**I. Background**

Physical activity and public health guidelines suggest that children with cerebral palsy (CP) participate in aerobic and muscle-strengthening activities at moderate-to-vigorous intensities.1 However, because of deficits in muscle tone, range of motion, cardiorespiratory endurance, and balance and coordination, it is difficult for them to satisfy this recommendation, especially non-ambulators classified at Gross Motor Function Classification System (GMFCS) levels IV and V. This community-based health promotion program seeks to promote physical activity in children with CP, regardless of their functional ability, through aquatic exercise and stationary cycling, guided by the Transtheoretical Model and stages of change.

The Transtheoretical Model posits that health behavior change occurs over time, progressing through six stages: precontemplation, contemplation, preparation, action, maintenance, and termination.2 Seeing that being physically active depends on a child’s decision, and their parents’ decision, to make a lifestyle modification, thought should be given to their readiness to change. Through a series of surveys and interviews, facilitators and barriers to physical activity in children with CP, or children with another physical disability, have been categorized by the stages of change.3,4 Families at the precontemplation stage had negative attitudes about the supports that their child needs for athletic participation.3 Facilitators were the child’s desire to be active and parents’ awareness of its benefits.3 In the contemplation, preparation, and action stages of change, families were more likely to identify environmental barriers related to the social environment and the program they chose.3 Program feasibility was a facilitating factor, along with the joy that children receive from exercise and group interaction.3

Children commented on other factors to being active, such as the “lack of appropriate and inclusive opportunities” and the physical limitations of their disability.4 When asked about playing with their peers, one person said, “It makes me feel awkward and I feel like I will be judged by those around me.”4 This program, designed for children with CP, accounts for these thoughts in and of itself; but with added consideration to what stage of change they are in, the program and its staff can appreciate barriers and use facilitators of that stage to urge children and their families to take action on increasing physical activity behavior.

Land-based exercise is a first-line intervention to establish a baseline of physical activity, but gravity compromises children’s joint integrity and freedom of movement.5,6 Aquatic exercise offers an alternative environment where the properties of water counterbalance the effects of gravity. Buoyancy enables decreased joint loading and weight-bearing by supporting an individual’s body weight, and it can assist in exercise performance, depending on the position and direction of motion.7 Water immersion results in hydrostatic pressure that is proportional to the depth of the water and equal in every direction. This property forces fluid from the extremities to the chest, promoting lymphatic return and cardiovascular conditioning.7 Hydrostatic pressure and turbulence create resistance that can increase the intensity of exercise and allow for strengthening in all planes of motion,7 offering yet another advantage.

In recent years, aquatic exercise has emerged as a potential lifelong fitness activity that may aid in the prevention of secondary conditions, such as hypertension and depression, in children and adults with CP.7 It not only targets their mental and physical fitness, but when provided in a group setting, it presents the opportunity for peer motivation, known as an interpersonal component of the Social Ecological Model. Moreover, Lai et al8 determined that aquatic exercise has a positive effect on children’s enjoyment, which incentivizes their participation, as well as their parents’.

As an impairment-focused activity, the effectiveness of aquatic exercise at the individual level is clear. Several researchers have documented the outcomes of aquatic exercise in children with CP, including improvements in spasticity, walking endurance, gait and balance, quality of life, and gross motor function.8-11 A systematic review conducted by Dolbow et al12 found that studies reported statistically significant improvements in at least one functional or physiological measure following activity-based interventions in an aquatic environment. Using a group protocol like the one proposed, Ballaz et al13 and Fragala-Pinkham et al14 observed increases in energy expenditure and cardiovascular endurance secondary to “large doses of swimming and water play activities that use aerobic energy systems.”12 Dosing across age categories and GMFCS levels have yet to be determined. Parameters vary between studies, with hour-long sessions ranging from 2 to 5 times per week for 6 weeks or longer.8-11 One 10-week study showed maintenance of gains at follow-up, whereas a comparable 6-week study failed to do so.10,12 This may indicate that the length of the intervention is related to functional preservation after the program’s cessation, but the hope is that aquatic exercise will become a permanent addition to children’s exercise regimens.

Lower-extremity cycling has traditionally been utilized in able-bodied populations, but with its potential to simultaneously strengthen the hip, knee, and ankle musculature without the need for motor control, it is equally appropriate for children with CP.15 Strong outcomes, with statistical differences between experimental and control groups, provide preliminary support for its use in both research and clinical settings. The Pediatric Endurance and Limb Strengthening (PEDALS) project, one of the first community-based stationary cycling interventions of its kind, demonstrated improvements in walking and running endurance, gross motor function, and measures of lower extremity strength.15 While the inclusion criteria for PEDALS specified subjects classified at GMFCS levels I-III, similar results were confirmed in a trial of non-ambulatory children with CP who belonged to categories IV and V.15,16 Anterior and lateral trunk support, wrist supports, footplates, and ankle straps were added to the stationary bicycle to accommodate those with poor sitting balance, thus maximizing their participation. After 3 sessions per week for 6 weeks, “all participants were able to pedal against a harder resistance, for longer and faster.”16 Their progress in functional skills was supported by the Gross Motor Function Measure-66 (GMFM-66), a performance-based outcome measure in which the majority of participants’ standing ability and walking, running, and jumping scores were higher at the end of the intervention.16

These studies differ in terms of parameters, yet both are deemed successful. The PEDALS protocol was designed for a total of 30 sessions, occurring 3 times per week within a 12-week period, while the second study maintained this frequency for 6 weeks.15,16 Based on the gap in duration, it seems logical that the minimum be upheld in future applications, in order not to risk the effectiveness of the program.

Considering the feasibility of riding an adaptive stationary bicycle, cycling training caters to all GMFCS levels, thereby eliminating a salient barrier to physical activity in children with CP. As stated by Williams and Poutney,16 “The static bicycle [provides] a safe, effective means of exercise to a population with very limited opportunities for activity.” This advancement in equipment instills confidence in children with CP and those around them, providing reinforcement for continued physical activity on an individual and interpersonal level.

This community-based health promotion program will use the following outcome measures: dimensions D and E of the GMFM-66, the 6-Minute Walk (6MWT) or Push Test (6MPT), and the Physical Activity Questionnaire for Older Children (PAQ-C) or Adolescents (PAQ-A). The GMFM-66 is a 66-item subset of the original 88 items that assess gross motor function in children with CP.17 Dimensions D and E contain high-level motor skills of standing, walking, running, and jumping that have been labeled indicators of daily activities and sedentary behavior.18 The GMFM-66 is sensitive to change with a minimal clinically important difference of 1.3 points,19 hence it is expected to reflect improvements in children’s gross motor function, as well as their physical activity. The 6MWT and 6MPT are reproducible functional tests of exercise capacity. They track the distance walked or propelled with a manual wheelchair, with longer distances corresponding to higher levels of fitness. The psychometric properties of the 6MWT and 6MPT are understudied, but increases of more than 54.9 meters and 62.2 meters, respectively, are considered clinically meaningful.20,21 The PAQ-C and PAQ-A are 7-day recall questionnaires for elementary school- and high school-age students, both with and without CP.22,23 They generate an activity summary score from self-reported physical activity at school, in the evenings, and over the weekend.23 Combined with the performance-based outcome measures, an increase in the activity summary score indicates that children have increased their physical activity behavior, which also indicates success of the program.

**II. Program Goals**

As part of promoting physical activity in children with CP, this community-based health promotion program will use the above-mentioned outcome measures to monitor the growth of participants and the program itself. Associated goals are as follows:

1. By the conclusion of the 3-month program, participants’ scores for dimensions D and E of the GMFM-66 will increase by 1.3 points to demonstrate a statistically significant improvement in their gross motor function.19
2. By the conclusion of the 3-month program, participants’ distance walked or propelled in a manual wheelchair in the 6MWT or 6MPT will increase by 54.9 meters or 62.2 meters, respectively, to represent a clinically meaningful change in their exercise capacity.20,21
3. By the conclusion of the 3-month program, participants’ activity summary score for either the PAQ-C or PAQ-A will increase by 1 point between the values of 1 and 5 to signify an increase in their physical activity behavior.23
4. At the conclusion of the 3-month program, its attrition rate will total 25% or less as evidence of the feasibility of the aquatic and exercise and stationary cycling interventions for children with CP and their families.
5. At 3 months following the conclusion of the program, participants will maintain their activity summary score for either the PAQ-C or PAQ-A within 0.5 points of their post-intervention assessment to show a long-term improvement in health status and habitual physical activity, in particular.

**III. Methods**

*Program Resources*

This community-based health promotion program requires a variety of resources: a wellness center with an accessible warm water swimming pool and gym space; aquatic fitness equipment, such as pool noodles, kick boards, fins, and leg weights; 8 stationary bicycles with external supports for children with poor sitting balance16; adequate staffing to assist participants, which is outlined below; and tools for administration of outcome measures, including their user manuals and software, pen and paper, a tape measure, and exercise mats.17 The methods of this program are staged for the Triangle area of North Carolina, where there are not only convenient facilities that satisfy most, if not all, of these requirements, but there are children with CP at all GMFCS levels who are in need of its services.

*Participants and Personnel*

Flyers and brochures detailing the “who, what, when, where, and how” of the program will be distributed to pediatric offices, schools, and churches within a 25-mile radius. These promotional materials are anticipated to drive referrals from local healthcare providers in medicine, physical therapy (PT), occupational therapy, speech therapy, and beyond, making them the primary means of recruitment. Eligibility criteria include age between 5 and 18 years, a diagnosis of CP, being able to follow directions and answer questions about their health status, and receiving medical clearance to participate in an exercise program. Children will not be considered for enrollment if they have open wounds, swallowing precautions, chlorine or bromine allergies, or fear of water, as these are contraindications to water-based activities.7,10 Although not an official requirement, participants will be expected to have access to transportation, such as through the city or their support systems, for the duration of the program.

Cohorts will be limited to 16 participants in an effort to create a group environment that presents the opportunity for peer interaction during interventions that capitalize on their capabilities, thereby catering to the interpersonal and individual levels of the Social Ecological Model. Participants will be matched with PTs or other personnel with formal exercise and first aid training on a one-on-one basis, forging a 16-member staff for a single session. With PTs’ expertise in treating children with CP, they are well-suited for the responsibilities of this program; however, due to its part-time commitment and competitive employment opportunities, there may be an increased reliance on other trained professionals, whether volunteers or paid contributors.

*Program Structure*

This program is designed for implementation over a 3-month period. Based on recent research and physical activity guidelines, participants will join in aquatic exercise and stationary cycling 3 times per week for 45 minutes each.8-12,15,16 Sessions will be held on Mondays, Wednesdays, and Fridays from 3:30 to 5:00 in the afternoon, directly after school, to accommodate children’s schedules as they balance time between school, home, and extracurricular commitments.

Upon enrollment, participants and their families will meet with a PT on staff for a pre-intervention assessment, consisting of demographic data collection; baseline measurements of the GMFM-66, 6MWT or 6MPT, and PAQ-C or PAQ-A; and a discussion about the barriers and facilitators to their participation. This type of communication reinforces the Transtheoretical Model and stages of change as the governing principles of this program since it gauges the child and parents’ readiness to change. As stated in the program background, the staff will be compelled to consider what stage of change participants and their families are in and appreciate barriers and use facilitators of that stage to increase their physical activity behavior, while nudging them toward taking action to do so. Programming will begin the following week to give ample time for assessment of all participants, and reassessments will be scheduled at the end of the sixth and twelfth weeks of intervention and again at a 3-month follow-up. The post-intervention assessment during the twelfth and final week of the program will involve an exit interview regarding the program goals, stages of change, and overall program satisfaction, in addition to outcome measurements.

*Interventions*

Sessions will be 90 minutes in duration, allotting 45 minutes for aquatic exercise and 45 minutes for stationary cycling. Participants will be split into 2 groups of 8, where 1 group is stationed at an intervention and switched to the other intervention upon its completion. Leading with aquatic exercise, there will be 10 minutes of warm-up, 30 minutes of aerobic exercise and functional training, and 5 minutes of cool-down with slow-paced activity. These components are based on the Halliwick concept described by Lai et al,8 “which combines play, fun, self-help skills, and impairment-related goals.” The Halliwick concept focuses on improving muscle strength and endurance, motor control in the trunk and extremities, static and dynamic balance, and postural tone so that children with CP can participate in physical activity at a fuller capacity.7,8 Depending on the level of assistance they need in the water, as dictated by their GMFCS level, there are several exercises that align with this intent:

|  |  |  |
| --- | --- | --- |
|  | GMFCS Levels I, II, and III7,24 | GMFCS Levels IV and V7,24 |
| Warm-Up | Static stretching of upper and lower extremities, active range of motion exercises, shallow water walking, and step-ups onto a pool step | Static stretching of upper and lower extremities, active range of motion exercises, and shallow water walking |
| Aerobic Exercise | Treading water; swimming; prone kicking; forward, backward, and lateral shuffling; deep water walking; running; and relay races and tag games | Treading water, swimming, prone kicking, and shallow water walking |
| Functional Training | Stair and ladder climbing, heel and toe raises, single-leg stance, squatting, jumping jacks, tuck jumps, and ball games | Single- and double-leg stances, squatting, prone and supine floating, sitting balance on a kick board, and ball games |
| Cool-Down | Slow-speed swimming and shallow water walking | Slow-speed swimming and shallow water walking |

Exercise intensity will be increased by repetition of each movement, together with manipulation of the properties of water with aquatic fitness equipment and the depth of immersion, as the ability of each participant improves.8,9 For example, buoyant forces reduce weightbearing, but as less of an individual’s body is submerged in water, there is a greater need for trunk control, thus increasing the intensity of the activity.7

Stationary cycling will occur as a single phase of cardiorespiratory endurance training, granted that participants achieve independent cycling. It will consist of a 10-minute warm-up of lower extremity stretching for the hip adductor, knee flexor, and ankle plantarflexor muscles followed by pedaling without resistance; 30 minutes of continuous cycling in a target heart rate (HR) range; and a 5-minute cool-down of pedaling without resistance to return HR toward its baseline.15 A target HR range will be calculated for each participant using the Karvonen formula15: [(HRmax – HRrest) x 0.70 –0.80] + HRrest, where HRrest = resting HR and HRmax = 220 – age. Participants will begin pedaling at the lowest level of the constant power or constant watts setting on the stationary bicycle, which will be adjusted as their HR enters the target range. The resistance will be fine-tuned with participants’ responses to the OMNI Rating of Perceived Exertion Scale, a valid measure for children with CP that assesses their perceptions of physical effort on a numeric scale from 6 to 20.25-27

Children with CP who are classified at higher GMFCS levels, and who are unable to cycle independently, will undergo an adapted version of cardiorespiratory endurance training. They may need trunk, foot, and wrist supports and manual assistance to make a complete revolution. Participants will be asked to perform a graded exercise test in which the bike’s resistance is increased by 10 watts every 15 seconds until the maximum resistance they can pedal against is achieved.16 In subsequent sessions, this test will be replaced with a 10-minute warm-up of assisted revolutions. Then, to train for endurance, participants will pedal for as long as they can with a load of 75% of their maximum resistance.16 This sequence is not likely to take 45 minutes as planned, but for children with CP who are non-ambulatory, it is the equivalent of increasing the duration and intensity of the intervention in the preceding protocol.

**IV. Program Evaluation**

The goals of this community-based health promotion program reference both performance-based and patient-reported outcome measures that, as mentioned earlier, will be assessed twice during the length of the program and again at a 3-month follow-up. The program goals will be considered met if participants demonstrate the previously determined improvements, and maintain those improvements, in their scores for the GMFM-66, 6MWT or 6MPT, and PAQ-C or PAQ-A, all with continued enrollment from 14 or more children. While participants’ levels of physical activity are expected to increase in concordance with session attendance, the hope is that they will continue to participate in aquatic exercise, and maybe stationary cycling, after the conclusion of the program; therefore, not only is it important to quantify the change in their activity levels by the end of the twelfth week of intervention, but also to confirm or deny their upkeep when the responsibility to exercise is returned to the child and their family.

Although they are not formal goals, the stages of change and overall program satisfaction draw on the subjective, rather than the objective, success of this program. During the post-intervention assessment, participants and their families may be asked about their perceived benefits of the program, the feasibility of the program, its strengths and weaknesses, and suggestions for improvement. Their responses about what worked well and what did not, particularly in the context of barriers and facilitators to their participation, will steer the direction of the program for future cohorts.

Aside from goal assessment, the Centers for Disease Control and Prevention recommend their framework for program evaluation in public health.28 It has 6 steps, some of which are detailed below: engage stakeholders, describe the program, focus the evaluation, gather credible evidence, justify conclusions, and ensure use of evaluation findings and share lessons learned.28 In following these steps, the stakeholders of this program are the participants and their families, program staff, sources of referral, funding agencies, and members of the community-based organization in which the program will be held. Program participants and their families will be served by the program, while the program staff will operate it and the remaining stakeholders will use evaluation findings to tweak it. A description of the program, similar to what is already written, will be communicated with the stakeholders to produce clarity and consensus about the most central and important questions of the evaluation.28

Moving on to step 3, the newness of the program will merit a process evaluation that documents if the program has been implemented as intended.28 The aquatic exercise and stationary cycling interventions and their outcomes will be examined, along with staff competency and measures of access to the program’s services, to enable comparison of actual and planned program performance. From this point forward, quantitative and qualitative evidence will be gathered and interpreted accordingly. If all goes well, the evaluation findings will demonstrate that the program makes a contribution to increasing physical activity in children with CP, and that money is being spent appropriately and effectively in the process.

**V. Conclusion**

As a neurological population that survives into adulthood, children with CP are in need of a community-based health promotion program that prioritizes physical activity for the sake of preserving their mobility. The benefits of this type of program are twofold: being physically active promotes optimal physical, emotional, and psychosocial development,1 while reducing the risk for non-communicable diseases both in childhood and later in life.29,30 But the challenge in this patient population is that traditional modes of exercise, as in those on land, subject children with CP to the effects of gravity, and the movement difficulties that ensue become motives for sedentary living.7

In opposition, this program proposes an evidence-based strategy to promote physical activity through aquatic exercise and stationary cycling,12,15,16,24 paired with the Transtheoretical Model and stages of change.2,3 With thought to an individual’s readiness to change, and the barriers and facilitators to making that change, these interventions cater to the individual and their affiliation to their families, peers, and their community at large. Through the sole attention of trained professionals, even in a group environment, participants will be guided in activities that are adapted to meet their needs, thus optimizing their outcomes. By emphasizing both objective and subjective improvements in children’s physical functioning, this program seeks to make short- and long-term changes in the lives of its participants, as well as their families, for the betterment of their future.

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