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The effect of an integrated perceived competence and motor intervention in children with developmental coordination disorder

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ABSTRACT

Background and aims: Children with DCD have lower self-perceptions and are less physically active than typically developing children. The aim of this quasi-experimental study was to investigate whether an integrated perceived competence and motor intervention affects DCD children's motor performance, self-perceptions, and physical activity compared with a motor intervention only.
Methods and procedures: The intervention group consisted of 20 children and the care-as-usual group consisted of 11 children, all aged 7–10 years. The perceived competence component of the intervention focused primarily on providing positive, specific, and progress feedback to enhance self-perceptions. We assessed children at baseline, after 12 treatment sessions (trial end-point), and at 3-month follow-up.
Outcomes and results: Mixed linear models revealed no differences between the intervention and the care-as-usual group on any of the outcome measures. Children improved their motor performance and increased their perceived athletic competence, global self-esteem, and perceived motor competence after 12 treatment sessions. This improvement was maintained at 3-month follow-up. Motor task values and physical activity remained unchanged for all children.
Conclusions and implications: A perceived competence and motor intervention is as effective as care-as-usual in children with DCD. Future research should focus on improving physical activity in children with DCD.
What this paper adds: This is the first study that has investigated the effect of an integrated perceived competence and motor intervention (intervention group) on motor performance, self-perceptions, and physical activity compared with a motor intervention (care-as-usual

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group) in children with DCD. We made the perceived competence component explicit by providing positive, specific, and progress feedback to enhance children's self-perceptions. Also, this is one of the first studies that has investigated the effect after both 12 treatment sessions (trial end-point) and after 3 months of no intervention (3-month follow-up). We found no differences between the intervention and the care-as-usual group, but children improved their motor performance and increased (most) of their self-perceptions after 12 treatment sessions, while physical activity remained the same. The improvement was still present at the 3-month follow-up. We also benchmarked our results about self-perceptions and physical activity to a group of typically developing children. Self-perceptions in children with DCD had improved to the level of typically developing children after 12 treatment sessions, but their physical activity levels remained significantly lower. This result was the same at the 3-month follow-up, except for perceived athletic competence, which was lower in children with DCD at the 3-month follow-up. In accordance with previous intervention studies that have investigated children with DCD, we found large intra-group variability in the change in motor performance and self-perceptions in children with DCD. We argue that we need to better understand why some children with DCD improve and others do not after a motor intervention.

1. Introduction

Children with developmental coordination disorder (DCD) have trouble mastering and performing motor activities. This impairment significantly interferes with activities in daily life and/or academic achievement and is not due to a general medical condition (American Psychiatric Association [DSM-V], 2013). The prevalence of DCD is estimated at around 5–6% in school-aged children, where boys are overrepresented compared with girls (Blank, Smits-Engelsman, Polatajko, & Wilson, 2012). Also, large differences in motor problems exist. Some children with DCD experience fine motor problems, while other children experience gross motor problems (e.g., Noordstar et al., 2014; Vaivre-Douret et al., 2011). Children with DCD participate less in motor activities in daily life (e.g., physical activity) than typically developing children (Cairney et al., 2005; Cairney, Hay, Veldhuizen, Missiuna, & Faught, 2010; Noordstar et al., 2014).

Children with DCD are often referred to a pediatric physical or occupational therapist to learn to master motor activities (e.g., riding a bike, skipping rope). The motor interventions used can generally be divided into process-oriented interventions and task-oriented interventions (Zwicker, Missiuna, Harris, & Boyd, 2012). Process-oriented motor interventions focus on improving the underlying motor processes and body functions in order to master motor activities, while task-oriented motor interventions focus on the specific motor activity the child experiences problems in (Smits-Engelsman et al., 2013). There is little evidence that process-oriented motor interventions improve motor performance, but the results of the task-oriented motor interventions are encouraging (e.g., Miller, Polatajko, Missiuna, Mandich, & Mcnab, 2001; Smits-Engelsman et al., 2013; Thornton et al., 2016). In the Netherlands, more traditional pediatric physical and occupational therapy (i.e., care-as-usual) combines underlying process-oriented approaches with direct skill training (e.g., task-oriented approach) (Smits-Engelsman et al., 2013).

Children need an extensive number of (gross) motor activities to participate in physical activity. Motor interventions focus mainly on mastering these motor activities (*can do*), but it is unclear whether any improvement in motor activities results in more participation in physical activity (*does do*). Participation in physical activity can be defined as the frequency of attendance in physical activities (Imms et al., 2015). Motivation theorists argue that competence beliefs and task values influence motivation for achievement behavior (i.e., physical activity) (e.g., Eccles et al., 1983; Harter, 1981). Stodden et al. (2008) proposed a conceptual model in which competence beliefs (e.g., perceived athletic competence) mediate the relationship between motor performance and physical activity. Perceived athletic competence is described as the way children perceive their sports ability and athletic performance (Harter, 1982). Children with higher levels of motor performance and perceived athletic competence are likely to be more involved in physical activity (Stodden et al., 2008).

Children with DCD have a lower perceived athletic competence than typically developing children at 7 years old (e.g., Poulsen, Ziviani, & Cuskelly, 2008). Cairney et al. (2005) argued that differences in physical activity between children with DCD and their typically developing peers are mainly due to the difference in perceived athletic competence. The authors argued that perceived athletic competence should be a target for interventions in children with DCD to increase physical activity. However, to date, we have found no studies that investigated the effect of an intervention that aimed to increase perceived athletic competence and master new motor activities to increase physical activity in children with DCD.

Feedback has a powerful influence on learning (e.g., motor performance), competence beliefs (e.g., perceived athletic competence), and achievement behavior (e.g., physical activity) (Duijnhouwer, 2010; Hattie & Timperly, 2007). Feedback is commonly conceptualized as "... information provided by an external agent regarding some aspect(s) of the learner's task performance, intended to modify the learner's cognition, motivation, and/or behavior for the purpose of improving performance." (Duijnhouwer, 2010, p. 16). However, there are multiple types of feedback, and effect sizes show considerable variability (Hattie, 2012). Feedback is most effective when it is specific, goal-related, and not too elaborated (Hattie &

Timperly, 2007; Kluger & DeNisi, 1996; Shute, 2008). It is therefore important to set specific goals in order to provide effective feedback. Feedback is also most effective when it provides information on correct (*positive*) rather than incorrect (*negative*) responses (Losada & Heaphy, 2004). With regard to motor learning specifically, feedback is often differentiated in intrinsic feedback and extrinsic feedback. Intrinsic feedback is the sensory information that arises as a natural consequence of producing a movement, while extrinsic feedback is information that is provided to the child by some outside source (e.g., pediatric therapist) (Schmidt & Wrisberg, 2000). Children with DCD experience problems with their intrinsic feedback (i.e., sensory-perceptual function) (see for review Wilson, Ruddock, Smits-Engelsman, Polatajko, & Blank, 2013), resulting in less "learning by experience". Pediatric therapists provide extrinsic feedback during treatment sessions to improve the child's motor performance. This extrinsic feedback is further differentiated in two categories: Knowledge of results and knowledge of performance. Knowledge of results refers to information that tells the child something about the success of his action (e.g., you caught that ball 7 out of 10 times). Knowledge of performance provides the child with information about the pattern of his movements (e.g., you did not bend your knees before you made the jump) (Schmidt & Wrisberg, 2000). Furthermore, the feedback frequency also influences motor learning (e.g., Sullivan, Kantak, & Burtner, 2008).

Voerman, Korthagen, Meijer, and Simons (2014) made another distinction between effective types of feedback: *progress feedback* and *discrepancy feedback*. Progress feedback focuses on the improvement between the initial and current level of performance, while discrepancy feedback focuses on (closing) the gap between the current and desired level of performance (e.g., Kluger & DeNisi, 1996). They stated that progress feedback helps the student believe in his or her capacity to learn, and will subsequently stimulate performance (Voerman et al., 2014). Moreover, Duijnhouwer (2010) stated that progress feedback improves competence beliefs (e.g., perceived athletic competence) because it suggests that individuals are able to improve their performance.

However, most studies standardized their feedback to investigate the effect on motor performance, making generalization to daily practice questionable (e.g., Chiviacowsky & Wulf, 2007). The aim of the current study was to investigate if training a group of pediatric therapists in providing specific, (mainly) positive, goal-specific, progress feedback would affect motor performance, self-perceptions, and physical activity in children with DCD. Ultimately, the results of our study might be incorporated into the daily practice of pediatric therapists who treat children with DCD.

Specifically, the aim of this quasi-experimental study was to investigate the effect of an integrated perceived competence and motor intervention (intervention group) in children with DCD aged 7–10 years compared with a motor intervention (care-as-usual group) only. The effect of the intervention was investigated after 12 treatment sessions (trial end-point), and after 3 months of no intervention (follow-up). Primary outcome measures were motor performance, motor difficulties, perceived athletic competence, and perceived motor competence. Secondary outcome measures were motor task values, total physical activity, leisure physical activity, and global self-esteem.

The results of the psychological and physical activity outcome measures were also benchmarked to a group of typically developing children aged 7–10 years. In doing so, we investigated if differences between the children with DCD and the typically developing children decreased after 12 treatment sessions and at the 3-month follow-up.

We hypothesized that children with DCD in the intervention group would improve more than children with DCD in the care-as-usual group on both primary and secondary outcome measures directly after the intervention. We also hypothesized that this improvement would be maintained in the intervention group at the 3-month follow-up, but that the improvement would diminish in the care-as-usual group. Finally, as a result of the hypothesized improvement in children with DCD, we hypothesized that differences on outcome measures between children with DCD and typically developing children would decrease, with smaller differences between children with DCD in the intervention group and typically developing children than between children with DCD in the care-as-usual group and typically developing children.

2. Methods

2.1. Study design

The Medical Research Ethics Committee of the University Medical Center Utrecht approved this study. All families gave written informed consent for their child's participation.

In the Netherlands, treatment of children with DCD is performed by pediatric physical therapists, pediatric occupational therapists, and pediatric exercise therapists (Cesar/Mensendieck). Treatment of children with DCD is comparable, although small differences may exist, and focuses on improving the child's motor performance. The therapists who participated in this study were schooled as pediatric exercise therapists. We use the term pediatric therapist throughout the manuscript for clarity.

2.2. Participants

Pediatric therapists recruited children from October 2013 to April 2015 and administered the integrated perceived competence and motor intervention designed especially for this study. Other pediatric therapists recruited children from September 2013 to April 2015 and administered a motor intervention only (care-as-usual group). Children met the four diagnostic criteria for DCD as outlined in the DSM-V: They experienced motor difficulties substantially below expected levels given the child's chronological age and appropriate opportunities for skill acquisition (criterion A) and this disturbance significantly interfered with activities of daily living (criterion B). Also, the experienced motor difficulties had an onset in the early developmental period (criterion C) and were not better explained by another disability (criterion D) (American Psychiatric Association [DSM-V], 2013). More specifically, children were referred by a general practitioner or school medical officer and were included when they: (1) scored ≤ 16th percentile on the MABC-2 (criterion A), (2) had an indication of DCD or suspected DCD on the Developmental Coordination Disorder Questionnaire 2007 (DCD-Q) as reported by parents (criterion B), (4) scored below the advised number of daily steps for children (boys < 15000; girls < 12000) on a pedometer (Yamax CW700), (5) were between 7 and 10 years old (criterion C), and (6) had no known neurological disorder causing motor problems (e.g., Cerebral Palsy, Spina Bifida) (criterion D). Children were excluded when their total score ≤ 16th percentile on the MABC-2 was the result of a low score on the subscale manual dexterity only since no associations between manual dexterity, perceived athletic competence, and physical activity were expected (Noordstar et al., 2014; Piek, Baynam, & Barret, 2006). The control group of typically developing children consisted of a subsample of children who participated in the Move Along study, a longitudinal study that investigated the development of, and associations between, motor performance, perceived competence, global self-esteem, and physical activity in children in elementary school (see Noordsta, van der Net, Jak, Helders & Jongmans, 2016a,b). We used data from the second year (2012) of this longitudinal study, when the children were in grade 3 ($n = 143$; age 8.38; $SD = 0.52$; 66 boys). However, the Yamax CW700 Digiwalker Pedometer was only administered in the final year of the longitudinal study (2013), when children were either in grade 2 or grade 4 ($n = 94$; age 8.31; $SD = 1.11$; 41 boys), and was used to benchmark total physical activity.

2.3. Allocation and training of pediatric therapists

A total of 30 pediatric therapists participated in this study. All pediatric therapists received their specialist training at the University of Applied Sciences Utrecht. Years of experience ranged between 2 and 14 years. Nine of them administered the intervention and worked at a practice with locations spread throughout the Netherlands. They were trained before the start of the study at four 3-h meetings. During the first meeting, information was given about the study and measurements were actually practiced. Theories about learning enhancing verbal feedback were presented in the second meeting, along with practice in providing feedback when learning activities from each other in which they were experts (e.g., playing guitar). In the third and fourth meetings, therapists were video-coached in groups of 4/5 on the feedback they provided during the treatment sessions they had taped at their local practice. A trained coach (LV) supervised, demonstrated, and provided feedback. Therapists also provided peer feedback.

Twenty-one pediatric therapists administered care-as-usual. These therapists received information about the study and practiced the measurements. However, they were told that they would participate in an efficacy study that investigated the effect of care-as-usual on motor performance and physical activity in children with DCD and were therefore blinded for treatment.

Five assessors were trained in administering the measurements before the start of the study. Measurements were also practiced during the study period to make sure the assessments were performed correctly. The assessors were blinded for treatment allocation.

2.4. Sample size calculation

We based our sample size calculation on the minimum detectable change (MDC) on the MABC-2 of 1.21 (Wuang, Su, & Su, 2012). With an 80% probability that the current study would detect a treatment effect at a two-sided 0.05 significant level, the required number of participants was 19 for the intervention and 19 for the care-as-usual group (total of 38 children) (http://stat.ubc.ca/). The total sample size was set on 46 children because we anticipated 20% ($n = 8$) missing observations and dropouts.

2.5. Assessment

Children in the intervention and the care-as-usual group were assessed at baseline (T0), after 12 treatment sessions (trial end-point) (T1), and after 3 months of no intervention (follow-up) (T2). The intervening therapist performed the baseline assessment, while assessors performed the other two assessments. All assessments, except three, were performed in the practice of the therapist that administered the intervention. Trained assessors who were unaware of the current study assessed the typically developing children between January 2012 and June 2012. Assessments took approximately 1 h (20 min to fill in questionnaires and 40 min to perform the MABC-2, to provide instructions on how to use the pedometer, and to hand out questionnaires for the parents).

2.6. Treatment procedure

2.6.1. Care-as-usual

Children received 12 individual treatment sessions (each 30 min) once a week. Treatment goals were set for each child individually based on the clinical problem(s) and assessment of the child's motor performance. Next, treatment sessions focused on the intersection of the motor activity and the underlying motor skills problems resulting in a tailor made and reproducible intervention, in which deficient motor activities were being practiced. For example, in children who experience difficulties in ball activities (e.g., basketball), the underlying motor skills problems are first investigated (e.g., timing, bouncing, throwing). During treatment sessions, different kinds of ball activities are practiced whereby specific attention is focused on improving timing, bouncing and/or throwing. If these underlying motor skills problems are performed adequately they are linked back to, and practiced in, the motor activity (basketball).

2.6.2. Intervention group

Children in the intervention group received the same intervention as children in the care-as-usual group, but the therapists specially focused on enhancing children's perceived athletic competence by first setting specific treatment goals *with* the child in the first treatment session. Second, therapists gave positive, specific, and progress feedback throughout every treatment session. During several sessions, using a visual analogue scale (VAS) for children, the child was asked how he perceived himself in performing the task and how motivated he was in getting better in this specific task. In doing so, the child became aware of his progress.

2.6.3. Measurements: motor performance

2.6.3.1. Movement assessment battery for children – second edition (MABC-2). Motor performance was assessed using the Dutch edition of the MABC-2 (Henderson, Sugden, & Barnett, 2007). This test is divided into three different age bands (3–6, 7–10, and 11–16 years), each consisting of eight items to measure children's motor performance. The eight items are divided into three subsets: (1) manual dexterity (three items), (2) aiming and catching (two items), and (3) balance (three items). Raw scores are converted into standard scores (1–19) and percentile scores (0–100) so results can be compared with peers of the same age. Scores above the 16th percentile are regarded as normal motor performance. Scores between the 6th and 16th percentile are considered "at risk" for motor difficulties and scores $\leq$ 6th percentile indicate significant motor difficulties. We used standard scores (1–19) for analyses. The MABC–2 has reasonable to good clinical utility in identifying children with motor performance differences (Brown & Lalor, 2009). Test-retest reliability (ICC = 0.97) and internal consistency ($\alpha = 0.90$) for the total score are excellent (Wuang et al., 2012).

2.6.3.2. Developmental coordination disorder questionnaire 2007 (DCD-Q 2007). Motor difficulties were assessed using the Dutch translation of the Developmental Coordination Disorder Questionnaire 2007 (DCD-Q 2007). The questionnaire consists of 15 items divided into three subsets: (1) control during movement (six items), fine motor/handwriting (four items), and (3) general coordination (five items). Every item is scored by one of the parents on a five-point scale (maximum score 75) with higher scores indicating fewer problems in participation by the child. Raw scores (15–75) were used for analyses. Based on the total score, children are categorized as: (1) indication or suspected DCD ($\leq$15th percentile), or (2) probably no DCD (>15th percentile). Internal consistency of the DCD-Q 2007 for children $\geq$ 8 year is high ($\alpha = 0.90$), and sensitivity (81.6%) and specificity (84%) are acceptable (Schoemaker et al., 2006).

2.6.4. Measurements: self-perceptions

2.6.4.1. The self-perception profile for children (SPPC). The Dutch translation of the SPPC (Veerman, Straathof, Treffers, Van den Bergh, & ten Brink, 1997) consists of 36 questions divided into six subscales. In this study we used the subscales *perceived athletic competence* and *global self-esteem*. Each question consists of two contradictory quotes. The child has to choose which quote describes him best. For example: 'some kids are really good at sports' or 'other kids are not so good at sports'. After choosing one of the quotes, the child has to indicate whether this was either 'a little bit true for me' or 'totally true for me'. The total score per subscale ranges between 6 and 24 points and was used for analyses. Higher scores indicate a more positive perception of athletic competence and global self-esteem. Scores are converted to percentile scores (0–100), whereby children scoring $\leq$ 15th percentile are considered as having low perceived athletic competence or global self-esteem and children scoring > 15th percentile are considered as having normal to high perceived athletic competence or global self-esteem. The scale was developed for children between 8 and 12 years. Internal consistency was high for perceived athletic competence ($\alpha = 0.81$) and global self-esteem ($\alpha = 0.80$), and test-retest reliability was also high for perceived athletic competence (ICC = 0.90) and global self-esteem (ICC = 0.86) (Muris, Meesters, & Fijen, 2003).

2.6.4.2. How Am I doing questionnaire. Perceived motor competence and motor task values were assessed by asking children to complete the How Am I Doing questionnaire (Calame et al., 2009). This questionnaire consists of 13 items that can be divided into three subsets: (1) fine motor activities (five items), (2) ball activities (three items), and (3) athletic activities (five items). Every activity is scored on a 4-point-scale (maximum score 52) with higher scores indicating a more positive perception of motor competence or motor task values. The questionnaire was developed for children aged 6–12 years. Firstly, children were presented a photo of a specific motor activity (e.g., throwing, climbing, handwriting) and were asked how they perceived themselves in performing this specific motor activity, e.g., "how good do you perceive yourself at climbing". This resulted in the subscales perceived fine motor competence, perceived ball competence, and perceived gross motor competence. Secondly, for every item children were asked how important it was for them to be good at performing this specific motor activity, e.g., "how important is it for you to be good at climbing". This resulted in the subscales fine motor task values, ball task values, and gross motor task values. Internal consistency was acceptable for perceived motor competence

($\alpha = 0.66$) and motor task values ($\alpha = 0.76$). Likewise, test-retest was satisfactory for both perceived motor competence ($r = 0.76$) and motor task values ($r = 0.63$) (Volman, 2009).

2.6.5. Measurements: physical activity

2.6.5.1. Yamax CW700 digiwalker pedometer. Total physical activity was assessed with the Yamax CW700 Digiwalker Pedometer. The Yamax CW700 registers every step ("count") for each vertical motion that surpasses a threshold force of 0.35 g. Children were asked to wear the Yamax CW700 for 7 consecutive days. We used the average steps per day for analyses. An earlier version of the Yamax CW700, the Yamax S200-Digiwalker Pedometer, has excellent interinstrument reliability (ICC 0.96–0.99) (e.g., Barfield, Rowe, & Michael, 2004). The Yamax CW700 Digiwalker is a newer, more advanced version of the Yamax SW200 and is able to store day-to-day data for 7 days, unlike the Yamax SW200.

2.6.5.2. 7-day activity diary. Leisure physical activity was assessed using a 7-day activity diary. Parents were asked to report their child's activities after school and on weekends for 7 consecutive days. The activity diary consists of 30 min time blocks between 15:00 and 19:00 on Monday, Tuesday, Thursday, and Friday, between 12:30 and 19:00 on Wednesday,[1] and between 08.00 and 19.00 on Saturday and Sunday. Every time block was scored based on Bouchard's method (Bouchard et al., 1983) to assess the energy expenditure of the activity (scores between 1 and 9): higher scores indicated higher energy expenditure. Next, we categorized every time block as *physical activity* or *no physical activity*. Activities with a score of 6 (e.g., leisure activities outside) or higher were considered as *physical activity* and scores below 6 were considered as *no physical activity*. We divided the number of time blocks that were categorized as *physical activity* by the number of time blocks that were filled in to calculate the percentage that children were physically active after school and on weekends, as done previously in XXXXX. Proxy reports for physical activity appear to be adequate and suitable with parental proxy reports significantly correlating with heart rate monitoring ($r = 0.71$–0.81 per day and $r = 0.68$ for a 3-day period) (Manios, Kafatos, & Markakis, 1998).

2.6.6. Statistical analysis

First, normality tests (Kolmogorov-Smirnov test) were used to check data distribution. Only data of total physical activity and leisure physical activity were normally distributed ($p > 0.200$).

Second, we used Mann-Whitney *U* tests to analyze differences between the intervention group and the care-as-usual group at baseline for motor performance, motor difficulties, perceived athletic competence, perceived motor competence, motor task values, and global self-esteem. We used Independent T-tests to analyze differences between the intervention and the care-as-usual group at baseline for total physical activity and leisure physical activity.

Third, we used mixed linear models to estimate the effects of the intervention on all outcome measures. Mixed linear models are more able to handle missing data and uneven spacing between time points than repeated measures analysis of variance. We investigated differences between baseline and trial end-point, between trial end-point and 3-month follow-up, and between baseline and 3-month follow-up. Group, time, and the interaction between group and time were included as fixed effects in the model; a random effect was estimated for the intercept. If significant, uncorrected post-hoc analyses (i.e., LSD) were used to investigate differences between groups at different time points and between time points. There were no missing values for motor performance, perceived motor competence, and motor task values. We used multiple imputations to estimate the (negligible) number of missing items (<1%) for perceived athletic competence and global self-esteem. We removed the test result for a specific time point for motor difficulties (T0: $n = 0$; T1: $n = 6$; T2: $n = 6$), leisure physical activity (T0: $n = 6$; T1: $n = 9$; T2: $n = 10$), and total physical activity (T0: $n = 1$; T1: $n = 4$; T2: $n = 7$) if *less* than 50% of the values were filled-in. We estimated the missing values using multiple imputations for motor difficulties and total physical activity if *more* than 50% of the items were filled in. With regard to leisure physical activity, multiple imputations were not necessary because we calculated a percentage of leisure physical activity using only the time blocks that were filled in. All available data were used, with analyses based on the principle of intention-to-treat.

Fourth, we performed Kruskal-Wallis tests to investigate differences in self-perceptions among the intervention group, the care-as-usual group, and the control group of typically developing children. We furthermore performed one-way ANOVAs to investigate differences in total physical activity and leisure physical activity among the intervention group, the care-as-usual group, and the group of typically developing children. This way we investigated if differences in self-perceptions and physical activity became smaller over time between children with DCD and typically developing children. If significant, uncorrected post-hoc analyses were used to investigate differences between every pair of groups. All analyses were performed using SPSS 20.0. Statistical significance was set to $p < 0.05$.

[1] Children in Dutch elementary schools are free on Wednesday afternoons.

3. Results

3.1. Participant characteristics

Eight pediatric therapists recruited children for the intervention group while seven pediatric therapists recruited children for the care-as-usual group. Years of experience was the same between the therapists who administered the intervention (range 2–12 years) and the therapists who administered the care-as-usual (5–14 years), $U\ (n = 15) = 14.50$, $p = 0.121$.

The intervention group consisted of 20 children (13 boys), mean age 8.15 years ($SD = 0.93$). The care-as-usual group consisted of 11 children (8 boys), mean age 8.09 years ($SD = 1.14$). Age at baseline, $U\ (n = 31) = 102.50$, $p = 0.761$, school type distribution, $\chi^2\ (1,\ n = 31) = 0.132$, $p = 0.717$, and gender distribution, $\chi^2\ (1,\ n = 31) = 0.194$, $p = 0.660$, were the same in both groups. The two groups scored the same on all primary and secondary outcome measures at baseline with the exception of perceived gross motor performance. Children in the care-as-usual group perceived themselves higher for gross motor performance than children in the intervention group, $U\ (n = 31) = 39.5$, $p = 0.003$. Results on all primary and secondary outcome measures are reported in Table 1.

3.2. Motor performance

We found no effect of the intervention on motor performance. However, motor performance improved over time, $F(2, 58) = 6.07$, $p = 0.004$. Post-hoc analyses revealed that children in the two groups improved their motor performance after 12 treatment sessions ($p = 0.005$). This improvement was maintained at the 3-month follow-up ($p = 0.003$). On examination of the individual MABC-2 components we found no effect of the intervention for any of the individual MABC-2 components. We found that aiming and catching, $F(2, 58) = 3.76$, $p = 0.029$, and balance, $F(2, 58) = 6.03$, $p = 0.004$, improved over time in both groups, while manual dexterity, $F(2, 58) = 0.56$, $p = 0.572$, did not. Aiming and catching ($p = 0.053$) improved almost significantly, and balance improved significantly ($p = 0.034$), after 12 treatment sessions. This improvement in aiming and catching ($p = 0.011$) and balance ($p < 0.001$) was maintained at the 3-month follow-up.

We found no effect of the intervention on motor difficulties as reported on the DCD-Q. However, motor difficulties decreased over time, $F(2, 49.2) = 10.52$, $p < 0.001$. Post-hoc analyses revealed that parents rated their children in the two groups as experiencing fewer motor difficulties after 12 treatment sessions ($p < 0.001$). This improvement was maintained at the 3-month follow-up ($p < 0.001$) (Table 2).

3.3. Self-perceptions

We found no effect of the intervention on perceived athletic competence and global self-esteem. However, perceived athletic competence, $F(2, 58) = 9.00$, $p < 0.001$, and global self-esteem, $F(2, 58) = 3.51$, $p = 0.036$, increased over time in children in the two groups. Perceived athletic competence ($p < 0.001$) and global self-esteem ($p = 0.044$) increased after 12 treatment sessions. This increase in perceived athletic competence ($p = 0.002$) and global self-esteem ($p = 0.016$) was maintained at the 3-month follow-up.

With regard to perceived motor competence and motor task values, we found no effect of the intervention on perceived fine motor competence and perceived ball competence. However, we found that perceived gross motor competence, $F(1, 29) = 4.29$, $p = 0.047$, was higher in children in the care-as-usual group. Perceived fine motor competence, $F(2, 58) = 4.76$, $p = 0.012$, and perceived ball competence, $F(2, 58) = 4.99$, $p = 0.010$, increased significantly over time in children in both groups, while perceived gross motor competence did not, $F(2, 58) = 0.162$, $p = 0.851$. Perceived fine motor competence increased between baseline and the 3-month follow-up ($p = 0.003$), while perceived ball competence increased after 12 treatment sessions ($p = 0.007$). This increase in perceived ball competence was maintained at the 3-month follow-up ($p = 0.010$). There was no effect of the intervention on perceived fine motor competence, perceived ball competence, and perceived gross motor competence.

We found no effect of the intervention for any of the motor task values. Furthermore, motor task values did not change during the study period (Table 2).

3.4. Physical activity

We found no effect of the intervention on leisure physical activity and total physical activity. Furthermore, leisure physical activity and total physical activity did not change during the study period (Table 2).

3.5. Intra-group variability

Random intercepts of almost all primary and secondary outcome measures were significant, indicating large intra-group variability at baseline (Table 2). We investigated individual changes by examining the number of children that increased or decreased ≥ 1 MDD on the MABC-2. In doing so, the group data became more transparent. Sixty percent of the children in the intervention ($n = 12$) and 46% of the children in the care-as-usual group ($n = 5$) increased their motor performance after 12

Table 1
Means and Standard Deviations of Primary and Secondary Outcomes at Each Time-Point.

	Baseline				After 12-treatment sessions				3-month follow-up			
	n	Intervention *M* (*SD*)	*n*	Care as Usual *M* (*SD*)	*n*	Intervention *M* (*SD*)	*n*	Care as Usual *M* (*SD*)	*n*	Intervention *M* (*SD*)	*n*	Care as Usual *M* (*SD*)
Motor performance (1–19)												
Manual Dexterity	20	4.4 (3.1)	11	5.4 (3.4)	20	5.1 (2.6)	11	5.8 (4.3)	20	5.1 (3.0)	11	5.8 (3.1)
Aiming and Catching	20	4.6 (2.2)	11	5.7 (2.8)	20	6.3 (3.2)	11	6.2 (3.7)	20	6.3 (2.8)	11	6.9 (2.6)
Balance	20	5.1 (2.7)	11	5.5 (4.3)	20	5.9 (3.2)	11	6.7 (3.2)	20	6.6 (2.8)	11	7.2 (3.4)
Total score	20	3.1 (1.5)	11	3.8 (2.4)	20	4.2 (2.3)	11	5.6 (4.1)	20	4.5 (2.4)	11	5.5 (3.0)
MD (15–75)	20	41.5 (9.2)	11	41.3 (8.5)	17	50.3 (13.1)	8	48.1 (9.4)	17	53.4 (11.9)	8	47.5 (4.3)
PAC (6–24)	20	14.8 (4.3)	11	17.1 (4.0)	20	17.9 (3.6)	11	19.7 (4.1)	20	17.5 (4.2)	11	19.2 (3.3)
GSE (6–24)	20	19.1 (2.8)	11	19.8 (3.7)	20	20.3 (3.6)	11	21.5 (2.3)	20	21.1 (2.5)	11	21.3 (2.6)
PMC												
PFMC (5–20)	20	13.1 (2.3)	11	13.0 (3.7)	20	14.7 (2.3)	11	13.1 (3.4)	20	14.8 (2.6)	11	14.4 (2.2)
PBC (3–12)	20	8.0 (2.0)	11	8.8 (1.8)	20	9.7 (1.8)	11	9.4 (1.5)	20	9.4 (1.3)	11	9.5 (1.5)
PGMC (5–20)	20	16.3 (2.5)[a]	11	18.7 (1.6)[a]	20	17.0 (2.0)	11	17.7 (2.2)	20	17.5 (2.0)	11	17.7 (2.0)
MTV												
FMTV (5–20)	20	15.4 (2.9)	11	15.3 (3.5)	20	16.0 (2.0)	11	15.0 (3.8)	20	16.4 (2.9)	11	15.4 (4.3)
BTV (3–12)	20	9.0 (1.9)	11	8.4 (2.0)	20	9.1 (2.3)	11	8.7 (2.4)	20	8.7 (2.3)	11	9.4 (2.1)
GMTV (5–20)	20	15.9 (2.2)	11	17.2 (3.3)	20	16.1 (2.1)	11	16.1 (2.3)	20	15.8 (2.5)	11	15.9 (3.2)
PA (steps/day)	20	9607 (2280)	10	8340 (2233)	18	10161 (2686)	9	8968 (2551)	15	9870 (2735)	9	8770 (2390)
LPA (percentage)	17	.22 (.12)	8	.13 (.07)	13	.22 (.12)	9	.24 (.15)	12	.28 (.16)	9	.20 (.10)

Note. MD = motor difficulties (DCDQ); PMC = perceived motor competence; MTV = motor task values; PFMC = perceived fine motor competence; PBC = perceived ball competence; PGMC = perceived gross motor competence; FMTV = fine motor task values; BTV = ball task values; GMTV = gross motor task values; PAC = perceived athletic competence; GSE = global self-esteem; PA = total physical activity; LPA = leisure physical activity; [a] = significantly different at baseline ($p < .05$).

Table 2
Estimated fixed and random effects for primary and secondary outcomes between baseline, trial endpoint, and follow-up.

	Fixed effects									Random effects	
	Intervention			Time[1]			Intervention × Time[2]			Intercept	
	Est. (SE)	F	*p*	Est. (SE) T0-T2 Est. (SE) T1-T2	F	*p*	Est. (SE) T0 x Int. Est. (SE) T1 x Int.	F	*p*	Est. (SE)	*p*
MABC-2											
MDex	−0.77 (1.19)	0.730	.400	−0.45 (.99) 0.00 (.99)	0.564	.572	−0.20 (1.23) 0.05 (1.23)	0.022	.978	4.70 (1.74)	**.007**
A&C	−0.61 (1.08)	0.379	.543	−1.18 (.88) −0.73 (.88)	3.763	**.029**[b]	−0.52 (1.09) 0.73 (1.09)	0.656	.523	4.04 (1.46)	**.006**
B	−0.58 (1.19)	0.346	.561	−1.73 (.77) −0.45 (.77)	6.027	**.004**[ab]	0.18 (0.95) −0.30 (0.95)	0.125	.883	6.84 (2.09)	**.001**
Total	−1.00 (0.96)	1.728	.199	−1.64 (.77) 0.09 (.77)	6.071	**.004**[ab]	0.29 (.96) −0.39 (.96)	0.252	.778	3.35 (1.18)	**.005**
MD	6.52 (4.25)	0.840	.367	−5.44 (3.45) 1.07 (3.76)	10.516	**<.001**[ab]	−6.31 (4.20) −4.21 (4.54)	1.134	.330	54.77 (20.12)	**.006**
PAC	−1.73 (1.49)	2.514	.124	−2.04 (1.15) 0.55 (1.15)	8.995	**<.001**[ab]	−0.60 (1.43) −0.10 (1.43)	0.103	.902	8.48 (2.90)	**.003**
GSW	−0.22 (1.12)	0.840	.367	−1.44 (1.11) 0.18 (1.11)	3.510	**.036**[ab]	−0.54 (1.38) −0.93 (1.38)	0.229	.796	2.05 (1.21)	.089
PMC											
PFMC	0.39 (1.01)	0.657	.424	−1.36 (0.79) −1.27 (0.79)	4.757	**.012**[b]	−0.29 (0.98) 1.17 (0.98)	1.249	.294	3.89 (1.33)	**.004**
PBC	−0.20 (0.64)	0.244	.625	−0.73 (0.61) −0.18 (0.61)	4.992	**.010**[ab]	−0.57 (0.76) 0.48 (0.76)	0.957	.390	0.79 (0.41)	.053
PGMC	−0.23 (0.79)	4.288	**.047**	1.00 (0.78) 0.00 (0.78)	0.162	.851	−2.25 (0.97) −0.55 (0.97)	2.945	.061	1.12 (0.62)	.070
MTV											
FMTV	0.99 (1.17)	0.482	.493	−0.09 (0.91) −0.36 (0.91)	0.489	.616	−0.91 (1.13) −0.36 (1.13)	0.413	.663	5.12 (1.76)	**.004**
BTV	−0.71 (0.82)	0.024	.877	−1.00 (0.73) −0.64 (0.73)	0.273	.762	1.35 (0.91) 1.09 (0.91)	1.249	.295	1.84 (0.76)	**.015**
GMTV	−0.16 (0.96)	0.452	.507	1.27 (0.89) 0.18 (0.89)	0.839	.438	−1.12 (1.11) 0.17 (1.11)	0.799	.455	2.12 (0.98)	**.030**
PA	1206 (1027)	2.631	.116	−338 (892) 193 (923)	0.535	.589	60 (1117)8 (1148)	0.002	.998	2421178 (1019127)	**.018**
LPA	0.07 (0.55)	1.530	.228	−0.07 (0.06) 0.04 (0.05)	1.991	.149	0.02 (0.07) −0.11 (0.07)	1.743	.187	0.00 (0.00)	.241

Note. **Bold** = $p < .05$; [a] = significant difference between baseline and trial endpoint; [b] = significant difference between baseline and follow-up; [c] = significant difference between trial endpoint and follow-up; MDex = manual dexterity; A&C = aiming and catching; B = balance; Total = total score; MD = motor difficulties; PAC = perceived athletic competence; GSE = global self-esteem; PMC = perceived motor competence; PFMC = perceived fine motor competence; PBC = perceived ball competence; PGMC = perceived gross motor competence; MTV = motor task values; FMTV = fine motor task values; BTV = ball task values; GMTV = gross motor task values; PA = physical activity; LPA = leisure physical activity; Est. = estimate; SE = standard error; Int. = intervention. Time[1] = the upper estimate is difference between follow-up and baseline, and the lower estimate is difference between follow-up and trial end-point. Intervention × Time[2] = upper estimate is interaction between group and time at baseline, and the lower estimate is interaction between time and trial end-point, with follow-up as reference value.

Table 3
Change on the MABC-2 in Children who Scored ≤ 16th percentile at Baseline.

	After 12-treatment sessions			At follow-up		
	Decreased (≥ 1 MDD) *n* (%)	Remained stable *n* (%)	Increased (≥ 1 MDD) *n* (%)	Decreased (≥ 1 MDD) *n* (%)	Remained stable *n* (%)	Increased (≥ 1 MDD) *n* (%)
Intervention group						
Manual dexterity (*n* = 16)	2 (12)	3 (19)	11 (69)	4 (25)	4 (25)	8 (50)
Aiming and catching (*n* = 18)	3 (17)	6 (33)	9 (50)	2 (11)	5 (28)	11 (61)
Balance (*n* = 16)	4 (25)	2 (12)	10 (63)	3 (19)	1 (6)	12 (75)
Total score (*n* = 20)	5 (25)	3 (15)	12 (60)	5 (25)	2 (10)	13 (65)
Care as usual group						
Manual dexterity (*n* = 10)	4 (40)	1 (10)	5 (50)	4 (40)	0 (0)	6 (60)
Aiming and catching (*n* = 8)	2 (25)	4 (50)	2 (25)	1 (12)	3 (38)	4 (50)
Balance (*n* = 9)	1 (11)	0 (0)	8 (89)	0 (0)	1 (11)	8 (89)
Total score (*n* = 11)	2 (18)	4 (36)	5 (46)	1 (9)	3 (27)	7 (64)

Note. MDD = minimal detectable difference.

Table 4
Children who Changed Categories for Perceived Athletic Competence.

	PAC After 12-treatment sessions		PAC At follow-up	
	<15thpercentile*n* (%)	>15thpercentile*n* (%)	<15thpercentile*n* (%)	>15thpercentile*n* (%)
Baseline				
Intervention group (*n* = 20)				
<15th percentile (*n* = 11)	2 (18)	9 (82)	4 (36)	7 (64)
>15th percentile (*n* = 9)	1 (11)	8 (89)	0 (0)	9 (100)
Care as usual group (*n* = 11)				
<15th percentile (*n* = 3)	0 (0)	3 (100)	1 (33)	2 (67)
>15th percentile (*n* = 8)	1 (13)	7 (87)	0 (0)	8 (100)

Note. PAC = perceived athletic competence. Thirteen (9%) typically developing children scored ≤ 15th percentile, and 130 (91%) typically developing children scored > 15th percentile.

treatment sessions. This improvement was maintained at the 3-month follow-up. However, differences *within* both groups, and *between* the subsets of the MABC-2, were considerable (Table 3).

We also examined the change in perceived athletic competence on an individual level where we categorized children as having low (≤ 15th percentile) or normal (> 15th percentile) levels of perceived athletic competence. We found that the vast majority of children in the intervention (82%) and the care-as-usual group (100%) with low levels of perceived athletic competence at baseline had normal levels of perceived athletic competence after 12 treatment sessions. This number decreased at 3-month follow-up, but more than half of the children in the intervention (64%) and care-as-usual group (67%) still had normal levels of perceived athletic competence (Table 4).

3.6. Benchmark between children with DCD and typically developing children

3.6.1. Self-perceptions

We pooled the results of the intervention group and the care-as-usual group to increase power because there were no differences in treatment effects between the two groups[2] ($n = 31$). Children with DCD had lower levels of perceived athletic competence, U ($n = 174$) = 999.50, $p < 0.001$, global self-esteem, U ($n = 174$) = 1398.50, $p < 0.001$, and perceived fine motor competence, U ($n = 174$) = 1081.00, $p < 0.001$, than typically developing children ($n = 143$) at baseline, while perceived ball competence and perceived gross motor competence were the same (Supplementary material online).

Differences for perceived athletic competence and global self-esteem were no longer significant after 12 treatment sessions, but differences for perceived fine motor competence still were, U ($n = 174$) = 1609.00, $p = 0.016$. At the 3-month follow-up, differences for global self-esteem and perceived fine motor competence were not significant, but differences for perceived athletic competence were, U ($n = 174$) = 1719, $p = 0.049$.

Fine motor task values, ball task values, and gross motor task values were the same in children with DCD and typically developing children at baseline, after 12 treatment sessions, and at the 3-month follow-up.

[2] Differences in psychological variables between the intervention group, the care-as-usual group, and typically developing children are reported in the supplementary material online.

3.6.2. Physical activity

Again, we pooled the results of both groups to increase power. We compared these results with total physical activity ($n = 94$) and leisure physical activity ($n = 54$) in typically developing children. Children with DCD participated less in total physical activity and leisure physical activity than typically developing children at baseline, after 12 treatment sessions, and at the 3-month follow-up (Supplementary material online).

4. Discussion

We investigated the effect of an integrated perceived competence and motor intervention (intervention) in children with DCD, aged 7–10 years, compared with a motor intervention only (care-as-usual).

4.1. Motor performance

After 12 treatment sessions, motor performance and motor difficulties were the same in both groups. We hypothesized that motor performance would improve more in the intervention group, due to the specific (positive) progress feedback given by the pediatric therapists (see for review Hattie & Timperly, 2007; Shute, 2008). We based our hypothesis on a number of studies that found that specific progress feedback positively influences learning *cognitive* skills. However, no study had investigated whether specific progress feedback influenced learning *motor* skills. We argue that other determinants, like creating a playful, one-on-one situation where specific attention is paid to the child's current motor performance are stronger determinants for learning *motor* skills than specific positive progress feedback. This could explain the equal improvement in motor performance in both groups. The improvement in motor performance is in line with a number of studies that have investigated care-as-usual interventions in children with DCD (see for review Smits-Engelsman et al., 2013). We argue that manual dexterity did not improve because it was not the primary focus of the intervention.

4.2. Self-perceptions

After 12 treatment sessions, levels of perceived athletic competence and global self-esteem were the same in both groups. This result could be explained by the fact that the pediatric therapists in the care-as-usual group also enhanced, possibly unknowingly, children's perceived athletic competence during the treatment sessions. A number of teachers also provided specific positive feedback to their students *without* being specifically trained to do so (Voerman, Meijer, Korthagen, & Simons, 2012).

Global self-esteem is influenced by a number of domain specific self-perceptions (e.g., perceived scholastic competence), which are, in turn, influenced by specific activities (e.g., Schmidt, Blum, Valkanover, & Conzelmann, 2015). We argue that children in the intervention and the care-as-usual group improved in a number of specific activities during our study period, and, in turn, also in their self-perceptions. We speculate that this improvement in specific activities and self-perceptions was the same in both groups, resulting in an equal increase in global self-esteem.

Perceived athletic competence and global self-esteem were the same at the 3-month follow-up because children in both groups also improved equally after 12 treatment sessions.

With regard to the self-perceptions that were measured with the How Am I Doing questionnaire, we argue that perceived fine motor competence was the same in both groups because (perceived) fine motor competence was not the focus of our intervention. High levels of perceived gross motor competence were found in the care-as-usual group at baseline, which were also significantly higher than in the intervention group. Because of a ceiling effect for perceived gross motor competence in the care-as-usual group, significant differences in improvement between both groups was difficult to achieve after 12 treatment sessions.

Fine motor task values, ball task values, and gross motor task values remained the same over time in both groups. We argue that children are aware that the activities asked are important in daily life, whether or not they are able to perform them, resulting in fairly stable motor task values in both groups throughout our study period (Noordsta, van der Net, Jak, Helders & Jongmans, 2016c).

4.3. Physical activity

Total physical activity and leisure physical activity were the same in both groups, and remained the same over time. Although the model by Stodden et al. (2008) implies reciprocal *direct* associations between motor performance and physical activity, and *indirect* associations between motor performance and physical activity through perceived motor competence, the strength of these associations are only small to moderate in typically developing children (e.g., Davison, Downs, & Birch, 2006). Moreover, we think that the improvement in motor performance and perceived competence in children with DCD was too small to substantially influence their participation in physical activity.

We performed a second analysis, based on the activity diaries filled in by parents, where we investigated if the intervention group participated less in sedentary behavior than the care-as-usual group after 12 treatment sessions and at the 3-month follow-up. We found no differences between the intervention group and the care-as-usual group, but there was a significant decrease in sedentary behavior over time for all children ($p = 0.049$).

4.4. Intra-group variability

We found large intra-group variability in the improvement in motor performance. This result is in accordance with others (e.g., Ferguson, Jelsma, Jelsma, & Smits-Engelsman, 2013). Children with DCD are a heterogeneous group (e.g., Vaivre-Douret et al., 2011), so variability in improvement after a motor intervention can be expected. However, future research should take this intra-group variability into account. We argue that investigating determinants of the children with DCD who improve, remain stable, or decrease would provide vital information for developing motor intervention programs for children with DCD.

Also, we found large intra-group variability in perceived athletic competence at baseline, which is in accordance with others (e.g., Noordstar et al., 2014). Noordstar et al. (2014) speculated that the children with DCD in their study already received pediatric physical therapy, which increased their perceived athletic competence. However, in our study children were assessed before they received pediatric physical therapy. Apparently, there is a large number of children with DCD, aged between 7 and 10 years, who's self-perceptions are more positive than their actual motor performance, while self-perceptions are argued to be realistic from the age of 7 (Harter, 2006).

4.5. Differences benchmarked with typically developing children

4.5.1. Self-perceptions

Children with DCD had lower levels of perceived athletic competence, global self-esteem, and perceived fine motor competence than typically developing children at baseline. This result is in accordance with several other studies (e.g., Poulsen et al., 2008). However, children with DCD perceived themselves the same in perceived ball competence, perceived gross motor competence, and motor task values at baseline. We have no clear explanation for this result but, with regard to perceived gross motor competence, we speculate that the questions that were used to evaluate perceived gross motor competence made it difficult to make a qualified judgment. Moreover, children are able to perform the activity or not. This clear distinction resulted in a high and stable perceived gross motor competence because children were between 7 and 10 years of age and, therefore, able to perform most activities (e.g., climbing, running). With regard to motor task values, we feel, as mentioned before, that children are aware that the activities that they were asked to evaluate are important in daily life, equally so for children with DCD and typically developing children, resulting in an equal level of motor task values.

As children improved their self-perceptions after 12 treatment sessions, differences between children with DCD and typically developing children became smaller and were no longer significant. Perceived fine motor competence was the only exception, but as mentioned before, (perceived) fine motor competence was not the (primary) focus of the treatment sessions. Differences remained non-significant at the 3-month follow-up, except for perceived athletic competence, where children with DCD had lower levels for perceived athletic competence than typically developing children. Children with DCD received no positive feedback from their pediatric therapist during the 3-month follow-up period, possibly resulting in a decline in perceived athletic competence.

4.5.2. Physical activity

Children with DCD participated less in physical activity than typically developing children at baseline. This result is in line with other studies that have investigated differences in physical activity between children with DCD and typically developing children (e.g., Cairney et al., 2010; Noordstar et al., 2014). However, children with DCD participated still less in physical activity after 12 treatment sessions and at the 3-month follow-up. As argued before, the improvement in motor performance and perceived athletic competence was of insufficient magnitude to improve their participation in physical activity.

4.6. Weaknesses and strengths of the study

Several limitations of this study have to be recognized. Firstly, we included children based on their motor performance and physical activity scores, but not on their perceived athletic competence scores. We assumed, based on an extensive number of studies, perceived athletic competence in children with DCD to be low. However, in retrospect, we should have taken low perceived athletic competence as an inclusion criterion, as a number of children ($n = 17$) had normal levels of perceived athletic competence at baseline. Then the effect of the intervention might have been larger because the intervention focused on improving perceived athletic competence in addition to motor performance. Secondly, the number of children in the care-as-usual group was smaller than we had determined in our sample-size calculation, making it harder to find significant differences between the intervention and the care-as-usual group. However, we speculate that a larger number of children in the care-as-usual group would not have significantly influenced the results because scores on the outcome measures were fairly similar in both groups. Thirdly, a large number of physical activity data was missing at the 3-month follow-up, making our results possibly less valid. However, missing data was taken into account because we used mixed linear models to investigate the effect of the intervention group and the care-as-usual group. Fourth, we did not take parental influences into account, while, for example, parents' encouragement and support can increase children's physical activity (e.g., Xu, Wen, & Rissel, 2015). Finally, we did not investigate co-occurring disorders like attention deficit disorders and learning problems that frequently co-occur with DCD (e.g., Kaiser, Schoemaker, Albaret, & Geuze, 2015). These co-occurring disorders possibly affected the responsiveness to the intervention.

In terms of strengths of our study, this is the first study that investigated the effect of an integrated perceived competence and motor intervention in children with DCD on motor performance, self-perceptions, and physical activity. We also investigated if any improvement was maintained after 3 months of no intervention and benchmarked our results to a group of typically developing children.

4.7. Conclusion

We found no significant advantages of an integrated perceived competence and motor intervention compared with care-as-usual on motor performance, self-perceptions, and physical activity in children with DCD. Because this study was underpowered, the conclusions need to be interpreted with caution. Children in both groups equally improved their motor performance and self-perceptions after 12 treatment sessions. This improvement was maintained at the 3-month follow-up, while physical activity remained unchanged.

Unfortunately, no specific content of the care-as-usual was collected, but we speculate that the pediatric therapists that administered the care-as-usual may have unknowingly also enhanced the children's self-perceptions during treatment sessions. Based on the model by Stodden et al. (2008), we hypothesized that an increase in motor performance and self-perceptions would result in an increase in physical activity in children with DCD. We assume that other determinants may play a role, in addition to self-perceptions, for children's participation in physical activity. More specifically, Stodden et al. (2008) argued that, besides perceived competence, physical fitness also mediates the association between motor performance and physical activity, while others have argued that autonomy and relatedness are important determinants for participation in physical activity (Deci and Ryan, 2002). However, to date, studies investigating motivational principles to enhance physical activity are lacking for children with DCD.

It is worth mentioning that we found large intra-group variability on the improvement in motor performance and self-perceptions in children with DCD. Future research should focus on investigating motivational determinants of physical activity in children with DCD in order to develop intervention programs to promote physical activity in children with DCD, where the large intra-group variability should be taken into account.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ridd.2016.12.002.

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