Developing a protocol for an online exercise program for Cerebral Palsy clients using 'Physitrack'.

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A thesis submitted in partial fulfilment for the degree of Master of Applied Science

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August 2021
Declaration concerning Thesis presented for the degree of Master of Applied Science

I, Lauren Jayne Kelly
(Full Name)

Of
(Address)

Solemnly and sincerely declare, in relation to the thesis entitled:

**Development a protocol for an online exercise program for Cerebral Palsy clients using 'Physitrack'.**

a. that the work was done by me personally

and

b. that the material has not previously been accepted in whole, or in part, for any other degree or diploma

Signature: 

Date: 20/08/2021
Abstract

Background:

Children and adolescents with Cerebral Palsy (CP) often receive exercise programs to assist in therapy, habitual exercise, exercise motivation and rehabilitation. Adherence and motivation to exercise programs are two necessary components to achieve exercise goals but can be challenging to accomplish due to difficulties in acquiring novel motor skills, leading to poor performance in daily living activities and restricted participation. The advancement and accessibility of technology show successful integrations in other special populations of games and applications (apps) (i.e., Virtual reality (VR)). However, the use of task-specific online exercise programs/apps within the CP population is unknown.

Methods:

The literature review (Chapter 2) systematically searched and reviewed three main areas critical to this thesis: 1) exercises for CP clients, 2) uses of online apps/technology, and 3) reviewed relevant outcome measures. Data from the literature review was used to develop a protocol for a Randomised Control Trial (RCT) (Chapter 3).

Results:

Eleven studies were identified, and data was extracted regarding technology used, the frequency, intensity, time, and type (FITT) principle and associated outcome measures. This information was then used to develop an evidence-based training protocol using the Physitrack app that will serve as the basis of a future RCT. The protocol developed in Chapter 3 was submitted to the Journal of Strength and Conditioning Research for further research into technology-specific interventions for CP exercise programs.

Conclusion:
An 8-week individualised training program delivered using the Physitrack app, which evaluates clinical and non-clinical outcome measures would provide a robust and easy-to-follow program to reduce burnout/frustration/drop out of caregivers and CP clients. The impact of COVID-19 lockdown resulted in the main study RCT being a protocol as participants for the study were unable to be recruited. A future direction for this thesis would be to complete the RCT protocol in Chapter 3.
Preface

I, Lauren Kelly, completed the present Master of Applied Science (MAppSci) This thesis's research project originally stemmed from my interest in the Cerebral Palsy population and exercise/physical activity. My interest turned into finding how those diagnosed with Cerebral Palsy can have a cost-effective and motivating way to exercise for habitual health. I recognized that caregivers also had to adhere to exercises, so I researched how I could integrate this into a research project. My secondary supervisor, Richard Humphrey, assisted with the idea of using technology-based exercise programming.

This thesis involved a systematic review of the literature, followed by a Randomised Controlled Trial protocol for the main study.
Acknowledgments

I want to acknowledge the people that have assisted me throughout this thesis process.

To Dr Codi Ramsey, your enthusiasm, knowledge, and consistent support made all of this possible. Thank you for being the most supportive supervisor I could have asked for.

To my fellow Master students and staff members that were involved in the Master program. For being a strong support network and always offering brilliant advice through stressful times.

My family, partner, and friends had provided me with unwavering support throughout this process and my own time to exercise to clear the head when I needed a refresher.
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List of Abbreviations

%: Percent

ACC: Accident Compensation Corporation

ANZCTR: Australian and New Zealand Clinical Trials Registry

APP/S: Application/s

AVAS: Absolute Visual Pain Analogue Scale

CARDIO: Cardiovascular

CH: Chapter

CI: Confidence Interval

CONSORT: Consolidated Standards of Reporting Trials

CP: Cerebral Palsy

DHB: District Health Board

FITT: Frequency, Intensity, Time, Type

GMFCS: Gross Motor Function Classification System

GMFM: Gross Motor Function Measure

HIFCT: High Intensity Functional Circuit Training

KG: Kilograms

MA2: Melbourne Assessment 2

MACS: Manual Ability Classification System

MAL: Motor Activity Log

M/MIN: Meters per Minute

MM: Millimetres

MM/S: Millimetres per Second

MSC: Musculoskeletal
NZ: New Zealand

PMAL: Paediatric Motor Activity Log

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis

PSI: Pounds per Square Inch

RCT: Randomised Controlled Trial

S: Seconds

STEPS/MIN: Steps per Minute

TENS: Transcutaneous Electrical Nerve Stimulation

VAS: Visual Analogue Scale

VR: Virtual Reality

WMFT: Wolf Motor Function Test

WOTA2: Water Orientation Test Alyn 2
Chapter 1: Introduction

Chapter overview

This chapter presents an introduction to the thesis topic and research questions. This chapter describes the population of interest, the aims for this thesis and the layout of the following chapters.

What is Cerebral Palsy?

Cerebral Palsy (CP) is a life-long physical disability that refers to a group of neurological and physical disorders, which affect an individual’s movement and posture (1). CP appears early in life, usually in infancy or early childhood, is non-progressive (2) and depends on the occurrence of embryonic development or disruption to the brain's normal development process (3). In New Zealand (NZ), CP occurs at a rate of one child born with CP every three days, making it the most common physical disability in children (over 10,000 people living with CP in NZ) (1).

CP is often accompanied by secondary health problems (4). Undergoing treatments for these secondary health problems decrease the individual's quality of life and physical health (4). A wide range of health problems arise as a result of CP, such as cardiovascular disease, osteoporosis, obesity, type 2 diabetes, and depression (4). It is essential to introduce and maintain habitual exercise programs for CP clients to improve quality of life, bone strength, and muscle density (4). Additionally, physical activity is a critical factor in decreasing the risk of secondary health problems. (4).

The standardised system of Gross Motor Function Classification System (GMFCS) (Figure 1) has been recognised as a valid and reliable way to classify the degree of the CP individual's impairment, increasing in severity from one to five (5).
GMFCS level us a useful tool used by many researchers to access CP apparent motor function.

*Figure 1: Gross motor function classification system (GMFCS) adapted from (Daher et al., 2016)*

Another standardised system that is used with CP clients is the Manual Ability Classification System (MACS). MACS focuses on using the client's hands (Figure 2) and is useful for assessing handling ability levels (6). Physical therapy, habitual exercise, and rehabilitation are essential aspects of promoting positive performance for CP clients (7). The problem that arises with achieving a physically active lifestyle for CP clients is funding within the healthcare system (8). High- and low-income countries have the same barrier with the cost of rehabilitation for people with disabilities (8). Often unemployed receive lower incomes, those with disabilities struggle to make rehabilitation affordable, even with government support (8).
The role of caregivers

An essential role in the CP client's daily life is their caregivers. These may be their parents, teachers, support workers, or healthcare/exercise professionals. Caregivers assist with daily living tasks and may need to help their CP clients with physical activity depending on their CP's severity. While the focus is always on the CP clients; sometimes, the caregivers forget about their own health. Adherence to the CP clients exercise programs from the caregivers is a necessary, desirable, and essential behaviour (9); higher rates of family satisfaction, compliance, and therapeutic outcomes arise when there is a more family-centred focus to rehabilitation programs (10).

Adherence to the CP clients exercise program is crucial, caregivers are estimated to have a lower than 50% adherence rate (9). Basaran et al. estimated that caregivers' low adherence rates were more significant than their study results (11). One of the limitations of adherence in caregivers is the relationship between adherence and stress (11). Being a caregiver requires meeting the role; this can cause psychological distress (11). Burnout of caregivers usually comes from a failure to cope with stress; this can be
from a lack of motivation, tiredness, and disappointment (11). Adherence is lower in caregivers that do not accept the physical limitations of their CP clients (11). These caregivers may find it challenging to assist CP patients if they do not believe the client is capable of performing an exercise and may give up on them before starting (11). Exercise improvements in a CP client may decrease as they age due to the natural course of CP; therefore the reality of the circumstances can increase burnout of caregivers (11). Basaran et al. found that almost two-thirds of the caregivers within their study suffered from mild to severe depression and anxiety (11). This may hinder the amount of effort a caregiver puts into assisting the CP client with their exercise program (11). The caregiver’s role in physical activity is to assist the CP client in performing an exercise program that has been provided by a clinical exercise physiologist. This means that CP patients define the role of the caregiver to be assisting the CP patient with performing the exercises with the correct techniques.

Motivators and barriers for caregivers

With increased stress and emotional demands elevating psychiatric symptoms for caregivers (11), there needs to be a solution to help the caregivers decrease exhaustion and burnout. Caregivers may have increased stress because they are less knowledgeable in physical activity and exercise; it is essential that healthcare professionals support them through education and exercise programs for their CP clients to prevent frustration and stress (11). It may be advisable that professional therapists take the time to make sure caregivers are equipped with the necessary skills to perform exercises with their CP clients (9).

Caregiver adherence is improved when the therapists use the CP client as a model to demonstrate the usefulness of exercises and improved caregiver knowledge and abilities by information provided from the therapist (9). Higher functional
limitations in the CP client enhance caregiver adherence to physical activity (9,11).

Caregivers adherence increases when they identify the task as purposeful for their CP clients and observe the CP client having fun and enjoying physical activity (12), although caregivers usually choose the most straightforward exercises to perform due to low adherence rates (9). Satisfaction and self-efficacy are relevant to overall adherence from caregivers (9), this may be satisfied with therapists or with home exercise programs. (9). An example given by Lillo-Navarro et al. was the satisfaction of flexibility exercises; they can be considered as a complicated and painful activity which can result in lower adherence from caregivers (9). Caregivers show low adherence to exercises requiring a higher level of manual skills and only perform the whole home exercise program if it easily fits into the daily family functioning (9).

**Using an online exercise program**

Home-based exercise programs and caregivers' participation play a vital role in rehabilitating people with disabilities (11). Groff, Lawrence & Grivna report having trouble completing their intervention in its entirety due to the caregiver who had worked with the CP client for many years, resigning (13), this highlighted the critical role of caregivers. Programs that require caregiver assistance have been shown to enhance the CP client's improvement in rehabilitation goals and motor function (11). This clarifies the reason for educating caregivers and assessing their adherence (11). Caregivers are cost-effective for the rehabilitation process as they can exercise the CP client from home without needing a personal trainer who are more expensive to employ than a caregiver. Low adherence to the exercise programs can affect the treatment process; this is why caregiver adherence is so essential (11).

Home-based exercise programs offer an environment that the caregiver and CP client are familiar with; this can make the environment non-stressful and conducive to a
holistic rehabilitation model (10). Being in the home environment provides opportunities for repeated practice for new tasks within a familiar environment (10); the only issue is caregivers, and CP clients have added pressure of adhering to this style of exercise program (12). These children require more care, resulting in physical and mental stress for caregivers, especially with those who need specialised and long-term care that can carry on throughout their lives (14). Baloyi et al. found that most caregivers do not get social or emotional support from family or friends with their CP clients (14). This lack of support can be understood through society's view of a child born with a disability being negative (in some countries more than others), which has added challenges for parents and caregivers (14). Anxiety is quickly developed by parents when their child is diagnosed with a disability (14); it is only natural to protect their child from negative experiences (15). Stress comes with caring for a disabled client, as well as parental disbelief, guilt, rejection, shame, denial, and helplessness (14).

In New Zealand, Accident Compensation Corporation (ACC) may decline funding for rehabilitation to people born with a disability (16). Conductive Education is a program that provides rehabilitation for people that have been declined from ACC funding (16). Conductive Education delivers a system of training for people with motor disorders aiming to increase independence from artificial aids (16). This creates a barrier for those with disabilities who require the assistance of Conductive Education as funding is not available (16).

Online exercise apps are cost-effective and can improve poor exercise techniques (7) which may provide a solution to current barriers presented to people with CP and their caregivers. The use of online apps may be complimentary to rehabilitation, habitual
exercise, and physical therapy. However, current use of apps to provide evidence-based exercise programs is unclear.

Research aims and objectives

This thesis aimed to improve the adherence to exercise programs by reducing stress to caregivers. This was achieved by creating an evidence-based program that can be implemented using an app and developed an RCT protocol that, someday, could be used to determine effectiveness of apps.

To answer this research question, two main objectives were addressed: to review literature in a systematic review and to develop an evidence-based exercise program that will be used to write a protocol for a future RCT.

Thesis layout

1. Chapter 2 (Literature review) systematically searched and reviewed two main areas critical to this thesis: 1) current habitual exercises for CP clients, and 2) training systems with special populations. Search terms were developed using Boolean logic (AND, OR, NOT) and applied to five databases:
   
   I. SPORTDiscus  
   II. ProQuest Central  
   III. PubMed Central  
   IV. ProQuest Nursing & Allied Health  
   V. Physical Therapy and Sports Medicine Collection  

Relevant articles were screened based on pre-determined inclusion/exclusion criteria. A data extraction form was used to collate and analyze data on GMFCS levels, exercises of the experimental groups, and online-based exercise apps.
Additional measures included the frequency, intensity, time and type of activities performed by the CP clients.

2. Chapter 3 is a protocol for an RCT which will aim to evaluate the effectiveness of an app-based exercise program (Physitrack) on improving function of CP clients and increasing caregiver adherence. The protocol uses an evidence-based program, based on data collected in Chapter 2, that will be individualised for CP client’s specific needs.

Note: Referencing style – given that chapter 2 and chapter 3 were submitted to the same journal, the referencing style of the whole thesis is consistent with that of The Journal of Strength and Conditioning Research.

Impact of Covid-19 on this thesis

Originally, this thesis planned to conduct a feasibility study during Chapter 3 to determine if an online exercise video app was feasible for CP clients and caregivers in Dunedin, New Zealand. If feasible, the feasibility study would substantiate a widespread use of Physitrack and further studies on the exercises' efficacy. Category A ethics approval was originally approved. However, New Zealand entered COVID-19 Alert Level Four lockdown on the 25/03/2020. During this period, the participant recruitment phase for the feasibility study was underway. Participants were first recruited from two businesses: CCS Disability Action Dunedin, and Southern Rehabilitation. Due to the companies delay in offering their services due to COVID-19, contact and momentum was lost. This led to further Ethics amendments to expand the recruitment to social media and other businesses but, only one eligible participant was recruited by the recruitment end-date (31/05/2020). It was then under the advice of
academic supervisors, that this project was modified to undertake a more structured systematic review and develop the RCT protocol that is presented in Chapter 3.

**Ethical considerations**

**Category A**

The ethical considerations were as follows; because the main study was a protocol there were no ethical requirements, but this could transfer over to ethical considerations for an RCT. In order to adhere to these considerations, the researcher needed to protect the autonomy of the participants and their rights of freedom, non-maleficence to make sure there was no harm to participants in the research process and ensure de-identifying of the participants. Here are some points that were considered during ethics approval:

- Privacy/de-identification of participants.
- Data collected to be stored on a password protected computer and disposed of securely after 7 years.
- Consent forms for participants stating their privacy will be protected, data collected will be de-identified and consent will be obtained freely with support as some participants lack the ability to communicate and sign forms.
- Participants have the right to withdraw from the research up until two weeks after the completion of the data collection process. Past this point participants can not withdraw from the study.
- Support will be allowed at any time if needed for physical or psychological stress during the feasibility study (for example, support workers, counsellors, health professionals).
• Cultural considerations needed to be accounted for during the research (Maori ethical framework).

In the next chapter:

The following chapter presents a systematic review assessing the training modalities and exercises used for CP clients’ interventions.
Chapter 2: Literature Review

Chapter overview

This chapter presents a systematic review assessing current habitual exercises for CP clients and training systems with special populations. This chapter was submitted on 19/08/2021 and awaiting review as a manuscript to The Journal of Strength and Conditioning Research.

Introduction

Background

CP is one of the most common types of disabilities that arise from a static lesion in the developing brain (10). CP causes posture and motor impairment (10), which creates a need for clients with CP to be involved in therapeutic activities to promote positive adaptations through neuroplasticity (7).

An effective way to promote activity for CP clients is through intensive goal-directed interventions (7). Home-based exercise programs complement this goal as exercising in a familiar environment increases physical activity (7). Using an application (app) to deliver a home-based exercise program can also complement this goal as it is an easily accessible way to exercise (7). Other benefits of home-based exercise programs using an online app include: online learning is cost-effective and can be enjoyable for CP clients and their caregivers, apps are useful for caregivers who struggle with adherence (7) as the program exercises are outlined and demonstrated to achieve their goals (9) and apps and online trackers on smartphones are available and convenient (17).

Physitrack is an app that provides an exercise program via a website or app and includes video demonstrations on how to perform exercises in home-based and/or gym-
based programs (7). Videos can be chosen from an exercise library already installed into the app with audio instructions, or clinicians can upload customised videos for their specific client/individual/participant (7). Exercise programs within the app can be set to a weekly calendar that has a reminder setting for those using the app and a feedback centre where the clinician and client can communicate (7). The app does not have a template for CP clients or exercises specific to CP clients. Upon searching the literature for ‘Physitrack application’, Johnson et al., was the only article found to use Physitrack across all populations (7). Therefore, there was a need to review the literature to find trends with exercises used with CP clients.

Rationale

The rationale for the review is to develop an evidence-based training program that will be applied to an appropriate piece of technology in order to develop a protocol for future research.

Methods

Protocol and registration

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was used to report this literature review (18). PRISMA items 12, 15, 19, and 22 were not reported because this review is exploratory and, a risk of bias assessment was deemed unnecessary.

Eligibility criteria

This review includes studies published in English with the following study designs: prospective, cross-sectional, and cross over designs, RCT, or case studies that
evaluate the effectiveness of exercise programs on physical and functional outcomes of CP clients.

Information sources

An electronic search strategy was developed to identify relevant articles for this review. Five online databases (SPORTdiscus, ProQuest Nursing & Allied Health, PubMed Central, Physical Therapy and Sports Medicine Collection, and ProQuest Central) were searched on the 15 December 2019. After removing duplicates and non-English articles, titles, abstracts, and full-text articles were screened according to the inclusion criteria. An updated search was conducted on 05/10/2020.

Search

Search terms were combined using Boolean logic AND/OR expressions with the following key words and phrases 'cerebral palsy Gross Motor Function Classification System (GMFCS) level', 'online apps,' and 'experimental group exercises.' Search results from each database search were exported and stored in Mendeley (Version 1.19.4, 2008-2019 Mendeley Ltd) for title, abstract and full-text screening.

Study selection

Once duplicates were removed, titles, abstracts, and full texts were screened against the inclusion and exclusion criteria. Studies were included if they assessed the effects of exercise programs for CP clients. Studies were excluded if the primary outcome was focused on the physiological adaptations through surgery (i.e., paediatric hip locking compression plate, botulinum toxin-A injections) or other assisting devices
(i.e., transportation such as wheelchairs) intended to alter body positions and movements.

Data collection process and items

A data extraction sheet was used to collect relevant information from the studies included in the systematic review. Data extracted from the studies include study design, intervention, participant characteristics (i.e., age and sex, GMFCS levels), exercise protocol (frequency, intensity, time and type), training systems (i.e., gym-based, apps, virtual reality) and outcome variables (i.e., Gross Motor Function Measure-88 (GMFM-88), grip strength).

Due to the exploratory nature of this review, the data were only extracted from the experimental groups to assess what types of exercises and equipment are being used in CP client’s exercise regimens. The exercises used by the studies were grouped into three categories; 'cardiovascular (CV),' 'musculoskeletal (MSC),' and 'cardiovascular + musculoskeletal (CV + MSC)' as the exercises demonstrated these training styles.

Summary measures

Data was combined in the results as percent of change when the same outcome variable was used across multiple studies. For the purpose of this review, clinical outcomes were defined as measurable changes in health, function or quality of life that result from care. Non-clinical outcomes were defined as measurable changes in strength, fitness or stability/balance that result from repetitive exercise.

Synthesis of results

Due to heterogeneity between studies, a meta-analysis showing the effectiveness of training programs was not possible. However, the percentage of change
was calculated for each variable to allow for descriptive analyses between baseline, midpoint, and endpoint. Data is presented graphically and sub-grouped by clinical and non-clinical outcomes. Paired sample T-tests indicate any differences in the percentage of change between time points for each outcome variable.

**Results**

*Study selection*

There were 1633 articles identified in the original (15/12/2019) and updated search (05/10/2020) combined; of these, 9 were classified as meeting the inclusion criteria for the literature review (Figure 3).
Study characteristics

A total of 9 articles were included for qualitative synthesis in this review (Table 1). Of the included studies, four were randomised controlled trials (19–22).
<table>
<thead>
<tr>
<th>Author, year &amp; location</th>
<th>Study design &amp; intervention design</th>
<th>GMFCS level</th>
<th>Participants age/gender (M/F)</th>
<th>Exercises from experimental group</th>
<th>Training systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryant et al., 2013</td>
<td>Randomised controlled trial</td>
<td>Level IV &amp; V</td>
<td>8-17 yrs / M=14, F=21</td>
<td>Cycle ergometer &amp; treadmill</td>
<td>Cardiovascular training program</td>
</tr>
<tr>
<td>London</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimitrijevic et al., 2012</td>
<td>Randomised controlled trial</td>
<td>Level I, II, III, IV &amp; V</td>
<td>5-14 yrs / M=17, F=10</td>
<td>Swimming</td>
<td>Aquatic intervention</td>
</tr>
<tr>
<td>Serbia</td>
<td></td>
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<tr>
<td>Do et al., 2016 Korea</td>
<td>Single-subject experimental design</td>
<td>Not reported</td>
<td>5-7 yrs / M=2, F=1</td>
<td>Canoeing, golf, swordsmanship, cycling, basketball &amp; moving boxes</td>
<td>Nintendo Wii</td>
</tr>
<tr>
<td>Dodd et al., 2003</td>
<td>Randomised clinical trial</td>
<td>Levels I, II, &amp; III</td>
<td>8-18 yrs / M=10, F=11</td>
<td>Bilateral heel raises, bilateral half squats, &amp; step-ups</td>
<td>Strength training program</td>
</tr>
<tr>
<td>London</td>
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</tr>
<tr>
<td>Groff et al., 2006</td>
<td>Case study</td>
<td>Level V</td>
<td>11 yrs / M=1, F=0</td>
<td>Walking, sit-ups, push-ups, hand grip strengthener &amp; soccer</td>
<td>Therapeutic recreation intervention</td>
</tr>
<tr>
<td>Urbana</td>
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<tr>
<td>Kassee., 2015 Ann Arbor</td>
<td>Pilot study</td>
<td>Level I &amp; II</td>
<td>7-12 yrs / M=6, F=0</td>
<td>Tennis, archery, swordplay, basketball, bowling, canoeing, golf, frisbee</td>
<td>Nintendo Wii</td>
</tr>
<tr>
<td>Study</td>
<td>Design Type</td>
<td>Conditions</td>
<td>Age</td>
<td>Gender</td>
<td>Intervention Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------</td>
<td>-------------------------------------</td>
<td>----------------------</td>
<td>--------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MacIntosh et al., 2020</td>
<td>Randomised single-case</td>
<td>Not reported</td>
<td>8-18 yrs</td>
<td>Not reported</td>
<td>Biofeedback enhanced therapeutic exercise video game intervention</td>
</tr>
<tr>
<td>France</td>
<td>feasibility study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polat et al., 2020</td>
<td>Randomised controlled</td>
<td>Levels I, II, &amp; III</td>
<td>4-11 yrs / M=33, F=11</td>
<td>Gymnastics</td>
<td>Multi-model sport activity home program</td>
</tr>
<tr>
<td>Turkey</td>
<td>trial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unger et al., 2006</td>
<td>Randomised controlled</td>
<td>Not reported</td>
<td>13-18 yrs / M=19, F=12</td>
<td>28-station circuit targeting upper &amp; lower limbs and trunk (8-12 exercises) &amp; warm up on cycle ergometer</td>
<td>Strength training program</td>
</tr>
<tr>
<td>London</td>
<td>trial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**The Gross motor function classification system**

Two studies used levels I, II, & III (22,23) and three studies did not report any GMFCS levels (6,21,24).

**Exercise types**

There were 27 exercises used overall for the study’s experimental groups, and one study did not report what exercises they used (6). The exercises were grouped into three types in the results: CV, MSC and CV+MSC (Table 2).

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>Intensity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>2-5x/week - 6-10</td>
<td>Light-hard</td>
<td>30-55mins/session</td>
</tr>
<tr>
<td></td>
<td>weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal strength</td>
<td>1-5x/week - 4-6</td>
<td>Light-moderate</td>
<td>20-60mins/session</td>
</tr>
<tr>
<td></td>
<td>weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular &amp;</td>
<td>1-5x/week - 6-8</td>
<td>Moderate</td>
<td>40-60mins/session</td>
</tr>
<tr>
<td>musculoskeletal strength</td>
<td>weeks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Training systems

Studies used a cardiovascular training program (19), strength training program (21,23), therapeutic recreation intervention (13), Nintendo Wii (10,24), aquatic intervention (20), biofeedback enhanced therapeutic exercise video game intervention (6), and multi-model sport activity home program (22).

Results of individual studies

Frequency, Intensity, Time, Type (FITT) principle

Frequency

The articles’ based frequency of the interventions on the number of sessions per week for the duration of the intervention. Overall, the studies in this review reported a range of 1-5 sessions per week for 6-10 weeks. The most commonly reported frequency was two sessions per week for six weeks (13,25).

Intensity

The interventions’ intensity was split into ‘light,’ ‘moderate,’ ‘moderate-hard,’ and ‘hard’. Four studies encouraged their participants to work at a moderate intensity (13,19,21,23), two used light (10,20), and one used moderate-hard (24). No studies used ‘hard’ intensity.

Time

The time of the sessions varied between each study, with the range being from 20 minutes to 60 minutes and the mean being 40.5 minutes (10,13,19–21,23,24).

Type

The type was categorized into cardiovascular, musculoskeletal, and both. Four studies used CV (10,19,20,24), one study used MSC (23), and two used CV+MSC (13,21).
Synthesis of results

Clinical variables included in the studies were GMFM (19,20,23), Melbourne Assessment 2 (10), Pediatric Motor Activity Log (24), Sum of the ankle, knee, and hip angles at mid-stance (21), Water Orientation Test Alyn 2 (20), and Wolf Motor Function Test (24) (Table 3).
Table 3: Clinical outcome variables

<table>
<thead>
<tr>
<th>Clinical outcome variables</th>
<th>Exercise Category</th>
<th>Percentage of Change of outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline to midpoint</td>
</tr>
<tr>
<td>Gross Motor Function Measure (GMFM D) (%) (Dodd et al., 2003)</td>
<td>CV, No technology</td>
<td>7</td>
</tr>
<tr>
<td>Gross Motor Function Measure (GMFM E) (%) (Dodd et al., 2003)</td>
<td>CV, No technology</td>
<td>8</td>
</tr>
<tr>
<td>Gross Motor Function Measure (GMFM-66) Bike/ Treadmill (%) (Bryant et al., 2013)</td>
<td>CV, No technology</td>
<td>3</td>
</tr>
<tr>
<td>Gross Motor Function Measure (GMFM-88) (%) (Dimitrijevic et al., 2012 &amp; Polat et al., 2020)</td>
<td>CV+MSC, MSC, No technology</td>
<td>6</td>
</tr>
<tr>
<td>Gross Motor Function Measure (GMFM-88D) Bike/ Treadmill (p&lt;0.05) (points) (Bryant et al., 2013)</td>
<td>MSC, No technology</td>
<td>240</td>
</tr>
<tr>
<td>Gross Motor Function Measure (GMFM-88E) Bike/ Treadmill (points) (Bryant et al., 2013)</td>
<td>MSC, No technology</td>
<td>84</td>
</tr>
<tr>
<td>Melbourne Assessment 2 (MA2) (total %) (Kassec., 2015)</td>
<td>CV, Technology</td>
<td>11</td>
</tr>
<tr>
<td>Pediatric Motor Activity Log (PMAL) (points) (Do et al., 2016)</td>
<td>CV, Technology</td>
<td>97</td>
</tr>
<tr>
<td>Sum of ankle, knee and hip angles at mid-stance (degrees) (p&gt;0.05) (Unger et al., 2006)</td>
<td>CV+MSC, No technology</td>
<td>0</td>
</tr>
<tr>
<td>Water Orientation Test Alyn 2 (WOTA2) (%) (Dimitrijevic et al., 2012)</td>
<td>CV, No technology</td>
<td>111</td>
</tr>
<tr>
<td>Wolf Motor Function Test (WMFT) (points) (Do et al., 2016)</td>
<td>CV, No technology</td>
<td>13</td>
</tr>
<tr>
<td>Visual Analog Scale (VAS) (/10) (Polat et al., 2020)</td>
<td>CV+MSC, No technology</td>
<td>0</td>
</tr>
<tr>
<td>Test Description</td>
<td>Score</td>
<td>Condition</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>-------</td>
<td>-----------</td>
</tr>
<tr>
<td>Active wrist extension - open fingers (AWEO) (degrees) (MacIntosh et al., 2020)</td>
<td>0</td>
<td>MSC, Technology</td>
</tr>
<tr>
<td>Gross manual dexterity (B&amp;B) (blocks) (MacIntosh et al., 2020)</td>
<td>0</td>
<td>MSC, Technology</td>
</tr>
</tbody>
</table>
Non-clinical variables included in the studies were cadence (21), grip strength (10,13), stride length (21), timed stair (23), velocity (21), and walking speed (23). The outcome variables were tested at baseline, midpoint and endpoint; except for two studies that only used two-time points (13,21) (Table 4).

Table 4: Non-clinical outcome variables

<table>
<thead>
<tr>
<th>Non-clinical outcome variables</th>
<th>Exercise Category</th>
<th>Percentage of change of outcomes</th>
<th>Baseline to midpoint</th>
<th>Midpoint to endpoint</th>
<th>Baseline to endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadence (steps/min) (Unger et al., 2006)</td>
<td>CV+MSC, No technology</td>
<td>Cadence (steps/min) (Unger et al., 2006)</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Grip strength (/1) (MacIntosh et al., 2020)</td>
<td>MSC, Technology</td>
<td>Grip strength (/1) (MacIntosh et al., 2020)</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Grip strength (kg) (Groff et al., 2006)</td>
<td>CV+MSC, No technology</td>
<td>Grip strength (kg) (Groff et al., 2006)</td>
<td>0</td>
<td>0</td>
<td>186</td>
</tr>
<tr>
<td>Grip strength (psi) (Kassee., 2015)</td>
<td>CV+MSC, Technology</td>
<td>Grip strength (psi) (Kassee., 2015)</td>
<td>54</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>Stride length (mm) (Unger et al., 2006)</td>
<td>CV+MSC, No technology</td>
<td>Stride length (mm) (Unger et al., 2006)</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Timed stair (s) (Dodd et al., 2003)</td>
<td>MSC, No technology</td>
<td>Timed stair (s) (Dodd et al., 2003)</td>
<td>-23</td>
<td>19</td>
<td>-8</td>
</tr>
<tr>
<td>Velocity (mm/s) (Unger et al., 2006)</td>
<td>CV+MSC, No technology</td>
<td>Velocity (mm/s) (Unger et al., 2006)</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Walking speed (m/min) (Dodd et al., 2003)</td>
<td>MSC, No technology</td>
<td>Walking speed (m/min) (Dodd et al., 2003)</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Time standing on left foot (s) (Polat et al., 2020)</td>
<td>CV+MSC, No technology</td>
<td>Time standing on left foot (s) (Polat et al., 2020)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Time standing on right foot (s) (Polat et al., 2020)</td>
<td>CV+MSC, No technology</td>
<td>Time standing on right foot (s) (Polat et al., 2020)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>One minute walk test (m) (Polat et al., 2020)</td>
<td>CV+MSC, No technology</td>
<td>One minute walk test (m) (Polat et al., 2020)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Percentage of change was calculated at three points; baseline to midpoint (((midpoint − baseline)/baseline x 100)), midpoint to endpoint (((endpoint − midpoint)/midpoint x 100)), and baseline to endpoint (((endpoint − baseline)/baseline x 100)). Overall, the percentage of change for non-clinical variables and clinical variables significantly decreased from baseline to
midpoint period (p= 0.433 to 0.014) and midpoint to endpoint (p= 0.134 to 0.015), respectively.

*Figure 4: Baseline to midpoint percentage of change variables*
Figure 5: Midpoint to endpoint percentage of change variables

Figure 6: Baseline to endpoint percentage of change variables
Additional analysis

No exercises were used in multiple studies; therefore, data could not be combined in a meta-analysis.

Discussion

Summary of evidence

Nine articles were included in this literature review. From the 9 articles, there was a range of various exercises and variables used throughout the different exercise programs. Some of the exercises were suited to strength training, flexibility training, virtual reality, sports, home-based and gym based. As well as various exercises and variables, there were also a lot of different outcome measures and a range of frequency, intensity, time and type (FITT) variables. There was a total of 17 different outcome measures, with the most reoccurring measure being GMFM (19,20,23). The outcome measures/variables in some of the studies were specifically chosen to complement the exercises intended to improve test scores (10,13,20,23,24). The most popular of the range of variables for the FITT principle were 2-3 sessions per week for 6 weeks for frequency, moderate (based on resting heart rate measures) for intensity (26), 30-minute session for time and cardiovascular for type of training. The general trends from the results of the outcome variables showed positive and negative variances. No technology (No-tech) had a larger positive trend than technology².

Using the ‘GMFM’

Gross Motor Function Measure (GMFM) is an outcome measure that is best-known and most frequently used globally (27) with CP clients, down syndrome clients and clients with acquired brain injuries (28). GMFM-88 is the amount of items (88) categorised into five gross motor function dimensions to test using the GMFM scoresheet (27). The GMFM is used to test
the level of motor function over time and categorises the client to a level of the GMFCS (20). The effectiveness of interventions has been monitored by researchers to study the responsiveness of the GMFM-88 (27). Classifying participants into GMFCS level (severity) and age is an essential factor in the responsiveness of GMFM-88 (27). In this systematic review, three studies used GMFM-88 for measurement. Dodd et al. measured GMFCS level I, II & III CP clients (29), Bryant et al. measured levels IV & V (19), and Dimitrijević et al. measured levels I, II, III, IV & V (20). The responsiveness of the GMFM-88 would have been hindered by the levels not classified. Bryant et al.; Dodd et al. would have been more responsive to the intervention’s effectiveness as the GMFCS level were similar with only small amounts of function separating the classification level (19,29,30). Dimitrijević et al. would not have been as highly responsive to the intervention’s effectiveness because the GMFCS levels were not classified (20). This means that level I participants may have been tested against level V participants, with considerable gross motor function variance.

Although GMFM was the most popular, each measure was different depending on what variable of the GMFM was measured (88, 66, A-E). Variances were observed between the type of GMFM used; GMFM D & E (23), GMFM-66, -88D & E (19), and GMFM-88 (20). With six different types of GMFM measures used, analysing the results was problematic as it was hard to compare them to each other. Instead of comparing them to each other, the best way to look at the data all together was to collect the percentage of change between baseline, midpoint and endpoint and plot the data into a forest plot. The GMFM variable was confusing to look at together because of differing units, but it was an excellent variable to use to test gross motor function. GMFM-88E tests were walking, running and jumping on a scoresheet, which would be a significant variable to use for testing the less severe CP clients (GMFCS levels I-III). Additional outcome measures may also provide valuable insights into the impacts of exercise programs on CP clients.
Other Clinical outcome measures

The MACS test improved over a 4-week period for children with CP’s use of their hands/wrists to manipulate objects in daily activities (6). This is a useful test for CP participants, as most of the exercises conducted with CP clients require the use of their hands. A similar trend was found for a home-based RCT with stroke clients (31). The home-based RCT intervention was tested at baseline and one-month post-therapy; the experimental group used a MusicGlove for hand stimulation, and the control group used hand exercises (31). The intervention was 3hrs/week over at least three sessions for three weeks (9hrs total therapy) (31). The home-based RCT showed no significant data at baseline for the experimental and control groups (31). The only significant data was one-month post-therapy for the experimental group using outcome measures: Motor Activity Log (MAL) and ‘amount of use’ (31).

Visual Analogue Scale (VAS) was used in one study to rate pain levels (22) and showed exercise significantly reduced pain in the experimental group (Pre-test mean = 85.69, post-test mean = 88.65). Pain in adults with CP is in the lower extremities, as well as the hips and back (22). Polat et al. found 79.54% of participants suffered from calf muscle pain, 11.36% suffered foot pain, and 9.09% suffered pain in knees, hips, thighs, shoulders, and abdomen (22). Relating the pain region to GMFCS levels may be due to the unsteady gait of CP clients. Seeing improvements in pain may also see improvements in function levels. Absolute Visual Analogue Scale (AVAS) for pain was found to be a validated and reliable measure for pain (32,33). There was a considerable amount of attention devoted by clinicians to find a satisfactory method for measuring pain (33), and with many measures devised it was found that AVAS was more influenced by the effects of expectancy and deficient memory of pain (32), as it is a subjective experience (33). The measure for AVAS included a 10cm line that has ‘No pain’ on one end of the line and ‘Pain as bad as it could possibly be’ on the other (33). The measure did not include numerical scaling as certain numbers may be preferred by
the subject and therefore interfere with the distribution of results, rather it provides a continuous scale of measurement (33).

*FITT Principle*

 Majority of the data present no significance; Laddha, Ganesh, Pattnaik, Mohanty, & Mishra concluded that extending their intervention duration could have increased the data’s chances of being significant (34). Interventions to improve mobility and movement in impaired populations can show significant improvements (34).

A study that tested high intensity functional circuit training (HIFCT) versus moderate intensity aerobic exercise (control group) on healthy, inactive adults saw a linear relationship enjoyment and anticipation (35). The outcome measures were motor function and exercise motivation (which were similar to the search for CP clients) (35). The HIFCT group increased in leg strength, shoulder strength and maximum cycling workload compared to the control group and both groups improved in single leg hops for distance with higher effectiveness in the HIFCT group; although this was not significant (35). There was no statistical significance (P=0.05) for time or group difference for counter-movement-jumps and postural control, the HIFCT group increased in exercise motivation and between both groups self-concordance was statistically significant (35). Overall, subjects in the HIFCT group enjoyed their training more and looked forward to the next workout significantly more than the control group. A study testing stabilisation training for the improvement of trunk and hip muscle activation among healthy females saw improvements from pre to post intervention testing for all outcome measures (36). Five exercises were performed using five different muscle groups (Rectus Abdominus, External Oblique, Multifidus, Gluteus Maximus and Gluteus Medius) and were testing pre and post intervention using electromyography (36). Results showed all muscles significantly improved from pre to post intervention (36).
Both CP and healthy populations experience improvements from exercise programs, whether or not the data is statistically significant. There is not necessarily different data coming from CP clients, other than exercises may need to be more specific than healthy populations due to motor function and the degenerative progression of CP. With this in mind, exercise could help to slow the process of CP and the long term gains will potentially increase quality of life (37).

*Online/technology exercise applications versus paper-based programs*

Online/technology exercise applications include virtual reality (E.G. Nintendo Wii) and physiotherapist/personal trainer exercise programs (E.G. Physitrack) (7,10,24). The main difference between online apps and paper-based programs is apps are interactive; you can follow instructions given on the computer/device and copy demonstrations given (7,10,24). Paper-based programs means you are only reading from a piece of paper and, if any, diagrams as demonstrations. Caregivers who are delivering the exercises to their CP clients may find it easier to adhere to online/technology exercise apps as they are more interactive which may provide an easier understanding of demonstrations and how to perform an exercise, but whether online apps are an improvement to paper-based programs is yet to be determined.

*Limitations*

A limitation of the review was the data could not be combined due to heterogeneity. This also shows the opportunity that there is in this area working with those with CP to better create appropriate programs that are well adhered too. The GMFM can be confusing with so many options, but necessary because of the complexity of CP. Another limitation was all studies only had a short follow-up/intervention period and no studies used an individualised approach, which may be mitigated by the use of an app. The one study that used Physitrack
with CP clients was not included in the analysis because it did not meet the inclusion criteria (7).

Future implications

Using multiple clinical and non-clinical outcomes as well as mixing technology with analogue methods of delivery would be ideal for a future study(s). The need for longer intervention periods is justified by the results of this study, not showing huge improvements over the duration of the study but other (longer studies, (12+ weeks)) have seen improvements. Adding in outcome measures such as MACS will allow the motor function testing to be more accurate as MACS is specific to the hands.

Conclusions

There is a current gap in the literature as this review found no studies used an online app to assess exercise programs with CP clients. A combination of clinical and non-clinical variables may provide a holistic view of the effects of a tailored online app exercise program. Additionally, the specificity of exercises and descriptions for CP clients may help reduce stress for caregivers and improve adherence to the exercise program. Clinicians tend to prefer measures with specific data items related to specific information categories, meaning the data being significant is essential to whether clinicians will use specific outcome measures (38). This is why using an online app could be the point of difference needed for testing on CP clients. If there is a way to increase adherence and performance by simplifying exercise delivery, this may be worth testing through an online app.

In the next chapter:
The following chapter builds on the results from this review and presents a protocol for a randomised control trial that evaluates the effectiveness of an online habitual exercise program for Cerebral Palsy clients using 'Physitrack.'
Chapter 3: RCT Protocol

Chapter overview

This chapter presents a protocol for a randomised controlled trial assessing the effectiveness of an online habitual exercise program for Cerebral Palsy (CP) clients using 'Physitrack.' This chapter was submitted on 19/08/2021 and awaiting review as a manuscript to *The Journal of Strength and Conditioning Research*.

Introduction

The number of individuals using smartphones in 2020 is approximately 6.1 billion, 70% of the world’s population (39). Numerous applications (apps) are central to our lives, and using smartphone technology for medicine and physical therapy is becoming more prevalent and widespread (39) especially following the COVID-19 global pandemic (40). Users have indicated apps in general are “useful” and “viable” with research suggesting apps cover a variety of health topics (41). Apps can have a novelty effect on users with increased interest in new technology in the short term but decreased interest in the long term (42). Clinicians/researchers/therapists want participants to be interested and motivated to use the app for maximal effectiveness.

Using an app for an exercise program for CP clients and their caregivers may be a more comfortable, cost-effective way to promote physical activity with the extraordinary reach and availability of technology (43). There is a prominent gap in the literature regarding the use and behaviour change effectiveness of apps and technology (41) among CP clients and caregivers. Current literature presents a variety of exercises and outcome measures with little guidance on the frequency, intensity, type and time of exercises for CP clients (Chapter 2). Additionally, a common shortcoming in field-based practice is a high turnover rate of caregivers. Some reasons for the caregivers resigning from supporting CP clients include; confusing and/or hard
to follow programs designed by other medical professions (i.e., physiotherapists) and a lack of training, support and on-going development for working with CP clients (7). An online app could increase adherence, confidence and motivation among CP clients and their caregivers (7). Caregivers may not have exercise knowledge, but the app demonstrates exercise videos and provides descriptions to assist in performing the exercise program (9).

Objectives

This study aims to develop a protocol of a randomised controlled trial (RCT) that will determine the effectiveness of an online habitual exercise program for CP clients using 'Physitrack.' The effectiveness will be measured by determining whether apps improve Gross Motor Function Measure (GMFM), full body pain, grip strength, and caregiver adherence. The secondary aim determines whether Physitrack is a useful tool for CP and caregiver participants. The third aim is to assess whether caregivers find an online application to be better than a paper-based program; this will be measured in a survey. This study argues whether technology is just an advancement or an improvement from paper-based programs.

Methods

The Consolidated Standards of Reporting Trials (CONSORT) statement was used to report this protocol (44).

Trial design

This study is a protocol for a RCT that will determine the efficacy of Physitrack (London, 2012), an app-based resistance training program on gross motor function of CP clients and the adherence of the CP clients and their caregivers to the program. The trial design includes an experimental group with three sub-groups (cardiovascular (CV), musculoskeletal (MSC), and cardiovascular + musculoskeletal (CV+MSC)) that will use the Physitrack app and a control group with three sub-groups (cardiovascular (CV), musculoskeletal (MSC), and
cardiovascular + musculoskeletal (CV+MSC)) that will use the paper-based program (Figure 7). The experimental groups follow the online (Physitrack) individualised gym-based resistance training program for eight weeks (with a 4-week follow-up) with three sessions per week for 30 minutes per session. The control group follows a gym-based resistance training program as a paper-based program given to the caregivers (i.e., current practice). An adherence survey is given to the caregivers from both the experimental and control group following the completion of the program (Appendix B: Surveys). The aims of this protocol are to:

1. Develop a program based on currently available literature in the procedures, equipment and outcome variables used in programs for CP clients.
2. Design outcome measures that align with CP goals and improve adherence from both the CP clients and caregivers.

**Study sample and recruitment**

Male and female CP participants aged 10-16yrs with Gross Motor Function Classification System (GMFCS) levels II and III and Manual Ability Classification System (MACS) levels I, II and III and their caregivers 18+ will be recruited throughout New Zealand. Purposive sampling will be used to recruit through social media, word of mouth, and advertising at the following associations: Cerebral Palsy Society, CCS Disability Action, Well South, Southern Rehabilitation, Health Care NZ, and Enable NZ. The participants' recruitment is a rolling recruitment as the protocol is ongoing until 210 participants have completed the 8-week intervention with a 4-week follow-up.

**Inclusion criteria**

Eligible participants must have GMFCS level II or III and MACS level I, II or III CP and need a caregiver to assist with the program; they must be able to communicate and have the cognitive capacity and communication abilities to
understand the program to be able to give informed ascent (and parental consent) for the protocol. Caregivers who are not relatives must work for a registered support work company to assist CP clients. CP participants must be aged 10-16yrs, and caregivers must be over 18 year of age at the training programs commencement.

Exclusion criteria

The protocol excludes CP participants who do not require assistance (due to part of the protocol surveying caregivers), GMFCS level I, IV and V, and MACS level IV and V, and do not have the cognitive capacity to give informed ascent. Caregivers who do not currently work with CP participants will be excluded. CP participants with no exercise experience or have had physiological adaptations through surgery or botulinum toxin injections will be excluded. Any potential participant is excluded if they are outside of the age brackets.

Sample size

G*Power software (version 3.1, Germany) was used to calculate the sample size estimation for a fully powered RCT. The input parameters will be set for a two-tailed T-Test with a moderate effect size of 0.5 (α err prob = 0.05, β err prob = 0.95). A previous study has found moderate adherence (around 60% for both the treatment and control groups) (45). Based on these settings a total of 210 CP clients and their caregivers will be randomly allocated to either the experimental (Physitrack) or control (paper-based) exercise programs.

Randomisation

Eligible participants will be randomised using the Research Randomiser (Version 4.0) (46) to either the intervention group (Physitrack app) or the control group (paper-based exercise program). Participants in both groups will be further randomly allocated to receive
CV, MSC, or CV+MSC exercises (Figure 7).

**Figure 7: Experimental design**

- Eligible participants: Male and Female GMFCS level II and III CP patients and their caregiver

- Not eligible: No further contact

- Screening for eligibility criteria

- Baseline assessments (n=210)

- Randomization

- Experimental group (n=105)
  - Cardiovascular: n=35
  - Musculoskeletal: n=35
  - Both: n=35
  - Exercise program on physiTrac application

- Control group (n=105)
  - Cardiovascular: n=35
  - Musculoskeletal: n=35
  - Both: n=35
  - Paper-based exercise program

- End of intervention: 8 weeks. Follow-up assessment

- Resume usual daily schedule

- Final follow-up assessment: 12 weeks

- Screening and classification measures:
  - GMFCS
  - MACS
  - CP type
  - Caregiver adherence
  - Communication abilities
  - Exercise experience
  - Surgeries/Botox

- Baseline, follow-up, and final follow-up assessment measures:
  - CP participants:
    - GMFM-88E measure
    - Full body pain (tested with Visual Analog Scale)
    - Grip strength
  - Caregiver participants:
    - Adherence survey

**Gross motor function measure**
Gross motor function in CP children aged five months to 16 years is assessed using a tool named Gross Motor Function Measure (GMFM) (28). The International Classification of Functioning, Disability, and Health define the GMFM as measuring 'activity' and 'capacity' rather than 'performance' (28). The assessment of GMFM is scored on a 4-point ordinal scale of 0-3 (0 = does not initiate, 1 = initiates task, 2 = partially completes task 3 = task completed) and is assessed by a trained professional therapist using the original GMFM-88 version (28). Three trials will be taken for each item, and the best of the three is recorded (28). There are five dimensions of the GMFM-88, grouped into A) lying and rolling, B) sitting, C) crawling and kneeling, D) standing, and E) walking, running, and jumping (28). For the purpose of this protocol, only one variable (GMFM-88E) is used as it is focused on walking, running and jumping.

Study procedure

Participant information forms will be emailed to potential participants and an ascent/consent form and a pre-screening survey for inclusion/exclusion criteria evaluation. Potential participants will be identified through local NZ support agencies such as CCS Disability Action, Southern Rehabilitation/Habit Health Healthcare NZ, Access Community Health and Wellsouth NZ. All caregiver participants will be over 18 years of age so they do not require parental consent, but CP participants require parental consent due to the age bracket (10-16yrs). The participants and parents of CP clients have the opportunity to ask any questions about the intervention and protocol.

CP clients will attend an in-person session for baseline, midpoint (8 weeks), and endpoint (12 weeks) assessments (tools include GMFM-88E scoresheet, grip strength, and absolute visual pain analogue scale (AVAS)). Caregivers complete baseline, midpoint, and endpoint adherence survey assessments online using Qualtrics which is an online survey tool.
Participants in the experimental group complete a Physitrack program that is individualised from a selection of 12 gym-based exercises for each CP client. Participants complete either a CV, MSC, or CV+MSC Physitrack program, with one baseline assessment session, a midpoint assessment session (8 weeks), and an endpoint session (12 weeks) after the 8-week intervention. Participants in the control group complete exercises from a paper-based program (either CV, MSC, or CV+MSC) in the same format as the experimental group.

*Study intervention: Physitrack exercise training program*

The gym-based training program used is based on the information obtained from a previous literature review (Chapter 2). The training program consists of 12 exercises divided into 3 subgroups: CV, MSC, and CV+MSC (Table 5).

### Table 5: Exercises for each sub-group

<table>
<thead>
<tr>
<th>Exercises</th>
<th>Cardiovascular</th>
<th>Musculoskeletal</th>
<th>CV + MSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill walks</td>
<td></td>
<td>Seated leg press</td>
<td>Treadmill walks</td>
</tr>
<tr>
<td>Cycle Ergometer</td>
<td></td>
<td>Seated bent knee calf raise</td>
<td>Seated leg press</td>
</tr>
<tr>
<td>Arm crank machine</td>
<td></td>
<td>Grip squeeze</td>
<td>Grip squeeze</td>
</tr>
<tr>
<td>Gripping ball</td>
<td></td>
<td>Gripping ball</td>
<td>Cycle ergometer</td>
</tr>
</tbody>
</table>

The intervention runs three sessions per week for 30 minutes each session. Exercises will be prescribed in the same manner as the experimental group to the control group and to create the exercises and demonstrations for the Physitrack app for the experimental group. Surveys will be sent out (adherence, pre-screening) and GMFM-88E testing using the GMFM scoresheet will commence, full body pain using the Absolute Visual Analog Scale (AVAS), and grip strength using a dynamometer.

*Equipment*
Physitrack is an app available on the app store for Android and Apple devices (Figure 8). It is also available on search engines such as Safari and Google Chrome. Physitrack provides digitally aided education and healthcare, founded in 2012 in London, England. The app provides healthcare exercises for many different variables (injuries, disorders, disabilities), and can create exercise templates for personal training clients/participants to follow (Figure 9). The Physitrack app in this intervention includes a mixture of 'ready-made' exercises that are already available on the app and individually created exercises that are designed by the researchers. There are two interfaces of the app; one is specific for clients/participants. This is called ‘Physiapp,’ which includes the specific persons exercise template (they can access this with a personal code sent via email or text), showing the exercise demonstration through video, description, sets, repetitions, and duration (Figure 8). The second is ‘Physitrack’, which is where the healthcare professional can create programs, edit templates, and send through client’s programs and the online database (47) (Figure 9). All images associated with Physitrack (Figures 8-9 & 14-20) were given permission to use in this thesis (See Figure 12 in Appendix C).

Figure 8: Physitrack/Physiapp apps
Paper-based program (Control group)

The control group uses a paper-based gym program for their sessions. The sessions will be the same as the experimental group, except using a paper-based program rather than an app. The exercises chosen for the control group will be based on the knowledge and experience as a personal trainer working with the CP population regularly.

FITT principle

The frequency, intensity, time and type (FITT) principle will organise the data extracted. Both programs follow the FITT principle and include exercises that show positive
outcomes in the variables used in this protocol (Table 6). Additionally, we sought the expertise and training of a personal trainer specializing in working with CP clients. The participants will complete three sessions per week with each session being 30 minutes. The first two exercises in each sub-group (CV, MSC, CV+MSC) will be performed for 10 minutes each and the last two exercises will be 5 minutes each (equalling 30 minutes) (Table 5). The intensity will be based off the Borg Scale (6-20) and will be at an intensity of 13 (somewhat hard) (48). The MSC exercises (seated leg press, seated bent knee calf raise and grip squeeze) will be performed for two sets and ten to twelve repetitions (2 x 10-12).

Table 6: Frequency, Intensity, Time, Type (FITT) variables

<table>
<thead>
<tr>
<th></th>
<th>Cardiovascular</th>
<th>Musculoskeletal</th>
<th>CV + MSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (per week)</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Intensity (Borg scale)</td>
<td>13(somewhat hard)</td>
<td>13 (somewhat hard)</td>
<td>13 (somewhat hard)</td>
</tr>
<tr>
<td>Time (per session)</td>
<td>30mins</td>
<td>30mins</td>
<td>30mins</td>
</tr>
<tr>
<td>Type</td>
<td>CV</td>
<td>MSC</td>
<td>CV + MSC</td>
</tr>
</tbody>
</table>

Online survey’s

Qualtrics is used to collect demographic data prior to baseline testing. Participants are sent a link to the survey via email to complete. Once the participant completes the survey, an email will be sent to the researchers, who can see the surveys' results and questions. The survey for this RCT is a screening survey for CP and caregiver potential participants (See in Appendix B). All potential participants are sent an email, either stating they are not suitable for this particular research or an email inviting them to participate, including informed consent/parental consent and information sheets. Qualtrics is also used for the adherence survey for caregiver participants at baseline, midpoint and endpoint (see in appendix B). The survey for caregivers asks seven questions about the app and exercise in terms of adherence.
The caregivers are emailed the link to the survey at the three testing time points, and a confirmation email is sent from Qualtrics once participants have completed the survey.

**Outcome measures**

This protocol includes five primary outcome variables assessed pre-intervention, at eight weeks, and at 12-week endpoint.

*Primary outcome measures*

Differences in performance of exercises between the experimental (Physitrack) and control (paper-based) groups will be assessed for GMFM-88E, grip strength, and full body pain (Table 7).

**Table 7: Outcome measures and tools used to measure**

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Motor Function Measure</td>
<td>GMFM-88E Scoresheet</td>
</tr>
<tr>
<td>Grip Strength</td>
<td>Dynamometer</td>
</tr>
<tr>
<td>Pain</td>
<td>Visual Analog Scale</td>
</tr>
<tr>
<td>Caregiver Adherence</td>
<td>Adherence survey</td>
</tr>
</tbody>
</table>

*Gross motor function measure (GMFM-88E)*

The GMFM is chosen for this protocol because it is a standardised observational measurement (49) for people with CP and is valid for children with Down Syndrome and acquired brain injury (28). The scoresheet involves all five dimensions (A. lying & rolling, B. sitting, C. crawling & kneeling, D. standing and E. walking, running & jumping), with these scoring from 0-3 points (50). Specifically, the GMFM-88E is the primary measurement of function for participants in this study because the participant demonstrates motor skills from section E of the GMFM scoresheet (The score sheet can be viewed at:
The movements are scored as 0 (does not initiate), 1 (initiates), 2 (partially initiates), 3 (completes), and NT (not tested) (28).

**Grip Strength**

Grip strength is a measure in this study because there is a large increase in this variable with CP clients following an exercise intervention (10,13). A grip strength dynamometer (Figure 10) is used to measure grip strength on the CP participant's left and right hand. Grip strength is tested at baseline, midpoint, and endpoint. Exercises in the experimental and control group program are structured to improve grip strength throughout the intervention.

*Figure 10: Grip strength dynamometer ("Dynamometer, Chicago, United States, 1945-1955 (dynamometer)" by C H Stoelting Company is licensed under Creative Commons Attribution license [CC BY 4.0](https://creativecommons.org/licenses/by/4.0)).*

Full body pain (Absolute Visual Analogue Scale)

Full body pain is being used as a measure in this study because CP client’s motivation to exercise may be based on the amount of pain perceived whilst exercising (32,33). The Absolute Visual Analogue Scale (AVAS) (Figure 11) is used as a tool to measure the amount
of perceived pain a CP participant experiences during exercise. Pain is tested at the end of each exercise session for eight weeks. Exercises in the program for the experimental and control group are structured to improve pain throughout the intervention.

Figure 11: Absolute Visual Pain Analogue Scale (Scale from http://somepomed.org/articulos/contents/mobipreview.htm?19/3/19514)

<table>
<thead>
<tr>
<th>No pain</th>
<th>Worst Possible pain</th>
</tr>
</thead>
</table>

Secondary outcome measures

A secondary outcome measure in this study is caregiver adherence. Subgroup analyses is also carried out to evaluate any differences between exercise modalities within and between the experimental and control groups.

Caregiver adherence

Caregiver adherence is a measure in this study due to its significance in the role of caregivers assisting with exercise. An adherence survey containing seven questions is given to caregiver participants to complete at baseline, midpoint, and endpoint. The survey is completed through a link leading to Qualtrics. The questions are on a scale of strongly agree to strongly disagree. The question consists of; 1. 'We completed all scheduled exercise sessions,' 2. 'We completed all exercises prescribed,' 3. 'The sessions fit into our daily/weekly routines,' 4. 'We required extra assistance with exercise programs,' 5. 'We required extra assistance understanding and completing exercises,' 6. 'I feel motivated to support with exercises,' and 7. 'I feel competent in assisting with exercises.'
Adverse outcomes

An adverse outcome that could lead to a disadvantage is caregivers’ interpretation of the Physitrack demonstration videos and paper-based program descriptions. Caregivers may interpret these differently, leading to slight changes in exercise performance between groups and CP participants. This could affect the GMFM scores, AVAS scores, and grip strength measures.

Statistical analyses

Independent T-tests (for continuous data, if normally distributed), Mann-Whitney tests (for continuous data, if not normally distributed), and Chi-square tests (for dichotomous and ordinal data) will be used to evaluate between group differences at baseline and the midpoint/endpoint periods (8 and 12 weeks). Paired sample T-tests are used to determine the effect of the online training program, for the experimental group and the control groups (interaction between group * time). An ANOVA with a Levine’s test for normality of data will be conducted to investigate which group has the most benefits to those with CP. Statistical significance is accepted at p<0.05, and the statistical analysis is performed using IBM SPSS 18.2 software (SPSS, Chicago, Illinois, USA).

Ethical and dissemination

Ethical approval and trial registration

Full, national ethical approval is required by the district health board (DHB), and the trial needs to be registered with the Australian and New Zealand Clinical Trials Registry (ANZCTR) before running the 8-week intervention.
Data storage and dissemination of findings

Participants (CP clients and their caregivers) will be monitored by researchers on testing during the 8-week intervention at weeks zero and eight (with a 12-week endpoint test after the intervention). Participant information is stored on a password protected computer. Participant confidentiality is maintained for all data and forms by using numbers allocated to participants instead of names (e.g., participant 1, participant 2…). Final results will only be accessible to members of the research team. Results of the study may be released once findings are disseminated by publication in peer-reviewed journals, conferences, and research organisations. Results will be disseminated regardless of the magnitude or direction of effect on assessing the effectiveness of an online habitual exercise program for CP clients using 'Physitrack'.

Discussion

COVID-19 and technology

In a post-COVID world, online delivery, home-based exercise and apps are an important means of communication as we have all experienced the need to adapt our lives in a way that we can keep communication running through technology. A popular way that has been around since the early 2000’s but has now become highly efficient in a global pandemic is telehealth communication services (51). Having access to physical therapy/exercise programs at home are crucial to maintain maximum continuity for many populations including the CP population (51). Many healthcare providers have had to become creative with technologies and re-evaluate current models of distributing physical activity during this unnerving time, flexibility and innovation are key to providing clients with the resources needed to make home-based training via technology successful (51).
Conclusions

This chapter presents a protocol for an RCT assessing the effectiveness of an online habitual exercise program for CP clients using 'Physitrack.' Critical aspects of the study are outlined regarding the FITT principle; GMFM-88E, full body pain, and grip strength. Previous RCTs of CP clients using technology have not measured GMFM, full body pain, and grip strength but did measure adherence (7). Other physical activity training programs have assessed GMFM with some presenting conflicting results such as the improvement at endpoint not being statistically significant (19,20,29). The two major issues from previous studies that arose with GMFM was the results not being statistically significant or baseline measures, children with CP are unable to initiate tasks in the GMFM scoresheet measures (19,20,23). Previous studies suggested an increase in sample size (23) or longer duration in training interventions (19) to have statistically significant results. Another suggestion was made in terms of the limitations around detecting functional change in individuals with severe disabilities; the sensitivity to detect changes in the GMFM measure may not be suitable enough for the CP population (19). Keeping this limitation in mind, future research could look into creating a more suitable outcome measure for this population (19). The GMFM measure was chosen in this study’s intervention as they represented areas that CP children have difficulty within terms of motor function; but if another outcome measure were to become available, the validity and reliability of both measures would be tested to determine which would be best to measure. Previously, no RCTs have measured the effectiveness of Physitrack on GMFM, MACS, full body pain, adherence, and grip strength on three different subgroups (CV, MSC, and CV+MSC) in CP clients. Understanding the exercise programs with further instructional video demonstrations and descriptions might influence a better training technique and knowledge of the training program in this population and encourage clinicians to prescribe exercises using Physitrack. Burnout in caregivers comes from a failure to cope with the stress
due to low levels of motivation, tiredness and disappointment (11), but using an app that demonstrates and describes the required work could improve the level of adherence in caregivers.

**Strengths and limitations**

A strength of the present study was the RCT protocol was informed by a systematic review of the literature. This review provided the study with a variety of different outcome variables to test on the CP clients. These outcome variables included MACS, GMFM, AVAS, grip strength and caregiver adherence. The systematic review also assisted in the longer protocol timeframe.

A limitation of the present study was not including measuring the motivation and enjoyment levels of CP participants in the main study. With the age range from children to adolescents, exercising in a gym environment, doing the same repetitive exercises may not stimulate motivation and enjoyment for this population.

*In the next chapter:*

The following chapter presents an overall summary of the thesis topic.
Chapter 4: Discussion

Chapter overview

This chapter presents an overall summary of the thesis topic and the strength and limitations of the main study. Future directions are outlined, and complications of the COVID-19 pandemic are addressed.

Summary of thesis

The aim of this thesis was to evaluate the exercises and equipment used in the literature to develop a protocol for a large Randomised Controlled Trial (RCT) assessing the effectiveness of an online application (app); this was achieved by conducting a systematic review of the literature (Chapter 2) to analyse which outcome measures, exercises and interventions showed positive improvement with Cerebral Palsy (CP) clients and presenting these in the Chapter 3 protocol.

Online applications compared to paper-based programs

Throughout the literature review process for this thesis there was no published data found on the online application ‘Physitrack’, other than a developed RCT protocol (7). This created a gap in the literature to be able to design a study using Physitrack with CP clients. Since the completion of the literature review (and updated review), the completed RCT study was published (45). The hypothesis of the study was that Physitrack would improve home programming adherence, quality of exercise performance and goal achievement for CP clients and other neurological disability clients (45). This was due to Physitrack featuring exercise videos, adherence tracking and an application-based interface; but this was not supported by the preliminary findings (45). The method of delivery, from paper-based programming to online applications did not significantly affect adherence or other outcomes in this study (45).
This study was originally CP clients only in the protocol, but due to insufficient participant numbers of the CP population the study included children with other neurological disabilities (45). There were 47 participants who completed the full intervention (45). The RCT protocol (Chapter 3) having 210 participants would mean the validity of the intervention would be higher; and with 7,000 people with CP in New Zealand in 2019 (52) there would be enough participants to support the RCT protocol.

Use of online applications in physical activity

Online applications are used with many different populations for physical activity. They can be used as a rehabilitation, therapeutic, adherence and strength training application for those individuals with disabilities and disorders (13,23,45), they can be used for measuring various body functions during exercise (heart rate for example) (53), and online applications can have many other uses with youth sports, strength and conditioning and physical therapists. Online applications can be useful throughout many different populations with the way that technology is growing globally (39). With most of the world having easy access to a source of technology it creates an easier avenue into receiving the information promptly and with great detail (39), which makes it easier for caregivers to deliver programs to their disabled clients; especially children with CP who have difficulties with neuromuscular activity (1). Virtual reality is much more popular with special populations than online applications as they are more engaging for the client (45). Online applications are more than often used by those conducting the program, such as a physiotherapist, health professional or parent/caretaker (45). Exercise demonstrations through videos on a mobile/smartphone application are a popular way of using technology, this allows a user to access the information needed remotely (54). Being able to access video demonstrations remotely can reduce the cost of exercise rehabilitation as it can be performed at home (8). As stated in Chapter 1; Basaran et al. found that almost two-thirds of the caregivers within their study suffered from mild to severe depression and anxiety and with
increased stress and emotional demands elevating psychiatric symptoms for caregivers (11), there needs to be a solution to help the caregivers decrease exhaustion and burnout. Using online applications such as Physitrack could lead to increased caregiver adherence with the extra assistance with exercises an app provides.

*Impact of COVID-19 on this thesis*

2020 was a challenging year for many people globally. The year in which this thesis was to be conducted carried from June 2019 - June 2020. An extension was granted for the Master of Applied Science course due to the COVID-19 lockdown in New Zealand (NZ). Changes to the original thesis layout were made to resume writing during the global pandemic. The thesis was initially a feasibility study and required category A ethics with a population of vulnerable participants. A proposal was sent to the Otago Polytechnic Ethics Committee and was approved (Appendix A). Once ethics was approved, emails were sent out to CCS Disability Action and Southern Rehabilitation for participant recruitment in Dunedin, NZ. Included in the email were a participant recruitment poster and an intervention information sheet. These emails were sent on 07/02/2020. Most companies were preoccupied with COVID-19 emerging in neighbouring countries, sorting out plans in case NZ went into lockdown. There was a breakdown of communication between researchers and companies as emails, visits and phone calls led nowhere. Once NZ went into level 4 lockdown, there were amendments made to ethics for propulsive sampling for the whole of NZ (this allowed for recruitment through social media and word of mouth as well as emailing companies NZ wide), and changes were made so the intervention could be executed at home within the participant's isolation bubble. A timeframe from March 2020 to the end of May 2020 was set to recruit participants. Unfortunately, only one potential participant completed the eligibility test for inclusion in the intervention but was excluded based on criteria, therefore, it was decided that a systematic
review and a protocol for a RCT would be sufficient for a Master thesis and was implemented into the main study (Chapter 3).

Changes were made based on indications from the systematic review from the original thesis plan to the protocol for an RCT. The review helped to demonstrate the original study may have been a bit flawed and being more rigid with the review allowed for a more prescriptive plan on how to conduct the RCT. Changes were made with the age group of CP participants, the length of the intervention, type of intervention and testing and the outcome measures. The protocol still executed the aim of the thesis overall, to evaluate the exercises and equipment used in the literature to develop a protocol for a large RCT assessing the effectiveness of an online app.

**Strengths/Limitations**

The present study’s major strength was that the protocol in Chapter 3 was informed by a systematic review of current literature (Chapter 2). The updated search revealed different variables that added diversity into the protocol. These included Manual Ability Classification System (MACS) and pain using Visual Analog Scale (VAS). Adding MACS into Chapter 3 was relevant as it tested the CP participants handling ability (6), which was an essential part of the exercise programs as many exercises required handling objects/exercise machines. The main strength of the present study was the synthesis of various articles in the literature search to create one intervention (Chapter 3). All variables used in Chapter 3 came from separate articles that had not tested these specific variables together; Gross Motor Function Measure (GMFM) (19,20,23), grip strength (10,13), caregiver adherence (9,11), and full body pain (22). These variables all showed positive effects on CP clients and caregivers in their articles. Another major strength is using Physitrack as the experimental exercise modality for Chapter 3 and this thesis. Only one other study (7) used an online app to run an exercise program.
intervention to the best of researchers knowledge. With detailed descriptions and definitions and an easily accessible, cost-effective way to perform an exercise program, it was a robust way to develop a practical exercise program with this population and including caregivers as supporters of adherence (7).

A limitation was the accessibility to technology in lower-income families. Although online apps were deemed or considered cost-effective compared to clinician appointments (occupational therapists, physiotherapists, personal trainers), not all families have access to technology, or the internet and they can be expensive. Finally, a limitation of the Chapter 3 intervention, both the app and paper-based program were the same for each individual. CP participants are of Gross Motor Function Classification System (GMFCS) level II and III and MACS level I, II and III, but the motor function of each individual participant can vary depending on secondary disorders/disabilities and the exercises in the program, though the results of Chapter 3 were purely based on the effectiveness of the app/paper-based program.

A limitation with using Physitrack that the full study by Johnson et al, found, the online application is not designed specifically for children (45). Although Physitrack provides features that support exercise programs that conventional methods do not, a therapy prescription application designed specifically for children with disabilities is more engaging (45). This may be due to bright and playful colours used and games and rewards when completing exercises (45). This method is used effectively with virtual reality interventions for children with disabilities (6,10,24). This limitation was not taken into consideration when designing the protocol in Chapter 3, exercise adherence is important for the CP clients, but adherence was more aimed towards caregivers in Chapter 3, and an online application with exercise videos could be a useful tool. Modifications to this protocol could include an interface that uses child-friendly graphics in combination with the exercise descriptions for the caregivers.
Future directions

This thesis laid the groundwork for a RCT protocol which needs to be conducted to discover the intervention results. Will there be improvements and benefits for CP clients and caregivers? Will the intervention be effective? Future research may need to be conducted with a larger sample size or in a different location nationally and globally. With the number of articles in the original literature search and the updated search, it was evident that a large number of articles were published within this population. There will need to be updated literature searches conducted frequently, especially before the Chapter 3 protocol is conducted in case of new evidence in the field. With the impact of COVID-19 on this thesis, a future direction that could be addressed for Chapter 3 is creating an online exercise program that is home-based rather than gym-based. Exercises that can be performed with equipment used in the home environment would have been beneficial for the main study (Chapter 3) and could be a useful direction for future studies.
References


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Appendices

Appendix A: Ethics approval

Ethical Approval for original study

10 December 2019

Lauren Kelly
c/- Otago Polytechnic School of Sport, Exercise and Health
40 Logan Park Drive
Dunedin 9016

Dear Lauren

Application for Ethics Consent

Reference Number: 836
Application Title: Assessing the feasibility of an online habitual exercise program for Cerebral Palsy Patients using Physitrack.

Thank you for your application for ethics approval for this research project.

This letter is to advise that the Otago Polytechnic Research Ethics Committee review panel has approved your application, following amendments made in response to feedback.

We wish you well with your work and remind you that at the conclusion of your research to send a brief report with findings and/or conclusions to the Ethics Committee.

All correspondence regarding this application should include the project title and reference number assigned to it.

This protocol covers the following researchers: Lauren Kelly, Codi Ramsay, Richard Humphrey.

Regards

Dr. Liz Ditzel
Chair, Otago Polytechnic Research Ethics Committee
Ethical approval for amendments to original study

20 April 2020

Lauren Kelly

c/- Otago Polytechnic School of Sport, Exercise and Health
40 Logan Park Drive
Dunedin 9016

Dear Lauren,

Ethics approval for amendments to project

Reference Number: 836
Application Title: Assessing the feasibility of an online habitual exercise program for Cerebral Palsy Patients using Physitrack.

Thank you for notifying Otago Polytechnic Research Ethics Committee regarding proposed amendments to this research project as a result of the Covid19 Alert Level 4 Lockdown. We are satisfied that you have considered the necessary changes in response to the new ways that you will conduct your research.

This letter is to advise that the following have been approved:
1. Individuals within the cerebral palsy patient’s isolation bubble to conduct intervention.
2. Changes to sampling to include snowball sampling, contacting existing clients of the researcher to recruit other patients with cerebral palsy, through support worker colleagues, and social media sites.

We wish you well with your work and remind you that at the conclusion of your research to send a brief report with findings and/or conclusions to the Ethics Committee. All correspondence regarding this application should include the project title and reference number assigned to it.

Regards,

Dr. Liz Ditzel
Chair, Otago Polytechnic Research Ethics Committee
Appendix B: Survey’s developed using Qualtrics

Cerebral Palsy screening survey

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your DOB?</td>
<td></td>
</tr>
<tr>
<td>What is your Gross Motor Function Classification System (GMFCS) level?</td>
<td>I, II, III, IV, V, Unknown</td>
</tr>
<tr>
<td>What is your Cerebral Palsy type?</td>
<td>Ataxic, Dyskinetic, Mixed types, Unknown</td>
</tr>
<tr>
<td>Do you require caregiver assistance?</td>
<td>Yes, Occasionally, No</td>
</tr>
<tr>
<td>Do you require caregiver assistance during exercise?</td>
<td>Yes, Maybe, No</td>
</tr>
<tr>
<td>What are your communication abilities with others?</td>
<td>Verbal, Non-verbal, Written (paper or text), Visual</td>
</tr>
<tr>
<td>What is your exercise experience?</td>
<td>I exercise currently, I have exercised in the past, I have never been involved in exercise</td>
</tr>
<tr>
<td>Have you received any surgeries or Botox injections within 6 months of filling out this form, if so please state what you received below:</td>
<td></td>
</tr>
</tbody>
</table>
Do you have any surgeries or Botox injection appointments within the next 3 months?

- Yes
- No

Your email address

Your mobile number (optional)

Click to write the question text

I'm not a robot

---

**Caregiver screening survey**

What is your DOB?

Do you currently support an individual with Cerebral Palsy?

- Yes
- No
- I have previously

What is your exercise assisting experience with your Cerebral Palsy patient?

- I have assisted with exercises in the past
- I currently assist with exercises
- I have never assisted with exercises

Click to write the question text

Your email address

Your mobile number (optional)

Click to write the question text

I'm not a robot
**Caregiver adherence survey**

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>We completed all scheduled exercise sessions</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
</tr>
<tr>
<td>We completed all exercises prescribed</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
</tr>
<tr>
<td>The sessions fit into our daily/weekly routines</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
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<tr>
<td>We required extra assistance with exercise programs</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
</tr>
<tr>
<td>We required extra assistance understanding and/or completing exercises</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
</tr>
<tr>
<td>I feel motivated to support with exercises</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
</tr>
<tr>
<td>I feel competent in assisting with exercises</td>
<td>Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree</td>
</tr>
<tr>
<td>Did you prefer the online application/exercise program compared to paper-based exercise programs?</td>
<td>Yes, Maybe, No</td>
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</table>
Appendix C: Exercises in the Chapter 3 intervention and Physitrack permission email

Figure 12: Physitrack permission email to use images from the online application

Re: Physitrack images used in thesis

Phystrack Support <support@phystrack.com>

Dear Lauren,

Thank you for your email.

Go ahead. As long as the images are not distributed outside your thesis, and your thesis is not used commercially, this is fine.

Please do add appropriate credits / source information for the images, though.

Please feel free to email me, should you have any further questions - I’m always happy to help.

Best regards,

Nathan

Nathan Stevinsnow
CTO & co-founder
Phystrack PLC

support@phystrack.com
https://support.phystrack.com

Figure 13: Treadmill walk adapted from (Physitrack, 2012) (47).

Clip the safety stop buckle to your clothing. Hold onto the heart rate handles. Walk at a comfortable speed.

If you are unable to walk on a treadmill, contact the researcher for an alternative exercise.
Figure 14: Cycle ergometer adapted from (Physitrack, 2012) (47).

Cycle Ergometer

Use the boxes as steps to get onto the cycle ergometer if applicable. Secure the patients' feet onto the pegs and pedal at the lowest resistance (increase if the patient finds the exercise too easy).

If the patient is unable to cycle, contact the researcher for an alternative exercise.

Figure 15: Arm crank machine adapted from (Physitrack, 2012) (47).

Matrix crank cycle pull

Move your chair into position and ensure your brakes are locked. Change the machine lock pin from LOCK to ROTATE
Rotate the crank unit 180 degrees.
Adjust the handle to the LOCK position.
Adjust the crank to shoulder height and adjust the resistance level as required.
Take hold of the crank in both hands and perform a fluid rotational cycling movement in the backward direction.
Figure 16: Seated leg press adapted from (Physitrack, 2012) (47).

Place feet in the middle of the leg press platform, shoulder-width apart. Push forwards and backward, keeping your knees in line with the shoulders. Control the machine at a steady pace to the best of your ability.

If you are unable to move from a wheelchair, contact the researcher for an alternative exercise.

Figure 17: Seated bent knee calf raises adapted from (Physitrack, 2012) (47).

Sit on a bench with a box/step at the patient's feet. Place each foot, from the middle of the foot to the toes on the box/step. Raise feet towards the roof, then towards the ground. Repeat.
**Figure 18:** Grip squeeze adapted from (Physitrack, 2012) (47).

Hold a ball in your hand. Squeeze the ball as hard as you can and hold. Allow your wrist to move in whichever direction feels natural.

**Figure 19:** Gripping ball adapted from (Physitrack, 2012) (47).

Sit upright in front of a table. Place your weaker arm onto the table with your elbow bent, and hold a tennis ball in your palm. Squeeze the tennis ball in your hand and hold this position before releasing your grip. Aim to keep your elbow, shoulder, and body still during the exercise.
## Appendix D: Data extraction sheets

### Table 8: Data extraction sheet 1

<table>
<thead>
<tr>
<th>Review title</th>
<th>Study ID</th>
<th>Date form completed</th>
<th>Name of person extracting data</th>
<th>Study protocol</th>
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<tr>
<td>Can a six-week exercise intervention improve gross motor function for non-ambulant children with cerebral palsy?</td>
<td>Bryant, 2013</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Pilot randomised controlled trial</td>
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<td>A randomised clinical trial of strength training in young people with cerebral palsy</td>
<td>Dodd, 2003</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Randomised clinical trial</td>
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<td>Effects of a Therapeutic Recreation Intervention using Exercise: A Case Study with a Child with Cerebral Palsy</td>
<td>Groff, 2006</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Case study</td>
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<td>Nintendo Wii Resistance Training to Improve Upper-Limb Function in Children Ages 7 to 12 with Spastic Hemiplegic Cerebral Palsy</td>
<td>Kassee, 2015</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Home-based pilot study</td>
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<td>Strength training in adolescent learners with cerebral palsy</td>
<td>Unger, 2006</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Randomised controlled trial</td>
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<td>The effects of virtual reality-based bilateral arm training on hemiplegic children's upper limb motor skills</td>
<td>Do, 2016</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Single-subject experimental design</td>
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<td>The Effect of Aquatic Intervention on the Gross Motor Function and Aquatic Skills in Children with Cerebral Palsy</td>
<td>Dimitrijevic, 2012</td>
<td>11/12/19</td>
<td>Lauren Jayne Kelly</td>
<td>Randomised controlled trial</td>
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<tr>
<td>A biofeedback-enhanced therapeutic exercise video game intervention for young people with cerebral palsy</td>
<td>MacIntosh, 2020</td>
<td>5/10/20</td>
<td>Lauren Jayne Kelly</td>
<td>Randomised single-case experimental design feasibility study</td>
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</table>
The effects of an eight-week multi-model sport activity home program on function of children with cerebral palsy

Polat, 2020  5/10/20  Lauren Jayne Kelly  Randomised controlled trial

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**Table 9: Data extraction sheet 2**

<table>
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<th>Study</th>
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<td>Bryant, 2013</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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<tr>
<td>Dodd, 2003</td>
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<td>Yes</td>
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<td>Groff, 2006</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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<tr>
<td>Kassee, 2015</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
<td>Yes</td>
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<tr>
<td>Unger, 2006</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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<tr>
<td>Do, 2016</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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<tr>
<td>Dimitrijevic, 2012</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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<td>MacIntosh, 2020</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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<td>Polat, 2020</td>
<td>Cerebral palsy, GMFCS, Online apps, Experimental group exercises</td>
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