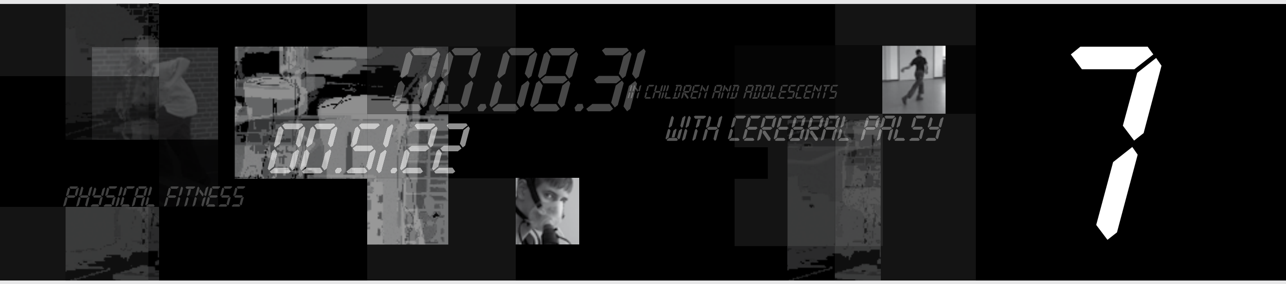

SUMMARY, GENERAL DISCUSSION AND CONCLUSION

Summary

Chapter 1 provides a brief introduction to the topic of the thesis. A review of the literature that focused on exercise training in children and adolescents with CP is presented in **Chapter 2**. We concluded that the methodological quality of the included trials was low. However, it appears that children with CP may benefit from improved exercise programs that focused on lower extremity muscle strength, cardiovascular fitness or a combination. The outcome measures used in most studies were not intervention-specific and often only focused on the International Classification of Function, Disability and Health (ICF) body function and activity level. There is a need to determine the efficacy of exercise programs to improve the daily activity and participation level of children with CP and increase their self competence or quality of life.

In **Chapter 3**, the newly developed 10-m shuttle run tests (SRT) for children who are classified at Gross Motor Function Classification System Level (GMFCS) I and II, are examined for their reliability and validity to measure aerobic capacity in children and adolescents with CP. The SRT-I was developed for children at GMFCS level I, and the SRT-II was developed for children at GMFCS level II. Twenty-five children and adolescents with CP (classified at GMFCS level I or II) participated in this study. To assess test-retest reliability the 10-m shuttle run tests were performed by the subjects within two weeks. To examine validity, the shuttle run tests were compared with a GMFCS level-based treadmill test designed to measure peak oxygen uptake. The results show that 10-m shuttle run tests yield reliable (intraclass correlation coefficients (ICC's) of 0.97 for SRT-I and 0.99 for the SRT-II) and valid (r=0.96 for both tests) data. Moreover, the shuttle run tests have advantages over a treadmill test for children with CP who are able to walk and run (GMFCS level I or II).

In **Chapter 4**, two running based measures, the Muscle Power Sprint Test (MPST) and the 10x5 Meter Sprint Test, are being studied on its reliability and validity to measure respectively the Mean and Peak Muscle Power and agility. Twenty-six children and adolescents with CP (classified at GMFCS level I or II) participated in this study. We found good feasibility and reliability for the 10 x 5 Meter Sprint Test and the MPST (ICC's of ≥ 0.97 for interobserver and test-retest reliability) in children and adolescents with CP (GMFCS classification level I or II). The validity of both tests is supported by significant differences in scores between children classified at GMFCS level I and children at level II. To assess the muscle power during running performance in children with CP the Mean Power derived from the MPST is the most appropriate outcome measure. To assess someone's running performance and coordination of speedy movements the 10 x 5 Meter Sprint Test is the most appropriate measure. In our opinion, the 10 x 5 Meter Sprint Test and the MPST can be incorporated in the exercise evaluation of the child with CP, classified as level I or II on the GMFCS.

In **Chapter 5**, two ways to measure muscle strength are being studied. For Hand-Held Dynamometry (HHD) the make- and break-method are being compared regarding their reliability. Moreover, in this Chapter a new instrument (the 30-sec Repetition Maximum(RM)) to measure functional muscle strength is examined on its reliability. To assess functional performance in children with CP we chose functional exercises in which the large muscle groups that are important for standing and walking are being tested. Three closed kinetic chain exercises were chosen: 1a) Lateral Step-upTest left, 1b) Lateral Step-upTest right, 2) Sit-to Stand, 3a) Attain stand through half kneel left, 3b) Attain stand through half kneel right. Twenty-five subjects with CP (GMFCS level I or II) participated in this study. The intertester reliability of strength measurement using a HHD was questionable with ICC values ranging from 0.42 to 0.73 for the break-method, and from 0.49 to 0.82 for the make-method. The Standard Error of Measurement (SEM) and Coefficient of Variation (CV(%)) values ranged from 27.9 to 58.9 and 22.2% to 35.3% for the break-method and from 30.6 to 52.7 and 16.2% to 56.2% for the make-method. The intertester reliability of strength measurement using the 30-sec RM was acceptable with ICC values ranging from 0.91 to 0.96, and SEM and CV(%) values ranging from 1.1 to 2.6 and 10.9% to 39.9% for the functional exercises. The results of this study demonstrate that the make-test is the preferred muscle strength test method when using HHD. Moreover, clinicians can use a 30-second RM as a functional strength test to obtain highly reliable measures of lower extremity performance when used conform a standardized protocol.
Chapter 6 describes the effects of a functionally based fitness program that is added to usual care for children with CP (GMFCS level I or II) on aerobic and anaerobic capacity, agility, muscle strength, self-concept, gross motor function, participation and health-related quality of life. To evaluate the effects of an eight-months training program with standardized exercises on aerobic and anaerobic capacity in children and adolescents with CP a pragmatic randomized controlled clinical trial was performed. A total of 86 children with CP (aged 7–18 years) classified at GMFCS-level I or II participated in this study. Sixty-eight participants agreed to participate and were randomly assigned to either the training group (TG; n=34) or the control group (CG; n=34). The TG met twice per week for 45 minutes circuit training in group format that focused on aerobic and anaerobic exercises.
Assessments were performed at baseline (T0), after 4 months (T1) and directly after the 8 months intervention period (T2) in both groups. There was a follow-up assessment with the same measures in both groups at twelve months after T0. Our primary outcome measures were aerobic and anaerobic capacity. They were assessed by respectively the 10-m shuttle run test and the Mean Power derived from the MPST. Secondary outcome measures included agility (10x5 Meter Sprint Test), muscle strength (30-sec RM), self competence (Self Perception Profile for Children), gross motor function (Gross Motor Function Measure), participation level

(Children's Assessment of Participation and Enjoyment) and health-related quality of life (HRQoL; TACQOL). A significant training effect was found for aerobic capacity ($p<0.001$) and anaerobic capacity ($p=0.004$). A significant effect was found for agility ($p<0.001$), muscle strength ($p<0.001$) and athletic competence ($p=0.005$) as well. The intensity of participation showed a similar effect for the formal ($p<0.001$), overall ($p=0.002$), physical ($p=0.005$) and skilled-based activities ($p<0.001$). On the HRQoL a significant improvement was found for the domains motor ($p=0.001$), autonomy ($p=0.020$) and cognition ($p=0.042$). Hence, an exercise training program improves physical fitness, the participation level and health-related quality of life in children with CP when added to standard care.

At follow-up we noted a significant difference in outcome measures. The training group reached levels that are similar to the levels at T1, after four months of training.

We concluded that an eight-month standardized exercise program consisting of functionally based exercises significantly improves physical fitness, the intensity of activities and health-related quality of life in children with CP when added to standard care.

General discussion

What we know

The RCT described in Chapter 6 showed that an eight-month standardized exercise program consisting of functionally based exercises significantly improves physical fitness, the intensity of activities (participation) and health-related quality of life in children with CP when added to standard care. However, at follow-up we noted a significant decrease in these outcome measures. The training group reached levels that are similar to the levels at T1; after four months of training.

Enhanced participation can be viewed as the ultimate outcome for pediatric rehabilitation.[1] Therefore, measurement of participation is necessary to evaluate the effectiveness of rehabilitation programs. King et al.[2] discussed that the Children's Assessment of Participation and Enjoyment (CAPE) could be useful in determining the effectiveness of clinical trials. The intensity-score of the CAPE showed its ability to detect change over time in our RCT. In a recent review by Sakzewski et al.[1] it was concluded that not one measure covered the full breadth of participation outlined by the ICF. This necessitates the use of multiple assessments to measure the broad perspective. The Children's Assessment of Participation and Enjoyment (CAPE)[3], the School Function Assessment (SFA)[4] and the Life Habits for Children (LIFE-H)[5] in combination cover participation in home, school, and community life.

Incorporation of participation measures in clinical trials will lead to a greater understanding of how interventions for children with CP have an impact on the broad context of participation.

Law et al.[6] provided a foundation from which to gain an improved understanding of the participation of children with physical disabilities in recreational and leisure activities. This information can assist families and service providers in planning activities that fit with their child's preferences and ensure active participation.

In using this knowledge it is important to consider that greater participation is not necessarily better, and lower participation does not imply personal failure.[7,8] A child could choose a variety of participation patterns, ranging from intense involvement in a few activities to participation in many activities. Participation in activities outside school is a choice that children and their families make to fit their needs, preferences, environment, culture, and lifestyle.[6]

As described in Chapter 1 (introduction) the human body makes adaptations to cope with the stresses placed on it during periods of exercise. For training adaptations to occur the bodies systems must be overloaded beyond their normal levels. If these extra stresses are applied over a period of time the system will adapt and this becomes its new norm. During periods of inactivity the human body will reverse these adaptations in an attempt to return itself to a norm as this is the current level of stress placed upon it. Therefore gains that have been made will be lost. Most training benefits are lost within a short period of stopping training. (Figure 1)

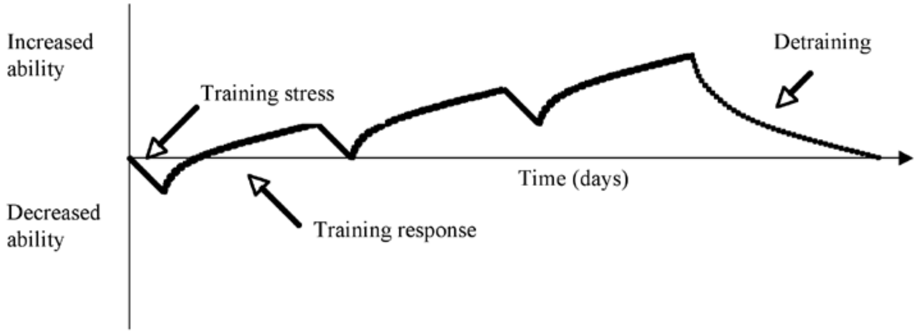

Figure 1. Schematic response of training and detraining.

The RCT described in Chapter 6 shows that changes seen in the school-based fitness intervention are reversed during a 4-month break. This observation illustrates the need to evaluate interventions for a sustained period. It is important to design interventions that will effectively improve childhood fitness. Developing and evaluating interventions to influence opportunities for healthful choices has been a focus of school-based health promotion research, including nutrition programs and physical education.[9] However, when interventions occur in a school-based setting, and are confined to the school year, an inherent question is one of sustainability.
In the RCT, that is described in Chapter 6 children were not specifically instructed to exercise during the four month summer break; in fact, no instructions were given about summer activity. Even during this relatively short break (four months) there was a loss of fitness benefits, resulting in a decline of fitness levels. These data show that in children with CP efforts to improve fitness should include exercise intervention in a sustained manner to improve fitness throughout the year, not just during the school-year. A more effective way to improve there general fitness could be by improving their participation in sports, play or active recreation outside the school-hours. Therefore, children with CP should be stimulated to participate in organized sports activities outside the rehabilitation center and schools for special education. However, at the moment, possibilities for handicapped children to be intensively active outside the rehabilitation center or school for special education are limited.
Moreover, it is unknown if barriers commonly observed in the general population (e.g. time, lack of interest, boredom) are similar or different in persons with CP. Therefore, barriers to exercise must be examined in persons with CP to have a higher chance of being successful.[10,11]

Effective assessment of outcomes in children with chronic health conditions is important to evaluate interventions.[12] The ICF provides a useful framework for both evaluation and intervention, considering aspects of body structure and function, activity, participation, and the influence of contextual factors on each domain. In order to conduct high-quality research into the effectiveness of rehabilitation and exercise programs, researchers need to be confident that their selected outcome will be sufficiently sensitive to change over time. The developed fitness tests in this thesis (10-m shuttle run test, Muscle Power Sprint Test, 10x5 meter Sprint Test and 30-sec Repetition Maximum) have not been investigated on its sensitivity to change.
The smallest detectable difference (SDD) is an indicator of sensitivity to change. Based on the Standard Error of Measurement (SEM), the SDD with 95% confidence is calculated as $1.96 \times \sqrt{2} \times SEM$. Only differences between two consecutive measurements greater than the SDD can be interpreted with 95% certainty as real change. There is an essential difference between 'clinically relevant change' and SDD. The SDD is a clinimetric property of a measurement instrument, while the 'clinically relevant change' is the change which clinicians and researchers minimally expect or judge as being an important change.[13,14] For the domains of functional outcome measured with the instruments in the present thesis, the 'clinically relevant change' is not known. However, in the RCT we found a 38% improvement for aerobic capacity using the 10-m shuttle run test, and a 25% improvement for anaerobic capacity using the Muscle Power Sprint Test after an 8 month exercise training program. Moreover, in the same study we found a 20 – 23% improvement in muscle strength using functional strength tests and a 15% improvement for agility using the 10x5 Meter Sprint Test. These values can be attributed with 95% certainty as real change since these values are greater than the calculated SDD. Moreover, these values are about the same magnitude as the measurement error of these outcomes, and show their sensitivity to change.
Therefore, it can be concluded that the newly developed outcome measures to assess aerobic capacity, anaerobic capacity and muscle strength are sufficiently sensitive to detect change over time.
As discussed in Chapter 2 (the literature review) the instruments used to measure the effects of fitness or strength training in the interventions were very diverse. Training effects are exercise mode specific.[15] Specificity of testing means that the modality of the testing tool needs to be similar to the type of activity the subjects train in. To find results that are more exercise-related, intervention-specific tests should be used in future research, since this may enhance the results of the studies and their interpretation. Therefore, efforts have to be made to develop core sets and standardize the exercise related outcome measures in CP. This will make study results interchangeable.

What we don't know

It is important to note the high prevalence of osteopenia and osteoporosis,[16] and poor nutrition[17] in people with CP, which are also very important health considerations that may affect and be affected by physical activity. Greater understanding of, and interventions directed at, these factors are also needed in order to optimize physical function and health-related quality of life in this population.[18,19] Information is lacking on the impact of exercise and fitness on specific health outcomes in people with CP, such as decreased body fat, lower blood lipids, and blood pressure; increased functional mobility; improved mood, self-efficacy, and life satisfaction. It is unknown if improvements in physical fitness will have similar benefits in improving various biomedical and psychological health outcomes observed in the general population.[20]

Bouchard et al.[20] have illustrated the relationship between physical activity, health-related physical fitness, and health outcomes (Figure 2). This indicates, that physical activity influences health directly as well as through its contribution to health-related physical fitness. Less clear is the impact of the amount or dosage of physical activity in this model. In children and adolescents with CP the dose-response relationship is unclear. Additional research is required to differentiate further the health benefits of daily physical activity versus exercise designed to enhance physical fitness.[21]

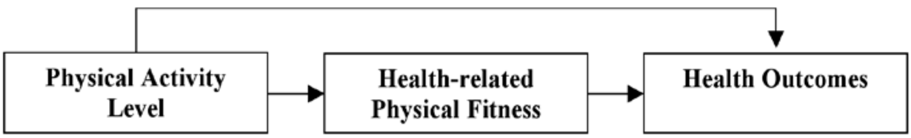

Figure 2. The relationship between physical activity, health-related physical fitness and health outcomes.[20]

Unwavering support from the individual's health care team for physical activity programming is essential. Their support is critical for assuring the child and their parents that physical activity is an important component in enhancing their overall health and well-being, and that exercise is safe for them.

A common problem among habitual exercisers is overtraining, which often results in musculoskeletal injuries.[22] Currently, there is no information on the prevalence of overuse injury in physically active persons with CP. Due to the higher incidence of inactivity and accommodating secondary changes (i.e. spasticity, contractures, joint pain), persons with CP may be more susceptible to overuse injuries than the general population.[23] Overuse injuries, which were not assessed in our randomized clinical trial, should be documented in future training studies to determine if certain exercises cause a higher or lower rate of injury.

In general, to be non-injurious to the patient and being effective for the purposes intended, physical activity must be prescribed according to age, gender, physical characteristics, related medical conditions, habitual physical activity and functional status. Special deficits or defects resulting from deformities and injury, and the needs and contra-indications imposed by these conditions must also be considered. The prescribed exercise dosage (i.e. intensity, frequency and duration) should be above the minimum level required to induce a "training effect", yet below the metabolic rate or intensity that evokes abnormal clinical signs, symptoms and/or injury.[24]

Evidence is increasing to suggest that fitness training is important for the pediatric CP population. However, little information is available on the clinical characteristics of the child that predict a response to such intervention. For the clinician it is important to have guidelines for selecting which children may benefit from an exercise program. Based on the data from the RCT we evaluated which baseline characteristics of the children and adolescents with CP could predict a positive functional response to the exercise program. The following baseline characteristics were used: GMFCS-level, sex, age, Body Mass Index (BMI), aerobic capacity, agility, muscle power, muscle strength (performance) and Gross Motor Function Measure (GMFM). In our RCT no baseline characteristics that could predict a positive functional response to the exercise program of the children that participated were found. In future studies possible characteristics, such as parent's attitude towards activity, cognition and motivation of the child and adolescent should be taken into account.

Because there are no specific exercise guidelines for individuals with CP, more innovative exercise research studies that develop and evaluate programs for accessibility, safety and effectiveness are needed. These types of studies will enable the exercise professional to develop an exercise program that is individually tailored to meet each patient's needs. Further, such studies will assist in developing guidelines for optimal exercise programming. As we gain experience, we will gradually be able to move beyond routine medical care issues to meeting the goals of optimizing physical functioning and overall health and well-being for children and adolescents with CP.

The general body of literature on physical fitness does not take into account the specific needs and concerns of persons with CP.[25] Public health recommendations often include guidelines for increasing physical activity that, in most circumstances, may be inappropriate for people with CP. For example, much of the exercise literature recommends walking is the safest and most convenient mode of exercise for improving cardio-respiratory fitness.[26] However, some persons with CP (e.g. GMFCS level III) have difficulty with walking, or may not be able to walk for a long enough duration or at a high enough intensity level to improve their

physical fitness. Other persons with CP (e.g. GMFCS IV and V) may not be able to walk. Alternative exercises (i.e. (wheel)chair exercises) are usually not provided in public health reports that recommend physical activity to the general population, which makes it difficult for people with CP to develop their own personalized training program adapted to their specific needs.
Given these limitations, a skilled multidisciplinary assessment of the patient's abilities will help define a sports and activity program that is safe and tailored to the patient's needs. Safe activities can be suggested based on function and current activity levels. Each individual's limitations should be the focus of the exercise programming.

Function often decreases with age. Deficits from CP are not progressive. However, aging is often accompanied by a progressive spiral of inactivity leading to weight gain and decreased exercise tolerance.[25] The persistent underlying low fitness level of CP results in decreasing ability to ambulate and participate in physical activity. Few studies have addressed functional longitudinal outcomes in adults. By establishing a pattern of activity prior to adulthood, patients may avoid the health dangers of inactivity, be physically prepared to handle the aging process, and internalize the importance of activity and therapy. Additional research is needed on longitudinal effects of sports and physical activity through the lifespan.
Many children with CP tire of prolonged physical therapy from childhood into adolescence and adulthood. Therapy programs are simply abandoned due to boredom, expense, or lack of time.[27] Sports and sports therapy may offer an enjoyable alternative, providing children with CP skills for lifelong activity. They may experience normal sports enjoyment and a sense of mastery. Family life may be more normalized as the children are able to participate in enjoyable activities.[27] In most studies that focused on fitness-elements, the sports model of activity had a strong influence on the children's desire to participate and to continue participation during and after the studies.[27]
While many persons with disabilities can be encouraged to initiate a physical conditioning program, motivating them to continue is critical to promote favorable adaptation and improvement. Unfortunately, negative variables often outweigh the positive variable contributing to sustained participant interest and enthusiasm. Such imbalance leads to a decline in adherence while program effectiveness diminishes.
Research and empirical experience suggest that certain program modifications and motivational strategies may enhance participant interest and enjoyment.[28]

These include:

- Establishing short term goals
- Emphasizing variety and enjoyment
- Providing positive reinforcement through periodical testing
- Recruiting spouse support of the exercise program
- Including a modified recreational game to the conditioning program format that minimizes skill and competition and maximizes participant success
- Using progress charts to record exercise achievements
- Recognizing individual accomplishments.

In future studies and when developing an exercise program for children and adolescent with CP, these modifications and strategies should be taken into account. The chance of success and maintaining their fitness levels may be enhanced.

To conclude, we have learned from our study that children and adolescents with CP enjoyed being physically active and that this leads to increased fitness levels as well as improvement in the intensity of activities and health-related quality of life.

Implications for future research and clinical practice

- Evaluate exercise interventions for a sustained period
- Examine barriers (e.g. time, lack of interest, boredom) to exercise in persons with CP
- Develop core sets and standardize the exercise related outcome measures for all children and adolescents with CP
- Examine possible characteristics, such as parents attitude towards activity, cognition and motivation of the child and adolescent that could predict a positive response to the exercise training
- Examine if improvements in physical fitness will have benefits in improving various biomedical and psychological health outcomes
- Develop exercise programs based on each individuals limitations

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