gained a sense of achievement from meeting the challenge. Some young people and therapists contrasted this to the experience of previous physiotherapy interventions, where the young person did not feel challenged.

*"Yeah, this, the home exercise programme and the class, I could feel my calf burning. I could feel it. That's what I liked because I knew it was working. I needed to feel that, I need that when I was younger to motivate me to do something like that because who knows, if I'd had that kind of reaction to my physio, I probably would've carried on doing it and I could be in an even better position than I am now, which is a shame to think because it's not something that's pushed me that would help so many more kids."; Shona, 19 years, GMFCS level II*

The leg press and hack squat machine were particularly useful for adding resistance incrementally because weight could be added using free weights in small values. Adolescents also liked using the machines, more than the weighted vests or ankle weights. However, not all adolescents could use the machines because of their strength or other impairment such as limited range of motion. It was also not

always possible to adjust the machines to the size of adolescents. This was demotivating, particularly when they were in a class with others who could use the machine.

*“I think the machine, we had the leg press....It was a challenge.....Yeah the kids, we didn’t really use it, they’ll be excited to use it and physically not able.”; Paula, therapist*

*“Well we had quite, we had quite some issues with it. Not working and like I’m in the middle between two different sizes, and it wouldn’t go high enough but it wouldn’t go low enough, so I was just struggling with that so I eventually had to go back to weights.”; Alex, 12 years, GMFCS level I*

Although the weighted vest was adaptable, and enabled therapists to increase weight in small increments, there were also difficulties with using it. Primarily, they caused shoulder and back pain or discomfort. Additionally, support was often needed to put it on and take it off, which limited adolescents’ independence in performing exercises. For some participants, it was not possible to add sufficient weight to the vest to reach the required intensity, either because it caused discomfort or the maximum amount of weight possible had been added to the vest.

*“I hit the maximum amount of weights that you could have. I couldn’t put any more on. I think it was because the jacket couldn’t hold it and then I couldn’t fit any other stuff.”; Mark, 12 years, GMFCS level I*

This prevented progression of the home exercises and potentially resulted in a plateau in strength gains. This experience was not unique to adolescents in GMFCS level I or older adolescents.

### ***“I wish I could do it on a permanent basis”*: continuing participation in and delivery of progressive resistance training**

The majority of young people expressed a desire to continue the programme, although there were varying degrees of enthusiasm among participants. The primary motivation to continue came from the perception that the programme was beneficial and the desire to see further improvement. Many adolescents commented that they had improved and that the programme had helped them, but did not expand on exactly what had improved or how it had helped them.

*“Yes, definitely [would continue the programme]. If I noticed improvement this much in ten weeks, what could I do in a year?”; Conor, 18 years, GMFCS level II*

For some young people, the motivation to continue came from the perceived impact of the programme on their sporting performance outside the class. A unique perspective from one of the oldest participants was the motivation to start and continue the programme came from observing a decline in her physical capacity during adolescence, which the programme counteracted.

*“Because I'd been so passive for about a year, year and a half of it, something stupid like that. So it was a really good kind of springboard for me to get back into being active rather than just... Yeah because at the beginning of the uni year, I felt... I didn't feel good in myself. Like I felt like I needed physio and that's not something that I have ever felt”; Shona, 19 years, GMFCS level II*

However, while adolescents expressed a desire to continue the programme, when discussed further, it was clear that the programme was not a priority for many. Some mentioned education was a priority while others would simply prefer to participate in other activities.

*“I think at the moment just because like I've got deadlines and I've got exams and things like that. It's not at the bottom, it's just there are a lot of things, with being a uni student, the assignments and things that I need to get in”; Maria, 18 years, GMFCS level III*

Further, the language used by adolescents suggested that even if motivated to continue, they lacked confidence to perform the programme independently. For many, a barrier to continuing the programme was a lack of understanding about the principles of exercise prescription, including progression, which was important for developing independence in completing the programme.

Therapists also largely believed that ongoing supervision was required. Many thought that specifically close supervision of one or two adolescents at the same time was necessary to ensure the exercises were performed and progressed appropriately.

*“I think they need one to one guidance with the technique by a therapist because even with X who had a really, really good technique if I was distracted because I was thinking oh yes he's doing really well I'll just let his mum do it with him, then he was saying, “I've fatigued I'm not doing anymore...”; Aisling, therapist*

There was debate among therapists about whether a therapist had to supervise the programme or if another person could fulfil this role. Some therapists believed that their expertise was required to appropriately prescribe and progress the exercises. They did not think that parents had the appropriate knowledge to ensure the exercises were performed correctly. This mirrored the opinion of adolescents that they did not trust their parents' knowledge.

*“Well, I think with a one to one there’d probably have to be either another physio or an experienced therapy support worker....I think with parents, they didn’t always quite understand in terms of slow, controlled movement watching the calf, making sure it was going through that full range of movement when they’re actually engaging with the exercises.”; Louise, therapist*

However, even if therapists thought they had a role in ongoing supervision of a programme, they identified several barriers that would prevent them from delivering the programme in the future. The primary barrier was lack of resources, including therapists’ time, equipment and space. Some also questioned the equity of providing a relatively intensive intervention to adolescents with CP and not providing the same level of intervention to others without CP on their caseload.

*“So I suppose just those really boring logistics of fitting it around the timetable and making sure that there’s an equity of service because obviously if you’re doing that sort of thing for one cohort of children.....it’s trying to make sure that the others are getting not the same because that might not be appropriate but a similar level of input.”; Gill, therapist*

Some therapists suggested that a possible solution was supporting adolescents to complete the programme in the community, for example in a local gym, where the appropriate equipment is available. Some also thought that participation in the community may normalise participation in resistance training as opposed to framing it as a therapeutic intervention. In this context, therapists saw their role in educating exercise professionals, as well as parents and young people, to support delivery of the programme.

*“we can go out and speak to the gym person with them if they want us to, yeah, because I think sometimes like you know, gym people will be a bit oh, can you do all this stuff and use the equipment safely?” Ava, therapist*

Education of exercise professionals may address a concern raised by an older participant who, based on her previous experience, thought they lack knowledge about disability and are unable to appropriately adapt exercises for her to perform.

*“...with personal trainers, I have to kind of take my talks with them kind of with a pinch of salt because it’s not something they do all the time, working with a disabled person. So I just kind of... You compromise and it is a lot of stretches or like off equipment work and it’s not necessarily what I want to do”; Shona, 19 years, GMFCS level II*

Further, although adolescents generally agreed that continuing the programme in a gym was appropriate, if adequately supervised, some commented that they were not permitted to access gyms or use certain equipment because of their age.

## **Discussion**

The aim of this study was to explore the acceptability of a 10-week progressive resistance training programme from the perspective of ambulatory adolescents with spastic CP and physiotherapists. The results indicated that the programme was broadly acceptable to adolescents and physiotherapists. Specifically, the majority of adolescents and therapists perceived that the structure of the programme was appropriate and not too burdensome, and that the exercises were possible to complete. A supervised session and appropriate equipment enhanced acceptability. However, challenges to implementing the programme were identified at both a personal and environmental level such as the child's size and degree of physical impairment, lack of suitable equipment, and insufficient staff time. These challenges may in part explain why strength training was not implemented in accordance with resistance training guidelines in several previous studies [4], which in turn may negatively impact effectiveness.

The duration of the programme and the use of equipment to progressively overload the exercises were in line with exercise training principles and guidelines for resistance training [5, 7]. However, both were perceived as novel and were contrasted by adolescents and physiotherapists against previous experience of physiotherapy for young people with CP. Although there is no evidence about what constitutes the typical duration of a physiotherapy programme for adolescents with CP within the NHS, physiotherapists reported that exercise interventions were commonly delivered over 6 weeks. This is similar to the duration used in many studies of exercise for people with CP [4]. Further, although adolescents and physiotherapists were familiar with the exercises, they had not added load to the exercises, suggesting that the exercises were not typically performed at an intensity in line with guidelines for resistance training. This agrees with a survey of current practice among physiotherapists in the UK, which identified that although 74% frequently used strengthening to improve or maintain lower-limb function among ambulatory adolescents with CP, only 18% used muscle strengthening with equipment [2].

Although using equipment was essential for delivering the programme according to guidelines, the equipment was not acceptable or accessible to all adolescents. This potentially resulted in some adolescents performing an exercise at a below-recommended intensity and may have contributed to

lack of effectiveness [3]. In a previous study, children and adolescents with CP reported similar issues with using backpacks to add resistance, such as them being too tight or affecting their balance [10]. It is noteworthy that intensity of the home exercises plateaued for some adolescents because they could not add more weight to the vest, even though the programme was targeting ankle plantarflexors only. The load provided by weighted vests is therefore likely inadequate to progressively overload exercises targeting larger muscle groups such as the quadriceps. This has implications for implementing the programme in the NHS, where access to the gym equipment required to progressively overload exercises is rare.

A further important finding was that the ability to adapt and individualise the type of exercise and challenge presented to the adolescent was central to the acceptability of the programme. It was not possible to sufficiently adapt the exercises for all adolescents however, which potentially contributed to wide variation in strength changes among adolescents with CP [16]. For the majority of adolescents who could complete the exercises, repetition of the same exercise was necessary to monitor and progressively increase intensity. Physiotherapists' concern that repetition would lead to boredom, suggests they may be reluctant to adhere to guidelines for fear that adolescents would disengage with the programme. Similarly, in comparison to physiotherapy assistants, physiotherapists are more likely to spend a larger proportion of treatment time instructing on self-directed exercise, rather than supervising repetitive active movements and functional practice [17]. In contrast, most adolescents were positive about the repetition of exercises because repetition was necessary to progressively add load, which enhanced adolescents' sense of being physically challenged. Overcoming the physical challenge and observing improvement, increased their confidence and motivation to continue the programme, as has previously been reported in relation to strength training [10].

Although the NSCA guidelines indicate 8-20 weeks is sufficient to increase muscle strength, guidelines for people with CP recommend using programmes of at least 12-16 weeks to allow people with CP time to adapt to the exercise [5, 6]. Insufficient duration of the programme may partly explain the lack of effect on muscle strength observed in the trial [3]. However, given the challenges with delivering a 10-week programme noted by physiotherapists, implementing a resistance training programme over ten or more weeks, may require changing the model of how physiotherapy is delivered to adolescents with CP in the NHS. Advocating for this change based on the potential for resistance training to improve function among children and adolescents with CP may be difficult given the evidence for benefits to functional outcomes is weak at present [4].

However, regardless of the effect on function, ongoing participation in resistance training is recommended for all people. The recently published UK physical activity guidelines for disabled children and young people recommend that disabled children and young people participate in manageable strength and balance-focused activities on average three times per week to accrue health benefits [18]. Thus, participation in resistance training as part of everyday life should be a goal for all adolescents with CP. Continuing participation in resistance training, beyond a 10-week physiotherapy-led programme, is essential for maintaining any improvements gained in muscle strength [7]. However, adolescents in this study largely lacked the confidence and skills to continue the programme independently, even if they wanted to. The programme did not include self-management skills such as education or goal-setting to support adolescents to transition from completing a programme under supervision to completing it independently in the community. Inclusion of such elements in the programme may alleviate some concerns raised by adolescents. Even with these skills however, adolescents may not be able to access appropriate facilities or use equipment without support. Adolescents' need for physical assistance to perform strength training has been previously noted [10]. In the absence of physiotherapists to support participation in exercise, family members may provide support [19, 20]. However, therapists and adolescents in this study agreed parents may not be able to appropriately supervise a resistance training programme. While participating in resistance training in a local gym under the supervision of an exercise professional is proposed as an alternative way to support ongoing participation, the findings of this study and others indicate it might not be acceptable to adolescents [19]. Although there are a growing number of exercise professionals with expertise in supporting people with disability, many exercise professionals may lack disability knowledge and have low expectations of adolescents with CP, which prevents them from providing an appropriate programme [19]. Further, equipment in gyms may not be easily adaptable to adolescents with CP and facilities may be inaccessible to people using a mobility aid or wheelchair [19]. Ongoing participation in resistance training is unlikely to be realised for many adolescents with CP if the environmental barriers to participating in physical activity are not addressed.

This study has a number of strengths and weaknesses to consider. Data collection and analysis was conducted by two researchers with a professional background in physiotherapy, and thus concerns about preconceptions may be relevant. However, debriefing and challenging theme development aimed to provide transparency and rigour to the process. Although we attempted to conduct all interviews face-to-face, two interviews with therapists were conducted by telephone in order to facilitate their participation. While telephone interviews may allow participants to feel more relaxed and disclose sensitive information, they may also compromise the researcher's ability to probe participants and

interpret responses [21]. All adolescents and physiotherapists who participated in or delivered the programme during the trial were invited to participate in interviews. All but one adolescent who participated in the programme were interviewed. Thus, the findings of this study are likely not limited to adolescents who solely had a positive experience and includes those who had relatively poor attendance at the supervised session. The multi-centre design ensures the results reflect the experiences of adolescents and physiotherapists from a range of geographical locations across England. Adolescents were also diverse in terms of age, GMFCS level and ethnicity. However, by selecting to participate in the trial, adolescents were likely highly motivated to participate or were well supported and encouraged by their parents or guardians. Similarly, as physiotherapists chose to deliver the programme as part of research study they are likely a unique group in terms of openness to try new approaches and possess altruistic tendencies [22].

In conclusion, this study found that resistance training is largely acceptable to adolescents and physiotherapists. However, the exercises were not acceptable to all adolescents and it was not always possible to adequately adapt the exercise to enable participation. The interviews also identified challenges with implementing progressive resistance training as part of routine practice in the NHS, which include limited time and equipment to support implementation according to resistance training guidelines. The majority of adolescents expressed a desire to continue the programme because they observed benefits in a relatively short period of time and valued the expertise provided by physiotherapists delivering the programme. Future work should explore how to bridge the gap between a short-term physiotherapy-led resistance training programme and long-term participation in resistance training in the community.

**Ethical Approval:** The trial was approved by Brunel University London's College of Health and Life Sciences Research Ethics Committee and the Surrey Borders Research Ethics Committee (ref: 15/LO/0843).

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**Data availability statement:** Data are not available.

**Table 1. Periodized progressive resistance training programme**

Weeks	Sets	Resistance	Muscle action
1 and 2	4	12 RM	ECC and CON
3 and 4	6	12 RM	ECC and CON
5 and 6	6	8 RM	ECC and CON
7 and 8	8	8 RM	ECC and CON
9 and 10	8	6 RM	ECC and CON

RM, repetition maximum; ECC, eccentric; CON, concentric.

**Table 2. Characteristics of adolescents**

	n (%)	Mean (SD)	Median (range)
Age, yr	32	13.5 (2.6)	13 (10-19)
Female			
<b>GMFCS level</b>			
I	15 (46.9)		
II	12 (37.5)		
III	5 (15.6)		
<b>Location of supervised session</b>			
University <sup>a</sup>	14 (43.8)		
NHS Trust	13 (40.6)		
School	5 (15.6)		
Attendance at supervised sessions, % <sup>b</sup>	32	-	80 (40-100)
Completion of home sessions, % <sup>c</sup>	32	-	77.5 (10-115)

<sup>a</sup>7 participants were recruited from an NHS trust but attended a University for the supervised session

<sup>b</sup>out of possible 10 supervised sessions

<sup>c</sup>out of possible 20 home sessions

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**Supplemental table. Additional supporting quotes for each theme**

Theme	Quote
<p><b>“It’s doable”; acceptability of the programme structure</b></p>	<p>“Yeah, well it fitted in quite easily to school. Some clubs like sports clubs takes a bit of getting used to. But yeah, all, in general quite good.” Andrea, 12 years, GMFCS level I</p>
	<p>“I think one time the group clashed with some of their other exercise commitments so they were too tired, they felt, to do the two on the same day.” Sandra, physiotherapist</p>
	<p>“...there were family commitments obviously and illness that interfered with ten consecutive sessions.”; Aisling, therapist</p>
	<p>“The only problem was when... Because I did it during the exams, some of the days I was absolutely knackered and then had to like come to a class or do the exercises.” Adam, 15 years, GMFCS level I</p>
	<p>“Probably at times the traffic was against us.” Matt, 16 years, GMFCS level I</p>
	<p>“So it’s two times a week. So, for some children, it was challenging to do twice a week but for some children, it was okay because they’re quite committed to the exercises”; Marian, therapist</p>
	<p>“Yeah, I found it quite good. It wasn’t too short, it wasn’t too long either. I think ten weeks was good. Because too short wouldn’t give you any proper results, and too long would just get really boring.” Andrea, 12 years, GMFCS level I</p>
	<p>“The length is quite good but I feel like it could go, like it’s long enough but also I think it could go, I could go longer. I think I’d probably do it at home and stuff.” Maria, 18 years, GMFCS level III</p>
	<p>“Maybe a bit longer because like ten weeks it seems long but it didn’t feel long, so maybe a bit longer. Change it to about 14 weeks.” Louis, 10 years, GMFCS level I</p>
	<p>“I’d do it for longer, just because if I’ve done that much in ten weeks it can move on more. I think if I carried on it would get better sort of thing.. I don’t know, not like ridiculously long, but I don’t know, but, like, how long was it, ten weeks? Probably 20 weeks or something to see that extra bit...” Conor, 18 years, GMFCS level II</p>
<p>“I like having the intensive ten weeks with someone, I think because you can see progress and you can kind of reinforce stuff, and you can also talk through other bits and pieces like</p>	

	splints, like shoes, like other things that are bothering them, because you spend the time with them....” Pia, physiotherapist
	So I do think ten weeks is a good amount of time and obviously with the research and stuff you need that amount to actually really see the development of the muscles, don’t you” Gill, physiotherapist
	“if you're doing 10 or doing 8, it still means that they get like a big chunk of them instead of just four or something, that’s not really going to do much” Ava, physiotherapist
	“I think it was good for us because it wasn’t every week, and it was good for her because she wasn’t having the same person like, but maybe you would have built up more of a rapport if it was the same, and I don’t know; you could have probably argued it both ways, but it was easy enough for us to be sure that we were being consistent with the paperwork and between us, so that worked fine.” Kim, physiotherapist
	“I think it’s really hard at about the six week time because they get a bit tired. However, once you get through the six week time I think ten weeks is a good amount of time, because you’ve had the time for them to understand how to do it and then they’re in to it. But I think possibly that six weeks’ time is where you need a bit more nurturing. “Pia, physiotherapist
<p><b>“They were difficult, but I did it”: acceptability of the exercises</b></p>	<p>“They [exercises] are set up to what you can do, so certain things that I just couldn’t do we would just change it.” Maria, 18 years, GMFCS level III</p>
	<p>Sometimes they got a bit repetitive but it was also good to see how I was improving with different weights and stuff.” Marisha, 13 years, GMFCS level III</p>
	<p>“So then when we had our first bit and realised that [it was heel raises] I was like oh actually that makes a lot more sense, god it’s going to be boring, but that makes a lot more sense and it’s a lot more focused which I think is what is needed, isn’t it, really.....I think because it was so focused and you could almost justify the time in focusing on that exercise and if they found it challenging you were able to focus in and properly rein it back and work out exactly where they were for that exercise” Gill, physiotherapist</p>
	<p>“I mean, at the end of the day they had to do a heel raise and I think you did it in the most... You know, a heel raise is a heel raise, you can’t jazz it up very much, can you, but I think it’s just a bit dull, isn’t it?” Lily, physiotherapist</p>
	<p>“It was dependent child to child so it depended on the individual; able children, it was fine, less able children, it was more challenging.”; Lily, therapist</p>

	<p>“Yes. And the tricky bits were that when it comes to plantarflexor it’s tricky to train them, because it’s a combination of balance and co-ordination and selective control as well as strength. So that is kind of hard for them and so I wonder how much of it is learning initially which it is anyway with strengthening. But it seemed that was quite hard to get right I think, much more than for able bodied people for the training. But that’s just the nature of that particular strengthening isn’t it?” Pia, physiotherapist</p>
<p><b>“It is completely different”: experience of using equipment</b></p>	<p>“Well yes I suppose the main difference was that I was using sort of equipment rather than just doing them without anything, just stretching.... whereas obviously now with these yes it’s on the stairs but using perhaps obviously the ankle weights, the weighted vest as well, so that was the difference.” Matt, 16 years, GMFCS level I</p> <p>“...but they didn't do it [previous physiotherapy exercises] with a weight or anything so you just kind of like plod, plod and you don’t really feel it.” Maria, 18 years, GMFCS level III</p> <p>“The ones [exercises] I did here, I've done a similar thing before, I think just not with as much weight.” Geoffrey, 15 years, GMFCS level II</p> <p>“It was quite different. All the weights. I just had to lift a lot of weights on my calf. I don’t usually lift weights.” Mark, 12 years, GMFCS level I</p> <p>“I think, because we do a strengthen and fitness group for our teenagers, but we do not use the weights. We do use the gym equipment, but there is no extra resistance in it.” Marian, physiotherapist</p> <p>“I don’t think we tend to use resistance that much. We might have probably given heel raiser before but not with ankle weights or jackets.” Olivia, physiotherapist</p> <p>“I think they [parents] could see that he was having physio as well but again wasn’t being pushed to that extent and then I think they could again see the improvement that it was having from doing the sessions.” Kate, physiotherapist</p> <p>“I liked using the machine, it was pretty cool to use the machine.” Lucy, 15 years, GMFCS level I</p> <p>“I didn’t really like our home exercises that we had to do because we had this massive weighted jacket and it got heavier every week.” Joanna, 10 years, GMFCS level II</p> <p>“I think the more that you progress especially with the jackets on the children was starting to find that it was really heavy and they were complaining that their backs were hurting.” Olivia, physiotherapist</p>

	<p>“Okay, so how many weeks did it take me to get to 20KG? I don’t know, maybe five I think, maybe. So after that point, where there wasn’t any more weight that I could add to the vest to develop the kind of strength at home, it was more about maintaining the muscle that I gained during the session during the week when I’d come in and use the machines. And obviously because there is no more weight that can be added, the exercise got easier because I was more used to the weight and I was used to lifting heavier weights.” Shona, 19 years, GMFCS level II</p>
<p><b>“I wish I could do it on a permanent basis”: continuing participation in and delivery of progressive resistance training</b></p>	<p>“I will probably continue with doing the trial because it’s actually done something and changed.” Maria, 18 years, GMFCS level III</p>
	<p>“I definitely would [continue] because it helped me a lot I think.” Marisha, 13 years, GMFCS level III</p>
	<p>“Yes, yes I would [use leg press on your own], because I know how to use it now. Knowing how to put everything on properly, and then knowing how much I should be doing instead of just doing loads and not doing it right.” Lucy, 15 years, GMFCS level I</p>
	<p>“Yes, I’d be more than happy [to continue the exercises on my own] because it’s quite simple - once you’ve grasped the ...Knowing how to do them yourself so that helps - and, yes, improvement yes.” Priya, 15 years, GMFCS level I</p>
	<p>“I would rather spend my time playing chess or reading” Antoni, 15 years, GMFCS level I</p>
	<p>Just like getting myself to do it, like I need motivation to do it...it was just because I want...I usually want to do more things than just doing those exercises” Jasvinder, 12 years, GMFCS level II</p>
	<p>“I think we were quite lucky there. Most of the ones that we have are quite motivated, and they were doing everything, because they were doing external exercise obviously from the first group we had, because we had the boy that was doing swimming, I think that complemented his training he was doing. So I think if they focus on the benefit from it, they’re quite happy to keep going with it.” Kate, physiotherapist</p>
	<p>”When we were doing it, it was much better at the clinic than it was at home. At home it’d be like, ahh, you know you get all the moans and everything, but obviously where you’ve got professionals doing it...I trust you, I don’t trust my parents.”; Louis, 10 years, GMFCS level I</p>

	So I think that you have to have this one-to-one actually” Marian, physiotherapist
	“I don’t know that you could do it more than two or three...because you’ve got to be able to keep a really close eye on signs of fatigue or anything haven’t you?” Sandra, physiotherapist
	“But I think that’s the tricky thing, it’s the progression. The physio has really got to do that progression or if there’s a way that they don’t have to but I can’t imagine a teaching assistant or I don’t know whether a physio assistant could do it, maybe they could if they’re doing it day in and day out and they’re learning how to look for fatigue and how to adapt.” Sandra, physiotherapist
	“I think it would easily work, as I say I think you just need to have the resources to do it” Kim, physiotherapist
	“Time, I guess it’s quite a lot of a therapist’s time especially if we’re saying that one to one is better because if it’s going to take an hour and a half and occasionally two hours if things aren’t going as smoothly as you can, so it’s that time and it’s having that flexibility of your caseload I guess to do it and fitting together those children because most of those children are at school so either them coming out of school for ten weeks or therapists working fairly late into the day but then you get the problem that the kids are tired.” Gill, physiotherapist
	“think the children get a lot more out of it when it’s out in the community. Because it’s in a normal environment, as opposed to coming here in the hospital, and there’s more equipment there, so there is the opportunity to be more progressive in those environment” Kim, physiotherapist
	“In my team, the paediatric team, we do not have this equipment so it means that we will have to ask our bosses to buy it. However, sometimes we use the gym but, as well, we use it more for cardiovascular fitness, for speed. It’s not for the strengthening” Marian, physiotherapist
	“we could apply the principles and advise their gym instructors at their local gym” Aisling, physiotherapist
	“we can go out and speak to the gym person with them if they want us to, yeah, because I think sometimes like you know, gym people will be a bit oh, can you do all this stuff and use the equipment safely?” Ava, physiotherapist

Appendix 1. Adolescent interview topic guide

Question	Prompts
<p>In your own words what was it like being part of the STAR trial?</p>	<p>Can you tell me what you liked and disliked?            What was easy or challenging?            How did you find the length of the programme?            Anything you would change?            How easy/difficult was it to fit into your normal routine?</p>
<p>In your own words can you tell me about your experience of taking part in the class?</p>	<p>Was there anything in particular you liked/disliked about the class?            - Anything you would change?            - Did you have any problems while training in the class?            How did you find completing the class on one day a week?            - Would you have liked to exercise for longer/shorter?            How did you find the exercises?            - Were they too easy or too difficult for you?            How did the class compare to anything you've done before?            - Before taking part in the STAR trial what sort of exercises did you do?            - How often would you do them?</p>
<p>In your own words can you tell me about your experience of taking part in the home sessions?</p>	<p>Was there anything in particular you liked/disliked about doing the exercises at home?            - Anything you would change?            - Did you have any problems while training at home?            How did you find completing the exercises on two days a week?            - what time of day were you most likely to do the exercises at home?            How did you find the specific exercises?            - Were they too easy or too difficult for you?            Before taking part in the STAR trial, did you have a home exercise programme?            - How did the home programme compare to anything you've done before?</p>

<p>If this programme was available in an outpatient or community setting in the future, do you think you would take part?</p>	<p>Can you tell me why?</p>
<p>Do you have any other comments about any aspect of the study?</p>	

Appendix 2. Therapist interview topic guide

Question	Prompts
<p>In your own words what was it like being part of the STAR trial?</p>	<p>Has there been anything you have especially enjoyed or found more challenging?            How did the programme compare to any physiotherapy care/intervention you have provided before?            Thinking of your previous experience, is there anything you would like to change, include or exclude and why?            How did the programme compare to anything you've prescribed before?</p>
<p>In your own words can you tell me about your experience of delivering the exercise class as part of this study?</p>	<p>Anything you particularly enjoyed or disliked or could it be improved?            How did you find the length of the programme?            - How was the time commitment? (Too long/short, class too frequent or not)            How did you find the sessions?            - Length, content?            How did you find the specific exercises?            - Were the exercises too easy/too challenging?            - How did you find progressing the exercises for the participants?            - What factors influenced progression or not?            Did you experience any problems/adverse effects when delivering the class?</p>
<p>In your own words can you tell me about your experience of the home exercise programme?</p>	<p>Is there anything you would change?            Was there anything in particular you may have liked or disliked about the HEP and why?            Were the exercises too easy or too difficult to deliver?            Could you tell if participants were doing the exercises or not?            - What were the facilitators or barriers to engagement with the home programme?            How did the home programme compare to what you would normally give as exercises?</p>
<p>If the results show this programme has been successful, do you have any thoughts about</p>	<p>What factors may help or hinder this process?</p>

how we can take the findings forward and implement this into clinical practice?	
Is there anything else you would like to say that you haven't had the opportunity to mention?	