Functional power-training in young children with cerebral palsy

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Summary

Children with cerebral palsy (CP) often experience problems with keeping up with their peers in daily-life walking and running activities due to muscle weakness. Strength training programs are commonly used in clinical practice to improve muscle strength and therewith walking capacity. These strength training programs showed, however, inconclusive evidence for improving walking capacity despite some improvements in muscle strength. Recent insights suggested that strength training with high-movement velocity incorporated in functional movements might be more effective for improving walking capacity than traditional strength training programs. Therefore, the primary aim of this thesis was to evaluate the effectiveness of a functional high-velocity resistance training (power-training) on muscle strength, walking capacity and parent-reported mobility performance of young children with CP. First, we aimed to investigate the feasibility and test-retest reliability of measuring lower-limb strength in young children with CP. In addition, we aimed to investigate whether changes in lower-limb muscle strength could explain changes in walking capacity in young children with CP. The aims are elucidated in **chapter 1**.

Chapter 2 described the results of a study that investigated the feasibility, test-retest reliability and the optimal test design of lower-limb muscle strength measurements in young children with CP.

Isometric muscle strength of the hip abductor, knee extensor, and the plantar flexors was assessed with handheld dynamometry (HHD) and dynamic muscle strength of the ankle plantar flexor was assessed with the standing heel-rise test (SH), on two test occasions. Twenty ambulatory children with spastic CP (3–5 years (n=10) and 6–10 years (n=10)) were included in this study. Intraclass correlation coefficients (ICC) and Smallest Detectable Differences (SDD) were calculated to determine the optimal test design for detecting changes in strength. The results showed that the strength test instructions were easily understood by the children, also in the younger age group. The ICC values were all above 0.77 for a single measurement, which indicated good reliability. Although the SEM and SDD's were high in a single test occasion—especially in the 3–5 years old children—the isometric strength tests had acceptable SDDs (9–30%), when taking the mean values of 2–3 test occasions (separate days) and 2–3 repetitions. The SH test had large SDDs (40–128% for the younger age group, 23–48% for the older age group). The results of this study can be used to determine an individual test design for HHD measurement in young children with CP, depending on expected changes in muscle strength, muscle group and age of the child. Choosing the most optimal test design is a balance between the smallest SDD and the feasibility of performing repeated measures on separate days. The SH test

in young individuals with CP can only be used to determine large changes in dynamic plantar flexor strength when the average is taken over 3 test occasions.

Chapter 3 described the protocol of a double-baseline designed trial investigating the effectiveness of functional power-training on muscle strength and walking ability in young children with CP. It was aimed to include 22 children with bi- or unilateral spastic CP, aged 4–10 years, and to compare a 14-weeks functional power-training (3 times a week) with a 14-weeks usual care period prior to the functional power-training and a 14 weeks follow-up period. This study protocol provided a detailed description of the design and methodology of the newly developed functional power-training and the measurements to investigate its effectiveness. The power-training exercises were loaded and performed at 50–70% of the maximum unloaded walking and running speed of the children. Load was increased when exercises were performed faster than 70% of the unloaded speed. Primary outcomes were sprinting capacity (15-m Muscle Power Sprint Test) and goal attainment scaling score of walking-related treatment goals. Secondary outcomes were walking speed (1-min walk test), endurance (10-m shuttle-run test), gross motor function, lower-limb strength and parent-reported mobility.

Chapters 4 and 5 described the results of the double-baseline study comparing the within-subjects changes in muscle strength and walking ability of a 14-weeks usual care period with the changes in a 14-weeks functional power-training period and the changes in a 14-weeks follow-up period, in young children with CP. Twenty-two children with a mean age of 7.5 years old and a spastic CP (13 bilateral and 9 unilateral) participated in this study. Changes during the training period were significantly larger than changes in the usual care period for all outcome measures. **Chapter 4** showed that large improvements were found during the training period for walking capacity (13–83% increases) and for muscle strength (18–128%), while outcomes remained stable in the usual care period. The increases in muscle strength and in walking speed were maintained in the follow-up period. A significant decrease in sprint capacity and in the shuttle run test was found in the follow-up period, however, participants, still had a better sprint capacity (67%) and shuttle run test outcome (33%) at the end of the follow-up period compared with the start of the functional power-training period. **Chapter 5** described the results of the study on the achievement on individual treatment goals and parent-reported mobility. Outcome measures were goal attainment scaling (GAS) of individual daily-life walking activity related treatment goals, mobility performance measured with the Functional Mobility Scale (FMS), and the parent-reported Mobility Questionnaire (MobQues). After the power-training 86% of the children achieved or exceeded their goal compared to 14%

in the usual care period. The probability for improvement by one point or more on the FMS-500 meters after functional power-training was 10 times higher compared to the usual care period. At FMS-500m 52% of the children used a walking frame, wheelchair or support by their parents at the start of the functional training period, whereas at the end of the functional power-training period only 13.6% of the children were dependent on a walking aid, wheelchair or support by their parents. No changes were found in the FMS-5 and FMS-50 meter categories. Improvement on the MobQues was significantly larger after power-training compared to usual care (7.9% (95% CI 2.7–13.0, p=.005)). Improvements in treatment goals and parent-reported mobility were maintained in the follow-up period. These results indicated that strengthening interventions are effective in improving muscle strength *and* walking ability in young children with CP if they involve high-velocity strengthening exercises incorporated in functional movements of sufficient intensity (maximal effort, 3 sets of 6 to 8 repetitions), frequency (3 times a week) and duration (14 weeks).

The relationships and the clinical implications between the changes in lower-limb muscle strength and the changes in walking capacity during the 14-weeks periods of usual care, functional power-training and follow-up, are described in **chapter 6**. The multivariate relationships between within-subject changes in muscle strength (isometric strength of gastrocnemius (GASTR), soleus, knee extensors, hip abductors (HA)) and walking capacity were evaluated. The results showed that changes in HA were strongly associated with changes in sprint capacity, changes in GASTR en HA (least affected legs) were associated to changes in walking endurance, and changes in GASTR (most-affected leg) were associated to changes in walking speed. The results of this study implied that walking capacity, especially sprint capacity, can be improved by increasing strength of these muscles, with functional power-training, in this population. Further research about the working mechanism on, e.g., the level of muscle morphology is needed to understand the underlying physiology of the increase of muscle strength after functional power-training.

In conclusion, young children with CP can improve their muscle strength and walking ability with functional power-training, indicating that this type of training is important to be considered in rehabilitation treatment. **Chapter 7** presented an extensive discussion of the studies described in this thesis and their clinical implications. The main findings indicated that with increasing movement velocity and functionality in strength training programs it is possible to improve muscle strength, walking capacity and mobility performance in children with CP.