Children with developmental coordination disorder (DCD) experience difficulties in performing and learning motor tasks. Their difficulties have a substantial impact on their physical fitness (PF) and their physical activity (PA). Therefore, the aim of this thesis was to develop and evaluate an intervention to improve PF and motivation for PA in children with DCD.

Preparing for intervention development: improving cardiorespiratory fitness

In preparation for the development of the intervention, we wanted to find out what the training requirements were for improving cardiorespiratory fitness (CRF). Therefore, we performed a systematic review to examine the available literature on the characteristics of PA interventions effective in improving CRF, implemented across different settings and developed for healthy children aged 6 to 12 (Chapter 2). A systematic search on this topic yielded more than 1,000 studies, this number was reduced to 23 studies after careful selection. We used treatment theory as a framework to gather all relevant information from the studies. Treatment theory differentiates between targets that can be directly changed, essential ingredients and their parameters, and the mechanism by which the ingredients bring about a change in the target. For this systematic review we extracted the target and essential ingredients such as the mode of activity, all relevant parameters (frequency, intensity, duration, monitoring of intensity, attendance) and methodological characteristics of the studies. Thirteen of the 23 studies found statistically significant improvements in CRF and eight studies showed medium to high effect sizes. On the one hand, this result is promising but it also shows that not every training effort automatically leads to an improvement in CRF.

What should we take into account when developing an intervention to improve CRF? In our systematic review, interventions with medium to high effect sizes focused more often on improving PF than PA behaviour, had slightly higher frequencies of activities and had a shorter duration than the less effective interventions. Moreover, interventions with larger effect sizes appeared to be more controlled, as they usually included protocolled training sessions and relied on smaller sample sizes than interventions with lower effect sizes. Defining and applying pre-set relative training intensity, as well as monitoring and adjusting relative training intensity, seem to be important aspects of successful interventions. Based on this systematic review, a duration of at least six weeks and a frequency of three to four times a week are recommended to successfully improve CRF.

Intervention development: We12BFit!

In chapter 3 and 4 we continue with the development of We12BFit! which consists of two intertwined parts: We12BFit!-PF to improve PF (Chapter 3) and We12BFit!-Lifestyle PA to improve motivation for PA in 7 to 12 year old children with DCD (Chapter 4). We12BFit! was developed using the steps of defining a treatment theory which includes the subsequent
definition of targets, mechanisms of action, and essential ingredients and their parameters.

We12BFit!-PF was developed by combining evidence from the literature, and insights and preferences of professionals with expertise in the field of DCD and/or training of PF. We12BFit!-PF targets CRF, muscle strength and anaerobic power. The mechanism of action to bring about a change in these targets relies on the training principles of inducing overload and specificity. The principle of overload means that the body should be challenged with an intensity, duration, or frequency of exercise to which it is not accustomed in order to reach a training effect. The principle of specificity entails that a training effect is specific to the recruited fiber types, the principal energy system involved, the velocity of contraction and the type of muscle contraction. Therefore the principle of specificity prescribes that the ingredients should match the activities that children generally engage in. In line with this, the essential ingredients include high intensity interval training using running exercises, strength exercises without external weights and plyometric exercises. Training sessions were planned twice a week for 60 minutes over a period of ten weeks. Training intensity during high intensity interval training should be monitored with heart rate monitors, if necessary the intensity should be adjusted. We12BFit!-PF is tailored to the needs and capabilities of children with DCD by for instance the extended duration of the training, the use of relative training intensity, gradually increasing the difficulty of the exercises, avoiding cognitive motor dual tasks, small groups and maximizing opportunities for experiencing success.

We12BFit!-Lifestyle PA was developed in close collaboration between researchers, paediatric psychologists, paediatric physical therapists and a paediatric rehabilitation physician. The target of We12BFit!-Lifestyle PA is motivation for PA, indirectly aiming to increase their lifestyle PA and participation in PA. The mechanism of action to bring about a change in these targets relies on the transtheoretical model of change which describes the processes that occur when progressing through the stages of change. The essential ingredients are tailored to the stages of change of the participant and rely on the use of a pedometer, a parent meeting, an information booklet for parents and coaching. The strategies used originate from social cognitive theory, problem-solving therapy, cognitive behavioural therapy and motivational interviewing.

**Intervention effectiveness and feasibility**
Using a single-arm design and mixed-methods, the effects and feasibility of We12BFit! were evaluated in 20 children with DCD (Chapter 5). We12BFit! was proven effective in increasing CRF, anaerobic power and motivation for PA in children with DCD. Indirectly, We12BFit! seemed to improve the children’s social emotional well-being, enjoyment of activities, motor skills and weight. The group aspect of We12BFit!-PF and the high intensity combined with the positive motivational climate of We12BFit!-PF may have improved children’s self-efficacy and reinforced their motivation for PA. Not only the children benefitted from We12BFit! as parents reported that they increased their activities, extended
Summary

their strategies to motivate their child to be active and improved their knowledge on PA. We12BFit! had high attendance rates and was shown to be feasible. Key aspects identified for improving the effectiveness and feasibility were: improving strength exercises to involve the right muscle groups and to be performed in a group, adding variety to the training sessions to make the exercises more enjoyable and establishing a connection between the coach, the child and his parents face-to-face before conversing over video or phone call during the coaching sessions.

Informing future intervention: participation in activities

Triggered by the indirect effects of We12BFit! on participation and to potentially inform the further development of We12BFit!, we performed a second systematic review. In this study we examined whether 4 to 12-year-old children with DCD differ from typically developing (TD) children regarding their participation involvement (enjoyment) and attendance (diversity, frequency, duration, intensity) in recreational and leisure activities. Moreover we aimed to determine in which recreational and leisure activity subdomains the participation of children with DCD differs from TD children (Chapter 6). The initial search yielded more than 2,000 studies of which 21 studies were found eligible for inclusion. The findings of these 21 studies were mixed with regard to enjoyment of participation in recreational and leisure activities: some studies found that children with DCD enjoyed their participation in certain activities less but this was not confirmed in other studies. These studies differed in how they measured enjoyment and they used varying definitions for recreational and leisure activity subdomains. Diversity and frequency were lower for a number of domains in children with DCD compared with TD children, and children with DCD spent less time in activities of moderate to vigorous intensity. When participation of children with DCD was lower than that of TD children this was mostly the case for physical, skill-based, self-improvement and play activity subdomains. For some measures, diversity and frequency seemed to decrease with age in children with DCD, whereas enjoyment seemed to increase. This may indicate that when children with DCD become older, they become more selective in the activities they engage in: choosing activities they are more likely to enjoy but engaging in less different activities and participating at a lower frequency. Importantly, only one study identified an activity in which children with DCD “participated” more than TD children, potentially compensating for their lower participation in other activities: time spent watching the activities of peers. This illustrates that additionally specifying the nature of participation may increase our insight in the participation of children with DCD. In order to increase our insight in the participation of children with DCD, the field is in need of a clear operationalisation of the definition of participation which would enable comparison of participation measurements. Moreover, as children with DCD form a heterogeneous group with regard to their motor difficulties and comorbidities, participation involvement and attendance may also differ between children with DCD. To inform future intervention development we need to gain insight into the characteristics
of children with DCD that do and do not participate less in activities than TD children.

**Conclusion**

Overall, this thesis underlines that moving does matter for children with DCD: the motor problems experienced by children with DCD may have a substantial impact on PF, PA and participation and We12BFit! led to improved CRF, anaerobic power and motivation for PA. We recommend that besides individually improving motor coordination, PF and motivation for PA are addressed. It is strongly recommended to combine targeting PF and PA, as high intensity group training in a positive motivational climate may improve self-efficacy and may consequently enhance the effect of behavioural intervention on motivation for PA. When stimulating PF and PA, trainers and coaches should focus on facilitating the experience of enactive mastery (i.e. progression and success), vicarious experience by providing the opportunity for children with DCD to see other children with similar problems putting in sustained effort and succeed, and providing verbal persuasion to let the child explore and push his physical boundaries. In addition, parents of children with DCD need to be given an active role in promoting their child’s PF and PA. Like the children, parents may benefit from experiencing success (in themselves or in their child), vicarious experience by seeing the abilities and progression of other children with DCD and their parents, and experiencing what it is like to try to become more physically fit and active themselves. Parents need to be provided with information about being active and DCD, both in writing and in person, and parents may benefit from the contact with other parents of children with DCD as well.

Matters to be moved include the further development of We12BFit! in co-creation with parents and children with DCD. In this process we should focus on improving strength exercises to involve the right muscle groups and to be performed in a group, we should focus on adding variety to the training sessions to make the exercises more enjoyable and a connection should be established face-face between the coach, the child and his parents before conversing over video or phone call during the coaching sessions. In addition, we should carefully plan for the implementation of We12BFit! and extend the methods for evaluation. From a broader perspective, the PF and (motivation for) PA of children would likely improve by increasing awareness of DCD among care professionals, teachers and parents to facilitate early identification of DCD, making sports more approachable and fostering a vision of being active as a way of life to live a long and healthy life.