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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

A highly intensive balance camp for children with developmental coordination disorder: Effects on different ICF-levels

Emma Liberloo
Lisa Vanempten
Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij kinderen

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2025

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Acknowledgements

This master's thesis marks the end of an intensive but rewarding process. We would like to take this opportunity to thank the individuals who played a crucial role in the process.

Writing our master's thesis would not have been possible without the help of certain people. We thank our mentors, Prof. Dr. Evi Verbecque, Prof. Dr. Katrijn Klingels, and Drs. Silke Velghe for their support throughout the process and for providing us with constructive feedback. They helped us expand our knowledge on this topic and describe this information appropriately in this thesis. Completing this master’s thesis successfully would not have been possible without their help.

In addition, we would like to thank Drs. Silke Velghe and Drs. Maja Van Grinderbeek for allowing us to participate as individual therapists in the intervention camp. This experience allowed us to observe the intervention firsthand, significantly enhancing our understanding of the research and its practical applications.

Finally, we would like to thank everyone who contributed directly or indirectly to the realization of this master's thesis.

Research Contextualization

This master's thesis is part of the course *Verdiepende Wetenschappelijke Stage en Masterproef* within the Faculty of Rehabilitation Sciences and Physiotherapy at Hasselt University, and is explicitly situated within the field of Paediatrics. Our thesis falls under the broader domain of *Gait and Balance*. More precisely, in the doctoral research conducted by Doctor of Philosophy (PhD) student Silke Velghe, titled '*Clinical insights into postural control in children with Developmental Coordination Disorder: the effect of time and a highly intensive balance intervention'*.

Children with Developmental Coordination Disorder (DCD) experience difficulties acquiring and executing motor skills, with postural control being a widespread problem. Although the existing literature describes interventions targeting postural control in this population, these often focus on a few postural control systems and are not always at the activity and participation level of the International Classification of Functioning, Disability, and Health (ICF). Furthermore, little is known about the necessary intensity required for an effective intervention within the DCD population. The doctoral study organised a highly intensive balance camp that focused on all domains of postural control in the intervention and assessed outcomes on all levels of the ICF. This study incorporates both a longitudinal and an interventional component. The study has a pre- and post-test interventional design with a triple non-training baseline. Both the quantitative and qualitative outcomes were administered at five time points at the REVAL building in Diepenbeek. The one-week circus-themed balance camp was organised at the Sint-Gerardus school in Diepenbeek.

Our master's thesis focuses on interventional components and quantitative outcomes.

The writing tasks were not divided, opting for equal contributions to ensure comprehensive engagement with all aspects of the research. Participation occurred as individual therapists in the August 2024 camp, along with assessments during the first year of the master's program. In the second year of the master's program, thesis writing began, utilizing the data provided by S.V. In consultation with our supervisors, three research questions were established.

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Abstract

Background*:* One of the key motor difficulties experienced by children with Developmental Coordination Disorders (DCD) is postural control. This problem affects their daily functioning. Several interventions targeting postural control lack a comprehensive multisystemic approach and do not adequately address the activity and participation level of the ICF. Intervention intensities have been effective in other pediatric populations, but effectiveness for DCD remains unclear.

Objectives*:* This study aims to evaluate the effectiveness of a highly intensive balance intervention camp for children with DCD.

Methods*:* A circus-themed camp for 35 children aged 6 to 12 with DCD was designed to improve postural control. Assessments of postural control (Kids-BESTest-2) and gross motor skills (TGMD-3) assessments were conducted before intervention, after, and at three-month follow-up using a linear mixed model. The correlation between changes in motor performance and self-perceived competence (COPM, CBSK/PSCPCSA) was examined. The last aim was to identify responders for successful outcomes using a descriptive statistical table that examined the p-value differences based on age, baseline score of the Kids-BESTest-2 and TGMD-3, therapy, natural motor growth, and comorbidities.

Results*:* At follow-up, children showed progress on the TGMD-3 and Kids-BESTest-2. Age and baseline performance significantly affected Kids-BESTest-2 outcomes, while only baseline scores influenced TGMD-3 outcomes. No correlations were found between motor performance and self-perceived competence. Age and baseline scores of Kids-BESTest-2 were key factors in determining responders.

Conclusion*:* The intensive balance camp shows promising effects, but further research is needed to confirm these findings, as this is currently the only available supporting study.

Keywords*:* Developmental Coordination Disorder, DCD, balance, highly intensive therapy camp, postural control, motor learning, physical therapy

Introduction

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder defined by difficulties acquiring and executing gross and fine motor skills (APA, 2023). Approximately 5-6% of all school-aged children are affected, particularly boys (Blank et al., 2012; Zwicker et al., 2012). Co-occurrence with other neurodevelopmental disorders, such as autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), and learning disabilities, is common (Blank et al., 2012; Zwicker et al., 2012). Children with DCD often struggle with various motor skills, leading to difficulties in daily activities and a clumsy appearance (Blank et al., 2019). These impairments affect all levels of the International Classification of Functioning, Disability, and Health (ICF) (Blank et al., 2019; World Health Organization, 2001). Issues may arise in areas such as motor planning, task automation, and coordination, which can impact children's ability to perform tasks like cycling, dressing, and self-care (Blank et al., 2019). Problems in participation occur, for example, in school gymnastics or playing with peers (Blank et al., 2019; Zwicker et al., 2012). Additionally, DCD can negatively impact emotional and mental health, resulting in lower self-esteem and increased anxiety (Blank et al., 2019; Zwicker et al., 2012). Impaired postural control is a prevalent issue in DCD, affecting balance in daily activities (Verbecque et al., 2021) and leading to decreased independence and an increased risk of falls (Shumway-Cook & Woollacott, 2017).

According to Horak, postural control is multisystemic and relies on six systems that help a person maintain balance and interact with their environment. The '*Biomechanical Constraints*' system describes physical aspects like foot deformities, muscle strength, joint range of motion, movement control, and pain. '*Movement Strategies*' can be divided into Anticipatory Postural Adjustments (APAs) and Reactive Postural Adjustments (RPAs) (Horak, 2006). APAs are preparatory muscle activations before an expected postural disturbance, whereas RPAs are reflexive muscle responses after an unexpected disturbance to restore balance (Horak et al., 2009). '*Sensory strategies*' rely on sensory input from the somatosensory, visual, and vestibular systems. These factors are crucial for maintaining balance, and their priority depends on the specific conditions. '*Orientation in Space*' helps preserve posture by considering factors such as surface, visual environment, internal reference points, and gravity. '*Control of Dynamics*' necessitates adjustments when the body's center of mass shifts during movement, whereas '*Cognitive Processing*' emphasizes the increased mental effort required as postural demands increase (Horak, 2006).

Children with DCD perform similarly to typically developing (TD) children in simple motor tasks (Johnson et al., 2024), for example, their gait parameters are comparable (Verbecque et al., 2021). However, their performance significantly deteriorates in situations that require complex sensory integration or rapid postural adjustments (Johnson et al., 2024). These children experience more challenges with limits of stability and APAs and rely more on slower control mechanisms due to inefficient motor planning and internal modeling (Johnson et al., 2024).

Several interventions aim to enhance postural control in children with DCD, including strength training (Kordi et al., 2016), taekwondo (Fong et al., 2013), Tai Chi muscle power training (Fong et al., 2022), and serious game-based interventions (Kokol et al., 2020), among others. However, most of them only address specific aspects of postural control, leaving gaps in the multisystemic framework (Velghe et al., 2025). Highly intensive therapy is often applied in other pediatric populations and has been proven successful (Araneda et al., 2020; Novak et al., 2020; Sudati et al., 2024; Thivel et al., 2019). In children with DCD, the results of highly intensive therapy appear promising (Krajenbrink et al., 2022; Zwicker et al., 2015). However, the effects on postural control remain unexplored.

This study evaluates the effectiveness of a highly intensive balance intervention camp for children with DCD. The aim is to assess the impact of the intervention on postural control and gross motor skills, considering factors such as age, comorbidities, and the presence of therapy in addition to the intervention. The suspicion exists that having comorbid conditions, such as ADHD and ASD, could influence the progression of motor skills. Hypothetically, older children are likely to have more motor experience than younger children, which is why better performance on motor assessments is expected. Additionally, concurrent therapy could interfere with the intervention, potentially creating a greater effect than observed in children who are not undergoing treatment. The study also explores the relationship between motor performance improvements, children's self-perceived competence, and goal satisfaction, expecting a positive correlation. The ultimate aim is to identify responders to the intervention, with younger children without comorbidities and those receiving therapy likely to benefit the most.

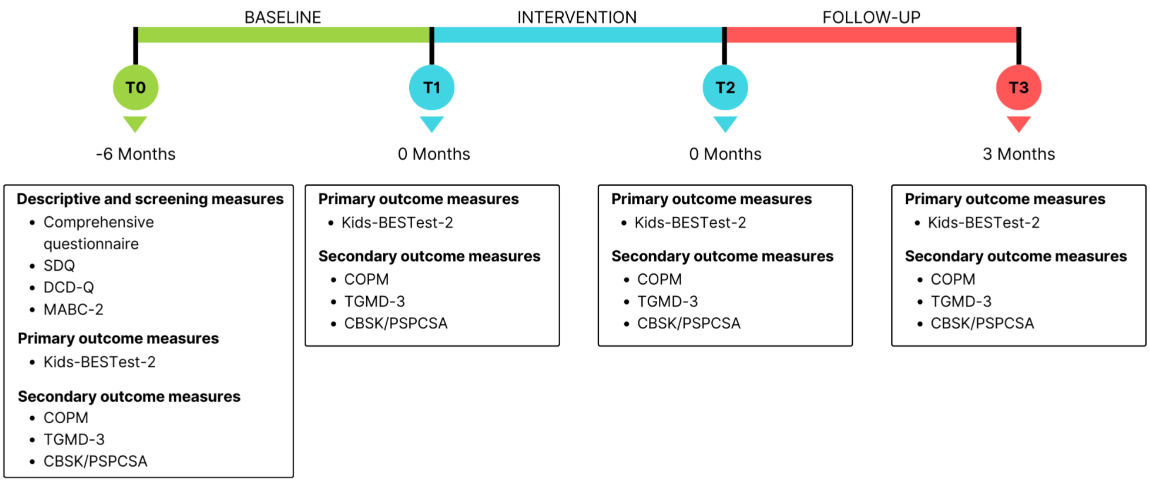
Method

Study design

This master's thesis is a quantitative study that follows the protocol of Velghe et al. (2024). This study employs a pre-post intervention design in a single-group setting, utilizing a clinical trial approach. At T0 (six months before the intervention), initial measurements and anamnesis are conducted to assess eligibility criteria and establish baseline scores on the different motor outcome measures (Kids-BESTest-2: the extended version of the Kids-Balance Evaluation Systems Test for children, and TGMD-3: Test of Gross Motor Development, 3rd edition). Immediately before the intervention, an assessment is conducted (T1), followed by two post-intervention assessments: one directly after the intervention (T2) and a follow-up assessment three months later (T3) (**Figure 1**). Children can continue with regular physical activities and therapy before the intervention. However, the analyses must take these factors into consideration.

Figure 1

Overview of the Assessments and Measures



Note. Abbreviation list: CBSK: Competentiebelevingsschaal voor Kinderen; COPM: Canadian Occupational Performance Measure; DCD-Q: Developmental Coordination Disorder Questionnaire; Kids-BESTest-2: The extended version of the Kids-Balance Evaluation Systems Test for children; MABC-2: Movement Assessment Battery for Children 2nd edition; SDQ: Strengths- and Difficulties Questionnaire; TGMD-3: Test of Gross Motor Development 3rd edition; PSPCSA: Pictorial Scale of Perceived Competence and Social Acceptance.

Participants

Recruitment

The participants in this study are children with DCD, ranging from 6 to 12 years at their initial assessment (T0). Recruitment was achieved through various ways to ensure inclusivity, including pediatric physiotherapists in Flanders, the DCD organization "V.Z.W. Dyspraxis" (an association for parents and children affected by DCD), flyers, social media, and a website. Three intervention camps were held: in April 2023, August 2023, and August 2024, with a total of 35 children taking part.

Inclusion criteria

Children officially diagnosed with DCD, as well as those with a probable diagnosis of DCD, were eligible to participate in this study if they met all the criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) (American Psychiatric Association, 2013; Blank et al., 2019):

1. The acquisition and performance of coordinated motor skills are below the expected age level, despite the opportunity to learn these skills. The Movement Assessment Battery for Children 2nd edition (MABC-2) is recommended for assessing motor skills. A total score at or below the 16th percentile indicates a risk of motor problems, while a score at or below the 5th percentile provides undeniable evidence of DCD;
2. Motor dysfunctions cause problems with activities of daily living (ADL), productivity at school, preparatory and vocational activities, recreation, and play, which the Developmental Coordination Disorder Questionnaire (DCD-Q) verifies;
3. An anamnesis with parents investigates the occurrence of the symptoms in childhood;
4. Motor difficulties experienced by the child cannot be attributed to intellectual disability, visual impairment, or other neurological conditions that affect motor function. A parent survey checked this item.

Children without formal diagnoses who met criteria 1, 2, and 3 upon evaluation, and for whom criterion 4 was confirmed through anamnesis and clinical examination, were labeled as probable DCD (Blank et al., 2019). In addition to the MABC-2, the Kids-BESTest-2 is used to evaluate postural control. To participate in this study, participants had to exhibit balance deficits, which were objectively assessed using the balance subscale score on the MABC-2. Children who scored below the 50^{th} percentile on the MABC-2 and below 80% on the Kids-BESTest-2 total score were included (Velghe et al., 2024).

Exclusion criteria

Children were excluded from this study if they did not meet the predetermined inclusion criteria, could not follow instructions, or exhibited uncooperative behavior due to behavioral problems.

Medical ethics

The Committee for Medical Ethics of Hasselt University, Belgium, approved this study (B1152022000001). Parents were informed about the study's purpose and protocol through a website, flyers, and online information sessions. Before participation, the parents and the child signed an informed consent form.

Intervention

The camp was based on the multisystemic framework of postural control (Horak, 2006), with functional activities categorized into six categories: running and walking, jumping, individual goals, circus, group activities, and sitting balance.

In addition to the activities within these various categories, the camp also emphasized individual goals. Most children had two or three personal goals they wanted to improve, such as learning to ride a bike without training wheels or mastering roller skating. These activities were challenging in their daily life. The time was divided equally among these goals, ensuring each child could practice and progress in the activities most relevant to them.

The intervention was developed around a circus theme to provide an attractive camp for the participants, primarily focusing on fun and enjoyment. Experiencing success was another essential component. Therefore, the activities were adapted each time to the child's level, either simplifying them or making them more challenging as necessary.

The highly intensive therapy program consisted of 40 hours spread over six consecutive days. Participants attended therapy from Monday to Saturday. Except for Saturday, each day consisted of seven 45-minute intervention blocks, with a 15-minute break between every therapy block. The children also received a daily 60-minute passive lunch break to ensure adequate rest between therapies. Every day ended with a 30-minute relaxation and discussion of the children's favorite and least favorite activities. The planning on Saturday consisted of three intervention blocks, ending with a show for parents and family. The table below shows an example of a camp schedule (**Table 1**).

Table 1

Overview of the Intervention Week

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
9:00-9:45	Introduction	Group activity	Running & walking	Group activity	Individual goals	Individual goals
9:45-10:00	Break	Break	Break	Break	Break	Break
10:00-10:45	Circus	Individual goals	Sitting balance	Hippo therapy	Circus	Sitting balance
10:45-11:00	Break	Break	Break	Break	Break	Break
11:00-11:45	Jumping	Running & walking	Individual goals	Hippo therapy	Group activity	Jumping
11:45-12:45	Lunch break	Lunch break	Lunch break	Lunch break	Lunch break	Lunch break
12:45-13:30	Individual goals	Jumping	Jumping	Sitting balance	Circus	
13:30-13:45	Break	Break	Break	Break	Break	
13:45-14:30	Sitting balance	Running & walking	Sitting balance	Individual goals	Circus	
14:30-14:45	Break	Break	Break	Break	Break	
14:45-15:30	Jumping	Jumping	Sitting balance	Running & walking	Sitting balance	
15:30-15:45	Break	Break	Break	Break	Break	
15:45-16:30	Group activity	Sitting balance	Running & walking	Jumping	Group activity	
16:30-17:00	Cooling down	Cooling down	Cooling down	Cooling down	Cooling down	

Note. This schedule is an example of a weekly program that the children receive at the beginning of the balance camp.

Guidance

The children were assigned an individual therapist who assisted them throughout the camp in various activities, tailoring each activity to the child's needs. The therapists were first- and second-year master's students in physical therapy and physical therapists at Hasselt University. The therapists received eight hours of extra theoretical and practical training. A manual of all activities was available, listing the activity, duration, materials, and the number of children or companions needed to perform each activity.

Location and materials

The camp took place at Sint-Gerardus Diepenbeek. These facilities had enough open spaces, which enabled the performance of circus activities. Circus materials included such items as cones, stilts, a giant ball, and various ordinary sports equipment. Some activities also required a bouncy castle and an Airex mat.

Division of groups

The camp consisted of both individual and group activities. Differentiation was made between the younger (under 8 years) and older children (older then 8 years), as well as the whole group. Each day, the children were also given 45 minutes to practice their personal goals individually with their therapist.

Motor learning

Children were taught to apply various motor learning principles to enhance functional activities, with a preference for implicit motor learning whenever possible. Implicit motor learning involves acquiring skills without conscious attention and with minimal verbal explanation. This learning approach typically benefits children with typical and atypical development (van Abswoude et al., 2021). In contrast to implicit learning, explicit motor learning requires verbal knowledge of the motor task, which involves cognitive processing and can load the working memory (Kleynen et al., 2014).

To effectively apply these learning principles, each child's characteristics, including age, individual skills, and stage of motor development, must be considered. The principles are also adjusted to the type of task and environmental factors. Modifying the environment and task can enhance the learning experience by utilizing analog learning techniques while keeping the instructions in focus (Kleynen et al., 2014).

In the context of child-specific tailoring, instructions and feedback are adapted to the child's developmental level by varying the content (general or specific), focus (internal or external), format (verbal, visual, tactile, or auditory), and dosage (frequency, amount, and timing). To preserve the 'time on task', sufficient attention must be given to repetition and movement experience (Kleynen et al., 2014).

Outcomes

Descriptive and screening measures

- ***General questionnaire:*** This parental questionnaire included questions about general characteristics such as name, age, birth date, height, and weight, as well as questions about comorbidities, medical history, pregnancy, and motor skills (Velghe et al., 2024).

Additionally, three descriptive measures were employed to identify specific issues:

- ***Dutch version of the Strengths and Difficulties Questionnaire (SDQ).*** The SDQ is a questionnaire suitable for parents and teachers that can be administered to children aged 4-16, measuring their behaviors, emotions, and relationships (Goodman, 1997). This version contains 25 items with three response options: '*not true*', '*somewhat true*', or '*certainly true'*. The questionnaire assesses five domains: hyperactivity-inattention, conduct problems, peer problems, emotional symptoms, and prosocial behavior (Goodman, 1997). The Dutch version of the questionnaire exhibits strong psychometric properties, characterized by acceptable levels of internal consistency, solid test-retest reliability, and good validity. These characteristics contribute to its reliability as an assessment tool (Muris et al., 2003; Van Widenfelt et al., 2003).

- ***Developmental Coordination Disorder Questionnaire (DCD-Q)*** is a parent-reported questionnaire developed to identify motor coordination problems in children aged 5 to 15 (Wilson et al., 2009). The child's motor coordination is compared to their peers across 17 items. Parents rate each question on a five-point Likert scale (Wilson et al., 2000). The Dutch version of the questionnaire is a valid and reliable instrument (Schoenmaker et al., 2006).

- ***Movement Assessment Battery for Children-2 (MABC-2)*** is a norm-referenced test that assesses motor skills across three domains: manual dexterity, aiming and catching, and balance (Henderson et al., 2007). The test is divided into three age groups: 3-6 years, 7-10 years, and 11-16 years. The tasks are specified within the different domains for each age group (Henderson et al., 2007). The MABC-2 has an excellent test-retest reliability and good to excellent validity (Griffiths et al., 2018). The Dutch version was used (Smits-Engelsman & Niemeijer, 2010).

Primary outcome measure

- ***The extended version of the original Kids-Balance Evaluation Systems Test (Kids-BESTest-2).*** The original Kids-BESTest is derived from the Balance Evaluation Systems Test (BESTest) (Dewar et al., 2017). The test contains six different domains: 1) Biomechanical constraints, 2) Limits of stability/Verticality, 3) Anticipatory postural adjustments/Transitions, 4) Reactive postural responses, 5) Sensory orientation, and 6) Gait stability. The test comprises a total of 36 items. The test employs a four-point ordinal scale, with scores ranging from 0 (worst performance) to 3 (best performance) (Horak et al., 2009). The extended version of the Kids-BESTest contains five age bands: 5 years, 6 years, 7 years, 8-10 years, and 11-12 years (Dewar et al., 2017, 2019; Johnson et al., 2024; Verbecque et al., 2025, manuscript under review). The tasks are evaluated based on quantitative results, qualitative observations, or a combination of both (Johnson et al., 2024; Verbecque et al., 2025, manuscript under review). In this test, a score is calculated for each domain by adding the scores of individual items within that domain and converting the total to a percentage of the maximum possible score. Finally, the scores from all domains are summed, and the average is calculated to determine the overall score (Johnson et al., 2024; Verbecque et al., 2025, manuscript under review). This master's thesis included the total scores of the Kids-BESTest-2.

Secondary outcome measures

- ***Canadian Occupational Performance Measure (COPM)*** is a measurement tool that identifies problems in daily life, in terms of self-care, productivity, and recreation (Law et al., 1990). This study examined the activities that contribute to children experiencing balance problems (Velghe et al., 2024). The children are asked in a semi-structured interview to identify activities that could be improved. A caregiver is involved if the children are too young to assess their problems. To determine the importance of each activity, a score from 1 (low) to 10 (high) is assigned. Two to three activities with the highest importance were included as individual goals. Besides the importance of individual goals, performance and satisfaction are also considered before and after intervention (Law et al., 1990). The COPM has good psychometric properties (Carswell et al., 2004).

- ***Test of Gross Motor Development, third edition (TGMD-3)***, comprehensively assesses basic motor skills, consisting of 13 items used with children aged 3 to 10 years. A subdivision is made between locomotor (run, gallop, hop, skip, horizontal jump, and slide) and ball skill items (two-handed strike, one-handed forehand strike, one-handed stationary dribble, two-handed catch, kick stationary ball, overhand throw, and underhand throw) (Ulrich, 2019). Three to five performance criteria are described per motor skill. If a child performs the requirements correctly, they receive a score of 1; otherwise, they receive a score of 0 (Ulrich, 2019). The child has two trials for each motor skill to complete the tasks. The scores from each trial are summed to calculate the total score. For locomotor skills, the maximum score is 46 points, while for ball skills, a maximum score of 54 points is achievable. Ultimately, the scores for locomotor and ball skills are combined, resulting in a maximum total score of 100 points (Ulrich, 2019). This test is a reliable measurement tool to verify gross motor skills in children with DCD (Suresh & Subash, 2023). The TGMD-3 exhibits moderate to excellent internal consistency, as well as good to excellent inter-rater and intra-rater reliability, along with moderate to excellent test-retest reliability (Rey et al., 2020).

- ***Competentie-Belevingsschaal voor kinderen (CBSK)*** measures how children perceive themselves and evaluate their abilities and competence in various critical areas of life. The 36-item questionnaire can be administered to children aged 8 to 12 and consists of six subscales: School Skills, Social Acceptance, Sports Skills, Physical Appearance, Behavioural Attitude, and Sense of Self-Esteem. For each item, the child is given a choice of two statements. The child must then indicate which statements fit them the most (Veerman et al., 1997).

- ***Pictorial Scale of Perceived Competence and Social Acceptance in Young Children (PSPCSA)*** is divided into four subscales: cognitive competence, physical competence, peer acceptance, and maternal acceptance. Each subscale consists of six items, resulting in a total of 24 items. Each item features two images from which the child must select. There are two versions of this test, one for boys and one for girls. Below each picture, the child must choose between '*I am a bit like the image*' or '*Very much like the image*'. This results in a four-point scale for each item, suitable for preschool and kindergarten children, as well as first- and second-grade students. The psychometric properties are acceptable (Harter et al., n.d.; Harter & Pike, 1984).

Evaluation

Two evaluators conducted the test and recorded the session on video. If there was any uncertainty about the score, the motor performance could be reviewed and rescored. The data were anonymized using a child ID. A blinded assessor scored the primary outcome (Kids-BESTest-2).

Data-analysis

Decision trees were employed to determine which statistical tests should be used (see **Appendices A, B, C1, and C2**) (Meesen & Verstraelen, 2022). Once the statistical test was established, calculations were performed using JMP Pro 17.2.0 software (SAS Institute Inc., Cary, NC, 1989–2025). Statistical significance was set when the alpha level was $p \leq .05$.

Step 1: Intervention effects on the total scores of motor outcome measures

Two linear mixed models were used for the statistical analysis (**Appendix A**), one with the dependent variable being the total score on the Kids-BESTest-2 and one with the TGMD-3. The analysis included the three test moments (T1, T2, and T3) to evaluate the child's progress on the motor outcomes. Child ID was included as a random factor to analyze the variations within an individual in the multivariate model.

The primary explanatory variable was 'Test Moment', which was used to evaluate the change in total motor skill scores over time due to the repeated structure. In addition, the following influencing factors were included as independent covariates: age at baseline (continuous), comorbidities (categorical), therapy time (categorical), baseline score on the Kids-BESTest-2 (KB_T0) (continuous) and TGMD-3 (TGMD-3_T0) (continuous), and natural motor growth six months before camp (KB_T0-T1) (continuous). The last variable refers to the difference between the total score on the Kids-BESTest-2 six months before the intervention (T0) and immediately before the intervention (T1). The first step involved a univariate analysis, where each covariate was combined with 'Test Moment' and their interaction term was included to evaluate the effect over time. If there was no interaction effect, the interaction was removed from the model. Only the variables that showed significant effects in the univariate models were subsequently included in the multivariate analyses, which employed a multivariate mixed model. The variables in this model were selected using backward selection until all remaining variables were significant at the 0.05 significance level.

Step 2: Relationship between the total scores of motor outcome measures and COPM and CBSK/PSPCSA

The relationship between the change in the Kids-BESTest-2 and TGMD-3 was calculated based on three measurement moments (T1, T2, and T3). For this calculation, the difference score was calculated between the three test moments: pre- and post-measurement (T2-T1), post- and follow-up measurement (T3-T2), and pre- and follow-up measurement (T3-T1). Correlations were calculated using Pearson's pairwise correlation coefficients (**Appendix B**), provided that the normality, linearity, and homoscedasticity requirements were met. If the conditions were not met, the test was not performed further. A further analysis was conducted using single-linearity regression to identify significant correlations.

The relationship between changes in motor performance, as measured by the Kids-BESTest-2 and TGMD-3, and self-perceived competence, assessed using the CBSK/PSPCSA, was examined. Again, difference scores were calculated across three test moments.

Finally, the relationship between the motor outcome measures (Kids-BESTest-2 and TGMD-3) and subjectively perceived functioning (COPM) was examined. For this analysis, cumulative scores for satisfaction and performance were calculated for each goal (G1, G2, and G3) at each measurement time point (T1, T2, and T3). Correlations were calculated between motor measures (Kids-BESTest-2 and TGMD-3) and COPM scores based on difference scores.

Step 3: Responder of the intervention

Children were classified as responders to identify the factors contributing to being a responder, based on the difference score between T2 and T1. In the longitudinal study and existing literature, a score increase of more than six points on the Kids-BESTest-2 was established as the threshold for being classified as a responder (Velghe et al., 2025, unpublished manuscript). The following variables were included in the statistical analysis: age, baseline score on the Kids-BESTest-2 (KB_T0), receiving therapy, comorbidities, and natural motor growth six months before camp (KB_T0-T1).

For continuous variables, such as age, the baseline score of the Kids-BESTest-2 at T0 (KB_T0) and the natural progression of postural control before intervention (KB_T0-T1) were first checked for normality and variance using the Shapiro-Wilk and Brown-Forsythe tests. If the assumptions were met, the 2-sample t-test was performed. If not, a non-parametric analysis was performed using the Wilcoxon rank-sum test (**Appendix C1**).

In cases where the sample size was below 10, an additional exact test was performed. The p-value of the two-tailed t-test was taken.

For the categorical variables, ‘Comorbidities’ and ‘Therapy’, the chi-squared test or Fisher's exact test was applied, depending on the predetermined conditions. Fisher's Exact Test was used for variables with five or fewer expected values. (**Appendix C2**).

Results

Demographic and clinical characteristics of participants

Based on the inclusion criteria, 35 children (Mean (SD) age: 8.29 (1.70) years; 7 females) participated in this study. The necessary measurement instruments were used to collect data from each participant. This data can be found in **Table 2.**

Table 2

Demographic and Clinical Characteristics of the Participants (N = 35)

Characteristics	Frequency (*n*)	Percentage (%)
Gender		
Male	28	80
Female	7	20
Comorbidities		
Yes	19	54.29
ADHD	6	17.14
ASD	8	22.86
ADHD + ASD	5	14.29
No	5	45.71
Therapy		
Yes	16	45.71
1x30 min/w	8	22.86
2x30/w	6	17.14
1x60min/w	2	5.71
None	19	54.29
	Mean	**Standard Deviation (SD)**
Age	8.23	1.71
Baseline score MABC-2	2.27	3.85

Note. Therapy is measured in minutes per week. Age in years. Baseline score MABC-2 is based on the total standard score. Abbreviation list: ADHD = Attention Deficit Hyperactivity Disorder; ASD = Autism Spectrum Disorder; ADHD + ASD = both ASD and ADHD; Baseline score MABC-2: Baseline score of the Movement Assessment Battery for Children 2nd edition at T0.

Intervention effects on the total scores of motor outcome measures

Change in Kids-BESTest-2 scores over time and influencing factors

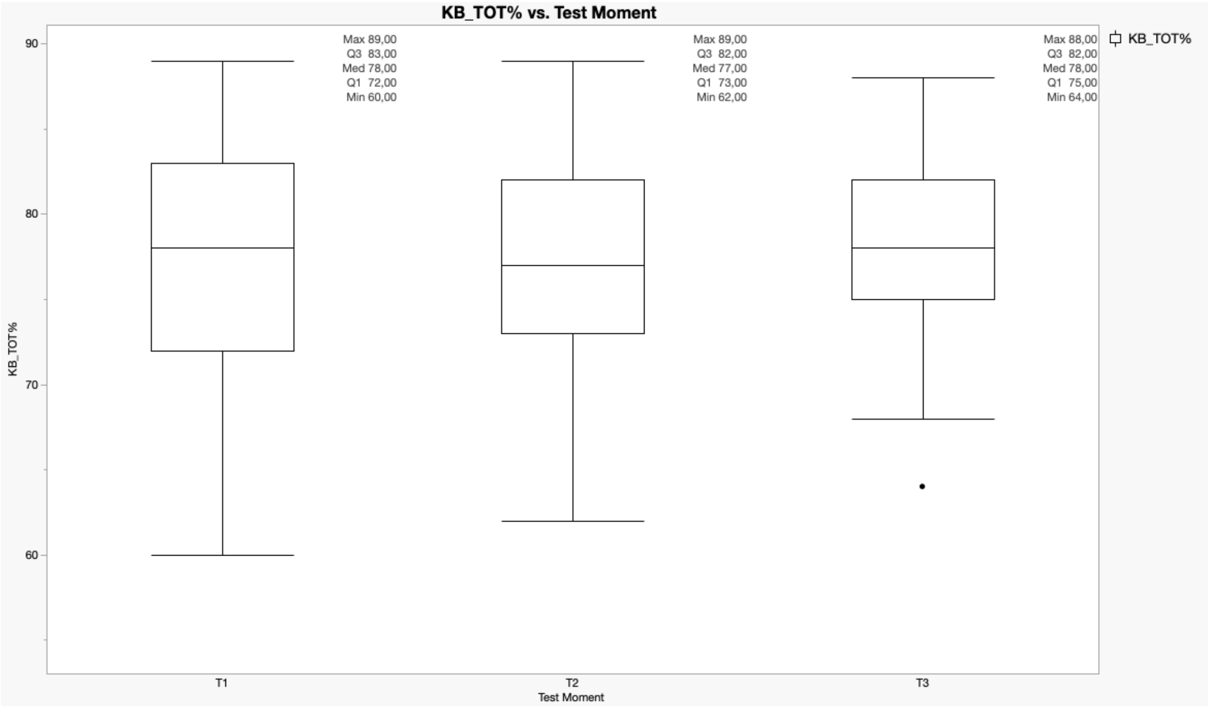
A multivariate analysis can be conducted on the total scores of the Kids-BESTest-2. **Table 3** summarizes the univariate analysis results, which formed the basis for selecting variables included in the final multivariate model. The significant parameters from the univariate analysis were Age, KB_T0, Test Moment, and the interaction between Test Moment and Baseline Score of the Kids-BESTest-2 (**Table 3**). Notably, the univariate analysis of 'Test Moment' did not produce a significant result. The decision to include 'Test Moment' in the multivariate analysis was based on the model's repeated structure.

First, there was a significant main effect of Test Moment on the total score of the Kids-BESTest-2 ($F(2, 66) = 3.72$, $p = .029$). This result indicates that scores on the Kids-BESTest-2 test varied significantly depending on test moment (pretest, posttest, follow-up). There was no significant difference between the pre-test and the post-test ($ß = .21$, $p = .960$), suggesting that there was no noticeable improvement in motor performance immediately after the intervention. In contrast, a significant difference was found at follow-up compared to the pre-test ($ß = 10.02$, $p = .023$), indicating an improved score on the Kids-BESTest-2 in the medium term.

A visual representation of this result is displayed in the boxplot (**Figure 2**). This figure illustrates the differences between the minimum and maximum total scores of the Kids-BESTest-2 from pre- to post-measurement. Notably, at follow-up, the minimum score for this motor outcome is 68, aside from one outlier. This score surpasses the minimum score of the Kids-BESTest-2 measured before the intervention. The boxplot indicates that children achieved higher scores in the follow-up assessments. Although the median scores remained relatively stable over the test moments, statistical analysis revealed a significant improvement between the pre-intervention and follow-up.

Figure 2

Visual Representation of Univariate Analysis Test Moment (Kids-BESTest-2) (Main Effect)

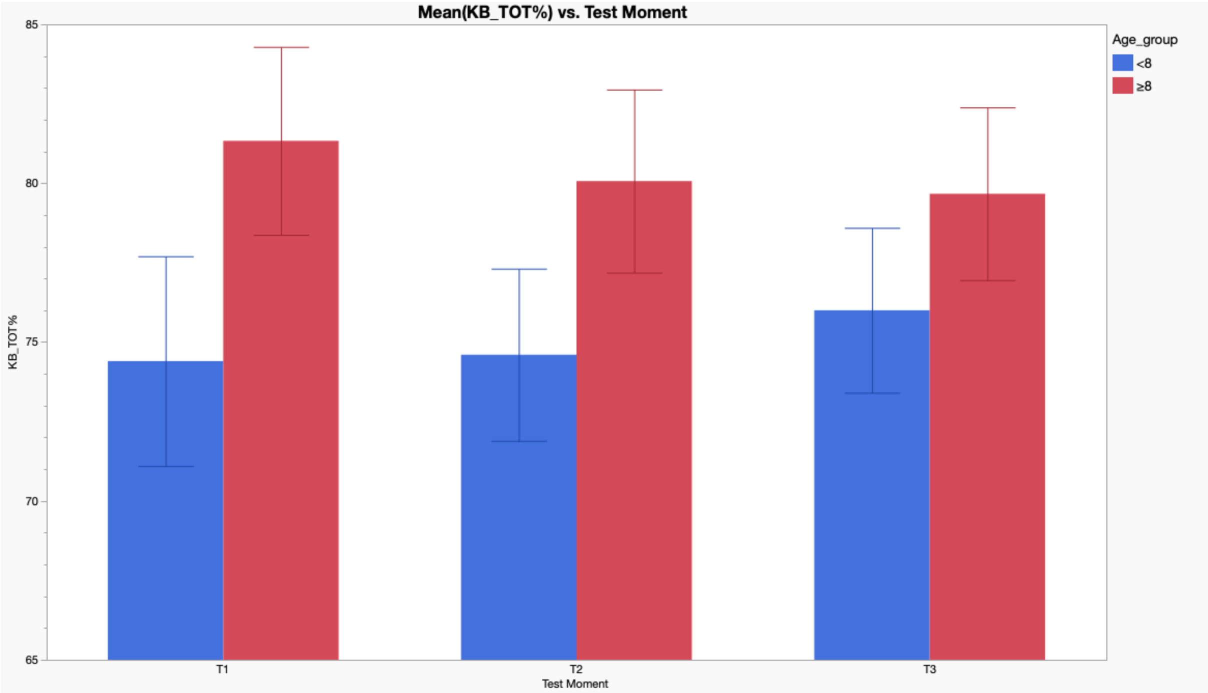


Note. This boxplot shows the distribution of the total Kids-BESTest-2 score on the three test moments. Abbreviation list: KB_TOT% = total score of the extended version of the Kids-Balance Evaluation Systems Test for children; Max = maximum; Min = minimum; Med = Median; Q1 = first quartile (25th percentile); Q3 = third quartile (75th percentile), T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

Age significantly affected the total scores of the Kids-BESTest-2 ($F(1, 33) = 21.56$, $p = .016$). Age had a positive effect size ($ß = .89$, $p = .016$), indicating that each additional year of life was associated with an average increase of 0.89 points in the total score (**Table 4**). This result suggests that older children achieved higher total scores on the Kids-BESTest-2 than younger children, regardless of the test moment (see **Figure 3**).

Figure 3

Visual Representation of the Total Score of the Kids-BESTest-2 by Age (Main Effect)



Note. This graph illustrates the **distribution of the mean** total Kids-BESTest-2 score by age across the three test moments. On the right side of the graph, a legend is located. Age is expressed in years. Children are divided into two groups: those under 8 years old (blue) and those 8 years old or older (red). Abbreviation list: KB_TOT% = total score of the extended version of the Kids-Balance Evaluation Systems Test for children; T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

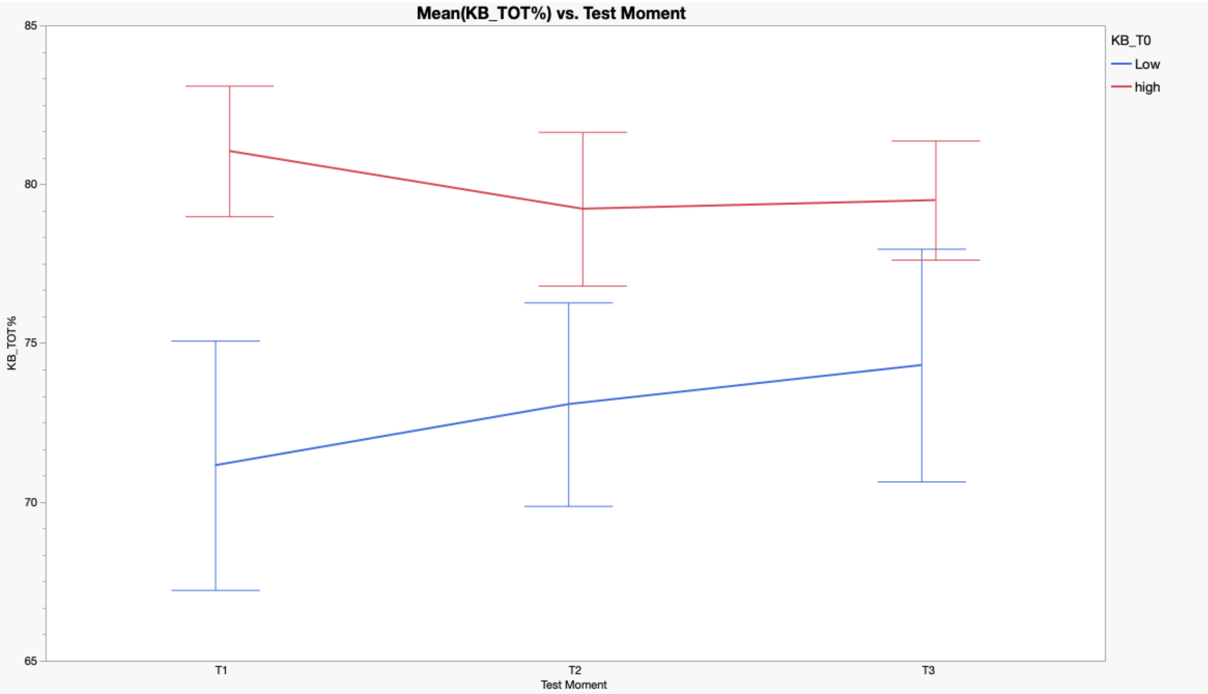
The Baseline Score had an estimated effect size of ($ß$ = .43, p < .000), meaning that for each additional point on the baseline score, the total score at later test moments increased on average by 0.43 points (F(1, 33) = 70.11, p < .000) (**Table 4**).

Regarding test results, no significant improvement was observed at T2 compared to T1 ($ß$ = .21, p = .960). However, a significant increase in the total score was observed at T3 ($ß$ = 10.02, p = .023), indicating a positive mid- to long-term effect of the intervention. The baseline score of the Kids-BESTest-2 influenced this increase: the interaction between Test Moment T3 and KB_T0 was significant ($ß$ = -.13, p = .025). This result suggests that children with a lower baseline score on the Kids-BESTest-2 showed greater medium-term improvements than children who already scored higher at the pretest. The interaction between the T2 and KB_T0 was insignificant ($ß$ = -.01, p = .895), indicating that this effect was not present during T2 (see **Table 4**).

Figure 4 visualizes that children with a lower baseline score show the greatest progress over time, with a clear and significant increase in mean score from T1 to T3 ($p < .025$). In contrast, groups with higher baseline scores display a relatively stable trend or a slight decline over time.

Figure 4

Visual Representation of the Total Score of the Kids-BESTest-2 by Baseline Score of the Kids-BESTest-2



Note. This figure illustrates the **distribution of the mean** total Kids-BESTest-2 score by the Baseline Score of the Kids-BESTest-2, along with their interaction effect across test moments. On the right side of the graph, a legend is located. Children are divided into two baseline score groups, each with a specific color: those with a baseline score below the mean (blue, indicating low) and those with a baseline score above the mean (red, indicating high). Abbreviation list: KB_TOT% = total score of the extended version of the Kids-Balance Evaluation Systems Test for children; KB_T0 = motor baseline score on the Kids-BESTest-2; T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

Other covariates, such as the presence of Comorbidities ($F(1, 33) = 1.29$, $p = .264$), Having Therapy ($F(1, 33) = 1.55$, $p = .222$), and Natural Motor Growth Six Months Before Camp (KB_T0-T1) ($F(1, 33) = .65$, $p = .426$), did not show significant effects and did not influence the total score, measured by the Kids-BESTest-2 (**Table 3**).

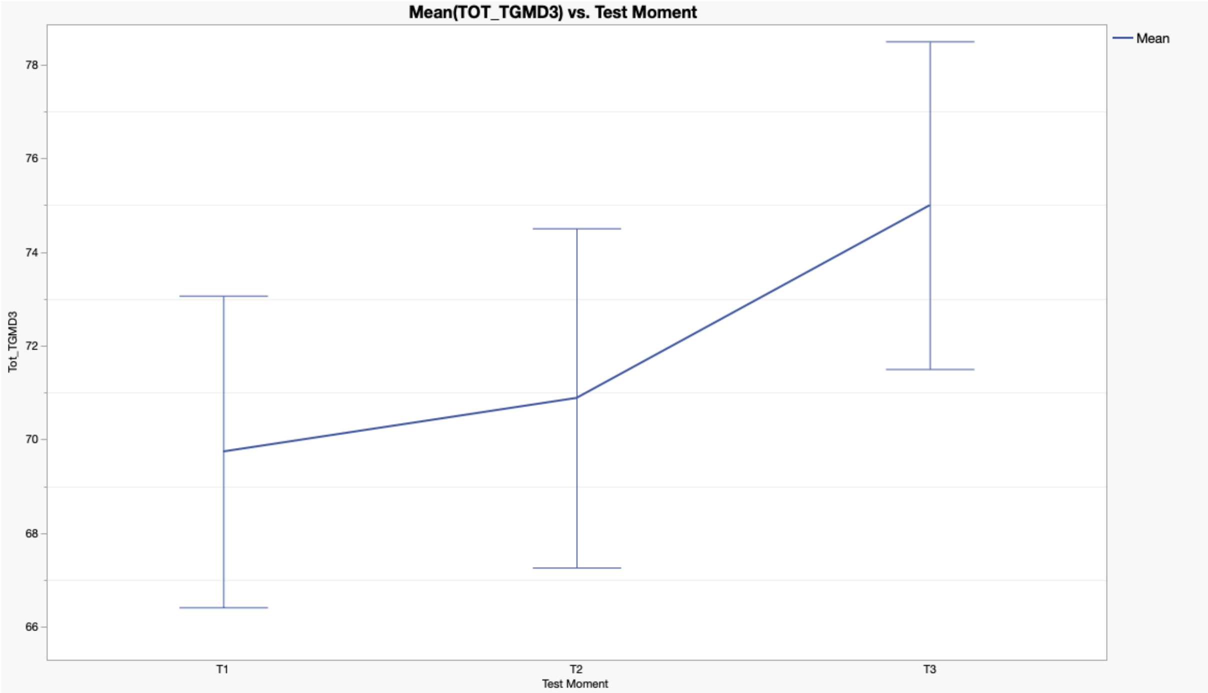
Change in TGMD-3 scores over time and influencing factors

The first univariate model, which included only Test Moment as an independent variable, showed that Test Moment significantly affected the total score of the TGMD-3 ($F(2, 68) = 6.37$, $p = .003$) (**Table 3**). This statistical result indicated a difference in TGMD-3 scores between the various test moments.

The difference between the TGMD-3 scores at T1 and T2 was not significant ($ß = -.99$, $p = .272$) (**Table 4**). These results suggest no immediate significant improvement following the highly intensive balance intervention. Conversely, T3 significantly impacted the total TGMD-3 score compared to T1 ($ß = 3.12$, $p = .001$) (**Table 4**). This result suggests notable progress in motor skills over the medium term, as indicated by the TGMD-3 scores at T3 (see **Figure 5**).

Figure 5

Visual Representation of Univariate Analysis Test Moment (TGMD-3)

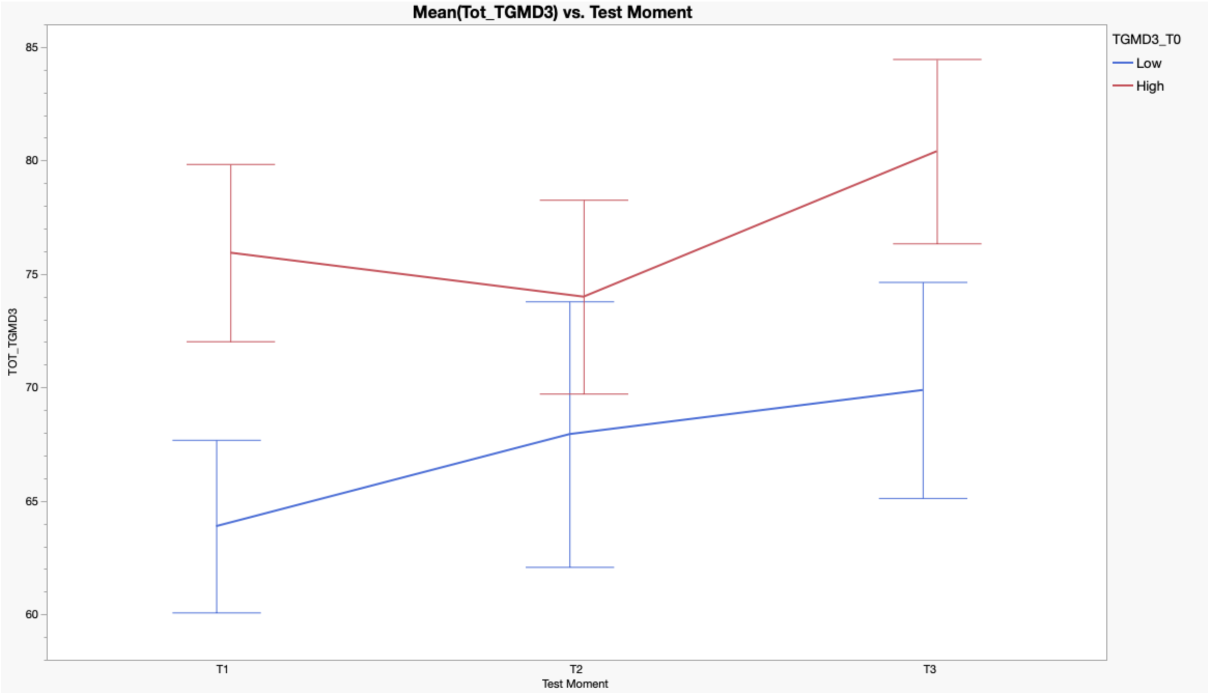


Note. This figure illustrates the **distribution of the mean** total score of the TGMD-3 across the three test moments. Abbreviation list: TOT_TGMD-3: Total score of the Test of Gross Motor Development 3rd edition; T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

The second univariate model included the Baseline Score of the TGMD-3 (TGMD3_T0) as a covariate, in addition to Test Moment. This result showed that TGMD3_T0 had a significant effect on the different test moments and could influence the total score on the TGMD-3 ($F(1, 33) = 52.25$, $p < .000$) (See **Table 3**). A higher baseline score was associated with better performance on the TGMD-3 at the T3 measurement (see **Figure 6**).

Figure 6

Visual Representation of the Total Score of the TGMD-3 by Baseline Score of the TGMD-3



Note. This figure illustrates the **distribution of the mean** total score of the TGMD-3 across the three test moments. On the right side of the graph, a legend is located. Children are divided into two baseline score groups, each with a specific color: those with a baseline score below the mean (blue, indicating low) and those with a baseline score above the mean (red, indicating high). Abbreviation list: TOT_TGMD-3: Total score of the Test of Gross Motor Development 3rd edition; T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

Other covariates, such as Age ($F(1, 33) = 2.03$, $p = .164$), Comorbidities ($F(1, 33) = .003$, $p = .940$), and Having Therapy ($F(1, 33) = .40$, $p = .529$), did not show significant effects. A multivariate analysis was deemed unnecessary, as only one variable (TGMD3_T0) significantly impacted the univariate analysis (see **Table 3**).

Table 3

Fixed Effects Test

	Fixed Effects Test		
	DF1;DF2	*F*-ratio	(Prob > *F*)
Parameters Kids-BESTest-2 (Total Score)			
Covariates Univariate Analysis			
Test Moment	2;68	.25	.777
Age	1;33	21.56	< .000*
Comorbidities	1;33	1.29	.264
Therapy	1;33	1.55	.222
KB_T0 - T1	1;33	.65	.426
KB_T0	1;33	70.11	< .000*
Interaction			
Test Moment*KB_T0	2;66	3.71	.030*
Covariates Multivariate Analysis			
Test Moment	2;66	3.72	.029*
Age	1;32	6.53	.016*
KB_T0	1;32	40.81	< .000*
Interaction			
Test Moment*KB_T0	2;66	3.71	.030*
Parameters TGMD3 (Total Score)			
Covariates Univariate Analysis			
Test Moment	2;68	6.37	.029*
Age	1;33	2.03	.164
Comorbidities	1;33	.003	.940
Therapy	1;33	.404	.529
TGMD3_T0	1;33	52.25	< .000*

Note. Age in years; comorbidities (yes/no); therapy (yes/no); Abbreviation list: Kids-BESTest-2: The extended version of the Kids-Balance Evaluation Systems Test for children; TGMD-3 = the Test of Gross Motor Development 3rd edition; KB_T0 = motor baseline score on the Kids-BESTest-2; KB_T0-T1 = natural motor growth six months before camp, Test Moment*KB_T0 = interaction between Test Moment and motor baseline score on the Kids-BESTest-2; TGMD3_T0 = baseline score of TGMD3. Significant results are indicated with an asterisk (*$p < .05$).

Table 4

Fixed Effects Parameter Estimates

	Parameters Estimates					
	ß	*SE*	*DF2*	*t*-ratio	Prob > |*t*|	95% *CI*
Parameters Kids-BESTest-2 (Total Score)						
Intercept	38.43	4.25	32	9.04	< .000*	29.78; 47.09
Test Moment Post (T2)	.21	4.29	66	.05	.960	-835; 8.77
Test Moment Follow-Up (T3)	10.02	4.29	66	2.34	.023*	1.46; 18.58
KB_T0	.43	.07	32	6.39	< .000*	.30; .57
Age	.89	.35	32	2.55	< .016*	.18; 1.59
Test Moment Post (T2)*KB_T0	-.01	.06	66	-.13	.895	-.12; .11
Test Moment Follow-Up (T3)*KB_T0	-.13	.06	66	-2.29	.025*	-.25; -.02
Parameters TGMD-3 (Total Score)						
Intercept	13.80	8.09	33	1.71	< .097	-2.66; 30.25
Test Moment Post (T2)	- .99	.89	68	-1.11	.272	-2.78; .80
Test Moment Follow-Up (T3)	3.12	.89	68	3.49	.001*	1.34; 4.94
TGMD3_T0	.84	.12	33	7.23	< .000*	0.61; 1.08

Note. Age in years; comorbidities (yes/no); therapy (yes/no); Abbreviation list: Kids-BESTest-2: The extended version of the Kids-Balance Evaluation Systems Test for children; TGMD-3 = the Test of Gross Motor Development 3rd edition; KB_T0 = motor baseline score on the Kids-BESTest-2; KB_T0-T1 = natural motor growth six months before camp, Test Moment *KB_T0 = interaction between Test Moment and motor baseline score on the Kids-BESTest-2; TGMD3_T0 = baseline score of TGMD3. Test Moment = pre-, post- and follow-up measurement. Significant results are indicated with an asterisk (*p < .05).

Results of 'Child ID' on the motor outcome measures.

The results obtained for the Kids-BESTest-2 and the TGMD-3 were at the group level. When the child factor is considered, differences occur for the two measurement instruments (**Table 5**). In the multivariate model of the Kids-BESTest-2, child ID is insignificant (p = .066) (**Figure 7**). The random effects of the multivariate model of the TGMD-3 indicated significant variance (p = .041): the impact of child ID explained 27.35% of the total variance (**Figure 8**).

Table 5

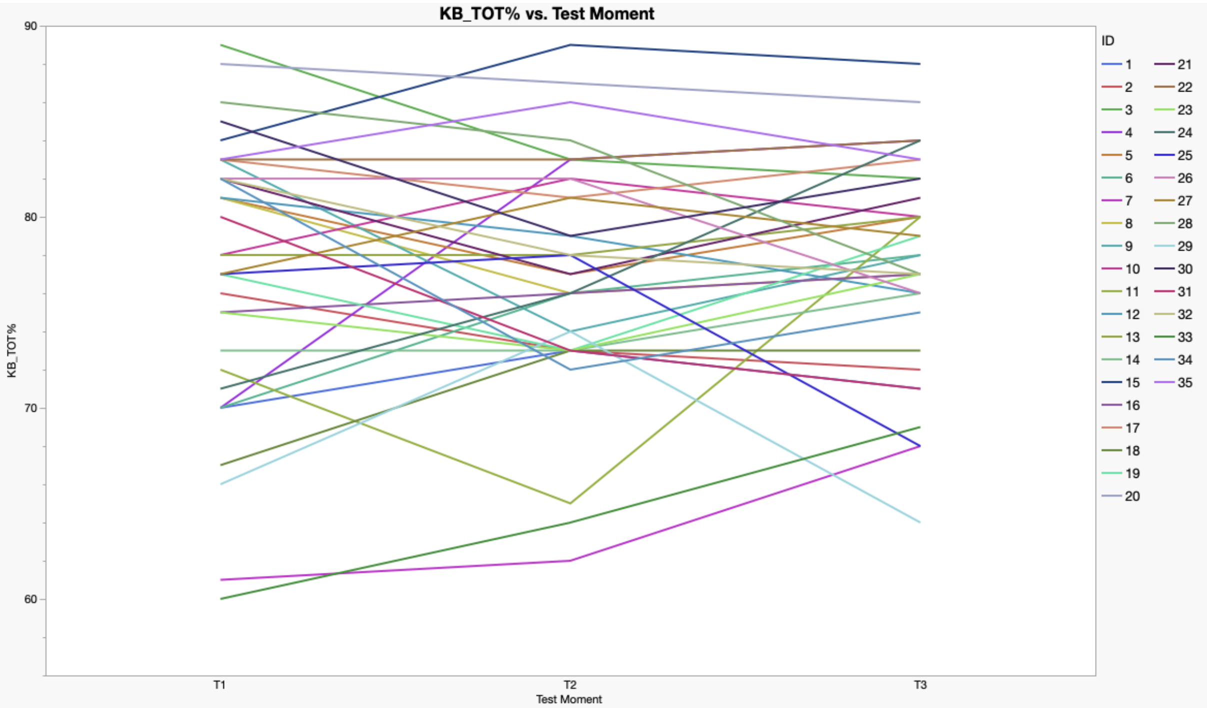
Random Effects Parameter Estimates

	Wald *p*-Value	% of Total
Parameters Kids BESTest-2		
ID	.066	24.13
Parameters TGMD-3		
ID	< .000*	59.12

Note. Abbreviation list: Kids-BESTest-2: The extended version of the Kids-Balance Evaluation Systems Test for children; TGMD-3 = The Test of Gross Motor Development, 3rd edition. Significant results are indicated with an asterisk (*$p < .05$).

Figure 7

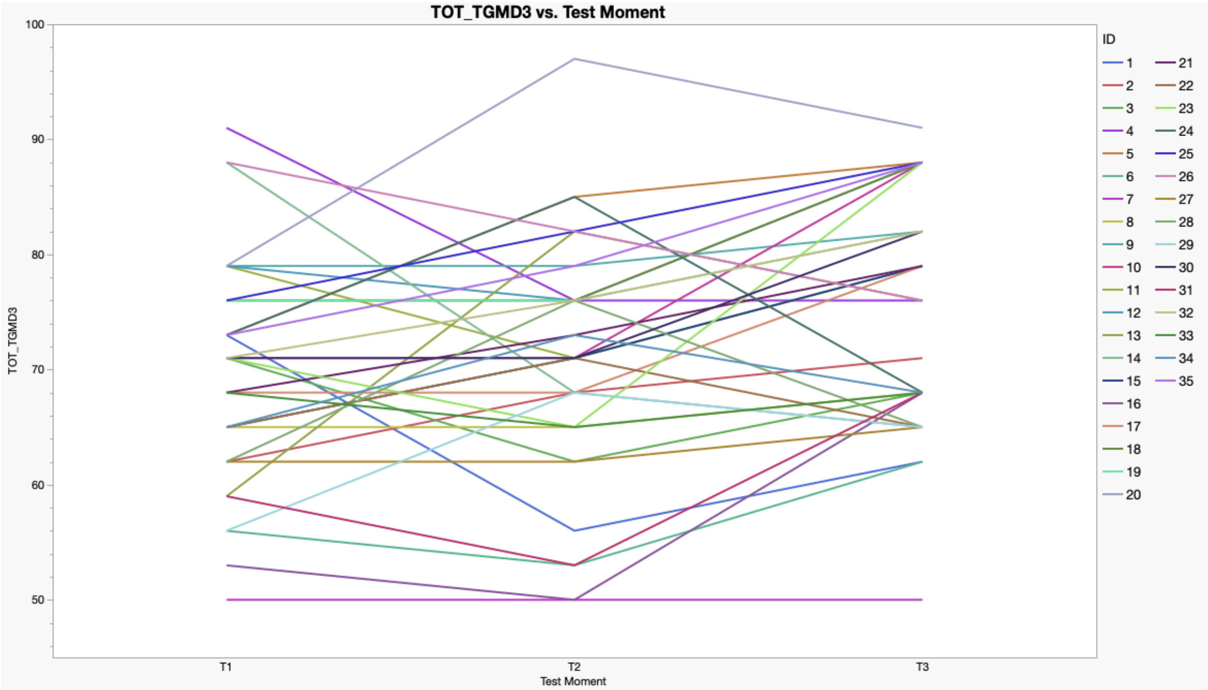
Visual Representation of Child-ID (Kids-BESTest-2)



Note. This figure shows the **distribution** of the child-ID in the Kids-BESTest-2 score across Test Moments. On the right side of the graph, there is a legend. Each child is individually presented. Abbreviation list: KB_TOT% = total score of the extended version of the Kids-Balance Evaluation Systems Test for children; T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

Figure 8

Visual Representation of Child-ID (TGMD-3)



Note. This figure shows the **distribution** of the child-ID in the TGMD-3 score across Test Moments. On the right side of the graph, there is a legend. Each child is individually presented. Abbreviation list: TGMD3_TOT% = Total score of the Test of Gross Motor Development 3rd edition; T1 = pre-intervention; T2 = post-intervention; T3 = follow-up.

Correlations between the total scores of motor outcome measures, COPM, and CBSK/PSPCSA

The results in **Table 6** show no significant correlations between the Kids-BESTest-2 and TGMD-3 across the different measurement times. The T1 and T3 correlation shows a weak and negative value (*r* = - .271), with a p-value of 0.056. As shown in **Table 6**, no statistically significant correlations were found. These findings indicate that changes in motor performance are not associated with changes in self-perceived competence. No significant correlations were found between motor functioning and goal performance or satisfaction, regardless of the goal or measurement time (**Table 6**). Some values are missing in the table because the statistical assumptions (normality) were not met, so the statistical tests were not performed.

Table 6

Pairwise Correlations

		Correlation T2-T1		Correlation T3-T2		Correlation T3-T1	
	By variable	***r***	***p*-Value**	***r***	***p*-Value**	***r***	***p*-Value**
KB	TGMD3	- .087	.624	.039	.824	-.271	.056
KB	CBSK/PSPCSA_Co	- .204	.278	.273	.125	.001	.995
KB	CBSK/PSPCSA_Ph	- .028	.837	.086	.663	-.008	.966
KB	CBSK/PSPCSA_Sa	.222	.304	.093	.607	.101	.576
TGMD3	CBSK/PSPCSA_Co	.044	.822	.021	.910	-.208	.246
TGMD3	CBSK/PSPCSA_Ph	.259	.174	.057	.753	.082	.650
TGMD3	CBSK/PSPCSA_Sa	- .092	.634	.124	.491	.150	.404
KB	COPM_G1	- .160	.358	- .285	.097	-.062	.723
TGMD3	COPM_G1	.043	.806	.090	.607	-	-
KB	COPM_G2	- .199	.253	.109	.540	-.081	.650
TGMD3	COPM_G2	- .011	.952	-.070	.696	-	-
KB	COPM_G3	- .005	.980	-.229	.242	.064	.748
TGMD3	COPM_G3	- .289	.137	.243	.214	-.065	.741

Note. When the statistical assumptions were not met, the statistical test was not performed. This fact is represented with '-'. Abbreviation list: CBSK: Competentiebelevingsschaal voor Kinderen; COPM: Canadian Occupational Performance Measure; Kids-BESTest-2: The extended version of the Kids-Balance Evaluation Systems Test for children; PSPCSA: Pictorial Scale of Perceived Competence and Social Acceptance; CBSK/PSPCSA_Co = CBSK/PSPCSA cognitive skills; CBSK/PSPCSA_Ph = CBSK/PSPCSA physical activity; CBSK/PSPCSA_Sa = CBSK/PSPCSA social acceptance; COPM_G1 = Goal 1 of COPM; COPM_G2 = Goal 2 of COPM; COPM_G3 = Goal 3 of COPM; TGMD3 = The Test of Gross Motor Development 3rd edition. Significant results are indicated with an asterisk (*p < .05).

Responder of the intervention

Following the decision tree (Meesen & Verstraelen, 2022) in **Appendix D** would lead to running a logistic regression. However, a descriptive table is provided because the sample size (*N* = 35) is too small to perform a reliable statistical analysis.

A descriptive table was constructed to check whether a given variable contributes to being a responder (See **Table 7**).

Table 7

Descriptive Statistics for Being a Responder or Not

	Responder (*n* = 7) Median (IQ ranges)	**Non-responder (*n* = 28)** Median (IQ ranges)	**Difference** *p*-Value
Age	6.4 (6 - 7.9)	8,2 (7.3 - 9.8)	.017*
KB_T0	65 (50 - 73)	76 (71 - 79)	.042*
Therapy	-	-	.820
Comorbidities	-	-	.930
KB_T0-T1	2 (-1 - 10)	4 (1.25 - 8.75)	.670
TGMD3_T0	68 (59 - 76)	69.5 (62 - 73)	.877

Note. Age in years; comorbidities (yes/no); therapy (yes/no). Abbreviation list: Kids-BESTest-2: The extended version of the Kids-Balance Evaluation Systems Test for children; KB_T0 = motor baseline score on the Kids-BESTest-2; KB_T0-T1 = natural motor growth six months before camp; IQ ranges = Interquartile ranges; TGMD3_T0 = baseline score of TGMD3. Significant results are indicated with an asterisk (*$p < .05$).

The results should be interpreted cautiously because the data comes from a relatively small sample size. Variable age ($p = .017$) and KB_T0 ($p = .043$) showed a statistically significant difference between responders and non-responders. No significant difference was found for the other examined parameters, including therapy, comorbidities, Kids-BESTest-2 score between T0 and T1, and TGMD3 score between T0 and T1. Suggesting that these factors may not determine the ability to be a responder after the intervention.

Discussion

Summary of main results

This study aimed to investigate the impact of an intensive circus camp on motor skills, self-perceived competence, and individual goals in children with DCD. While other studies focused only on aspects of postural control, this study emphasized Horak's complete multisystemic framework. The intervention, including all ICF levels, aimed to provide a more comprehensive understanding of the child's functioning.

In the existing literature, some studies also use a high-intensity camp for children with DCD (Dannenbaum et al., 2022; Krajenbrink et al., 2022; Zwicker et al., 2015). The effects of these camps were also evaluated with a pre- and post-intervention design. The duration of the camps varied between five days and two weeks. The children were required to set individual goals using the COPM. The interventions could occur individually or in a combination of individual and group activities.

Effects of the intervention on the motor outcome measurements

Based on the results, more significant progression was expected on the motor outcome measures (Kids-BESTest-2 and TGMD-3). In our findings, the TGMD-3 showed a greater statistically significant improvement than the kids-BESTest-2. This result may be explained by the fact that during the circus camp, interventions were mainly provided at the activity level of the ICF, e.g., running and walking, jumping, individual goals, circus, group activities, and sitting balance.

The TGMD-3 assesses motor skills at the activity level of the ICF framework (Ulrich, 2019). These motor skills are closely aligned with the intervention's focus and likely contributed to the observed improvements in the total motor scores of the TGMD-3. In contrast, the Kids-BESTest-2 evaluates postural control at the functional level of the ICF (Dewar et al., 2017; Johnson et al., 2023; Verbecque et al., 2025, manuscript under review). As a result, the effects at this level of the ICF can therefore be expected to be smaller, which is visible in the insignificance of the results on the Kids-BESTest-2.

What also stands out is that comorbidities and therapy did not affect the total scores of the two motor outcome measures. This result is unusual because a comorbidity can impact a child's motor functioning, and this factor should be considered when offering an intervention (Blank et al., 2019). Co-occurring disorders such as ADHD can significantly affect outcomes, complicate intervention strategies, and increase the risk of psychosocial difficulties (Smits-Engelsman et al., 2018; Zwicker et al., 2012). Additional research is necessary to clarify the individual effects of these co-occurring conditions, allowing for more tailored interventions (Smits-Engelsman et al., 2018). The lack of significant findings regarding comorbidities in this study may be due to the small sample of only 19 children with one or two co-occurring disorders.

The expectation for therapy was that children who did not have therapy would make greater improvements compared to children who had therapy. The results showed that this expectation was not the case. Children who received regular therapy did not demonstrate significantly different outcomes compared to those who did not receive therapy. This finding may be due to variations in the type, frequency, or intensity of the therapy. A literature search revealed a lack of studies that explicitly distinguish between therapy and intervention as separate variables in their statistical analyses. This finding indicates that the distinction made in this study is rare and deserves further investigation.

Relations between motor and non-motor outcomes

Our study revealed no significant correlations between changes in motor functioning and self-perceived competence, as assessed by the CBSK, PSCPSA, and COPM. This finding contrasts with a previous study in children with DCD, where an intervention did result in significant improvements in perceived athletic competence and global self-worth, even reaching the level of typically developing children (Noordstar et al., 2017). The study by Zwicker et al. (2015) and Krajenbrink et al. (2022) confirmed a positive effect on children's COPM satisfaction and performance scores after implementing a Cognitive Orientation to Daily Occupational Performance (CO-OP) intervention. A key point to note is that previous studies indicated an impact from the intervention. In contrast, this study only examined the correlation between motor functioning and perceived competence measures. Consequently, direct comparisons with results from other studies are limited, as this analysis primarily focused on exploring the relationships between variables rather than assessing intervention effects.

A possible explanation for the lack of correlation between these questionnaires and the motor outcome measures is that the COPM and the CBSK/PSPCSA are subjective due to their self-reporting character (Harter & Pike, 1984; Law et al., 1990; Veerman et al., 1997), whereas the motor measurement instruments (Kids-BESTest-2 and TGMD-3) are standardised and judged by the therapist (Johnson et al., 2024; Ulrich, 2019; Verbecque et al., 2025, manuscript under review). Children may overestimate their abilities on these questionnaires, or perhaps they have developed greater self-confidence, which does not necessarily lead to quantifiably improved motor performance. This discrepancy between subjective perception and objective measurement may explain the absence of a significant association.

Other studies, such as Noordstar et al. (2017), found that children with DCD initially reported lower athletic competence, self-esteem, and fine motor skills than their typically developing peers. However, after 12 treatment sessions spread over time, these self-perception differences diminished significantly. This result suggests that improvements may be attributed to increased confidence and opportunities for practice at home, rather than motor skill enhancement alone (Noordstar et al., 2017). The extended duration and the time between sessions to practice at home may have played a key role. This finding contrasts with the present intervention, which consisted of six consecutive days. This shorter intervention frame offered fewer opportunities for habituation and reinforcement of progress. Positive results were also observed regarding confidence, self-esteem, and willingness to try new things in children with DCD (Zwicker et al., 2015). However, these results followed a more extended intervention period.

Factors contributing to being a responder or not

Factors such as age and baseline score on the Kids-BESTest-2 could influence whether a child responds to the intervention. However, the results should be interpreted cautiously since only seven children are actual responders. Usually, a logistic regression should be performed based on the decision trees (**Appendix D**) (Meesen & Verstraelen, 2022). The sample was too small

(n = 7 responders, n = 28 non-responders), so a descriptive statistical table was created. This approach enables the use of descriptive statistics and allows for a cautious identification of predictive factors associated with responders.

The existing literature suggests that including baseline scores as covariates in the analysis can lead to a more accurate assessment of intervention effects, particularly in clinical trial settings (Nunes et al., 2011). However, to date, no studies have specifically investigated the influence of baseline scores in children with DCD. In other pediatric populations, such as children with cancer, baseline scores have significantly impacted responder classification, demonstrating the importance of baseline differences when evaluating intervention outcomes (Morales et al., 2018). Our findings align with this perspective: both the multivariate analysis and the descriptive statistics reveal that baseline scores significantly affect the interpretation of outcomes, highlighting their importance for future research on DCD.

One crucial difference to note is that age was not a significant predictor of intervention response in the previously mentioned study. In contrast, the intensive balance camp in this study found that age was a significant factor in determining response. Specifically, younger children with DCD appeared to benefit more from intensive therapy, such as this balance camp, than older children. This finding emphasizes the need for early intervention using targeted, intensive postural control therapies for children with DCD. Such interventions should not be postponed and should be provided as early as possible in the treatment process.

Lastly, additional therapy was also identified as an insignificant factor (Morales et al., 2018), which is consistent with the results of this study. Nonetheless, this finding should be interpreted cautiously, as the additional therapy in the article of Morales et al. (2018) did not involve motor-based interventions. In contrast to this study, the concurrent therapy consisted of physical therapy.

Age could also influence whether a child responds to an intervention. When performing Constraint-Induced Therapy (CIT), younger children are seen to respond better than older children (Chen et al., 2016). Again, the results of this study should be interpreted with caution because the mean changes in outcome measures were relatively small. When conducting intensive therapy in children with cerebral palsy (CP), older age is associated with poorer motor progression (Hong et al., 2017). In this master's thesis, age may contribute to being a responder. However, this result cannot specifically explain whether a child should ideally be older or younger.

Acknowledgement of the strengths of this study

The circus camps were organized at Sint-Gerardus, a school in Diepenbeek, which provided enough space to facilitate all activities effectively. Finding a suitable, spacious location should not be a problem for future editions.

One of the study's standout features was that each child was paired with an individual therapist during the intervention. This approach allowed the program to be customized specifically to meet each child's unique needs. Incorporating a circus theme into the intervention not only enhanced the children's enjoyment but also effectively motivated them to participate.

The study utilized reliable and valid standardized measurement tools, including the Kids-BESTest-2 and the TGMD-3. At the test moments of the Kids-BESTest-2, the assessor was blinded. This approach reduced bias in the assessment of results and ensured an unbiased and consistent evaluation of the test. The assessment was purely based on motor performance.

Additionally, the study did not concentrate solely on motor skills. The children's personal experiences were gathered through questionnaires. Confounding factors, such as age and comorbidities, were considered during the statistical analysis of various parameters.

Acknowledgement of the limitations of this study

The protocol study by Velghe et al. (2024) outlined an intensive therapy in which each child was individually accompanied by either a master's student or a pediatric physiotherapist. However, this approach could be logistically challenging. Assembling a sufficiently large and skilled team remains a significant obstacle, especially for future versions of the camp. Along with team capacity, the long-term implementation raises concerns about financial feasibility, particularly the costs associated with renting spaces and circus equipment. These practical barriers must be considered when evaluating the scalability of the intervention.

Furthermore, the sample size calculation in the protocol study by Velghe et al. (2024) indicated that the population was sufficiently large to draw meaningful conclusions. However, the DCD population is highly diverse, making a sample size of only 35 children inadequate for accurately representing the entire group.

During the administration of various motor outcome measurements, a camera was utilized to visualize the children's motor skills at the test moments and to re-score them if there was any doubt. However, the presence of a camera was not evident for all children. Some children were distracted by the camera, or rather, withdrawn. Other children were not bothered by the camera.

Relevance study

This study contributes to the existing literature on interventions for children with DCD. Children remain motivated during challenging balance tasks by focusing on a high-intensity playful intervention, framed as a circus camp. The approach emphasizes fun and learning, making the intervention relevant to the children’s everyday tasks, stimulating their intrinsic motivation, and suggesting that a highly intensive intervention can enhance motor skills in children with DCD, particularly at the activity level of the ICF framework. The intervention program combines structured planning with playful elements, supporting the integration of therapeutic goals while promoting social interaction.

In this context, the age covariates and baseline scores from the Kids-BESTest-2 covariates play essential roles. For the TGMD-3 assessment, baseline scores are crucial factors in determining the outcome.

In addition to objective measures, such as the outcomes from the Kids-BESTest-2 and the TGMD-3, the study also considers subjective outcome measures, including self-perceived exertion. This comprehensive approach across all domains of the ICF enhances our understanding of how children with DCD develop under the influence of a high-intensity balance camp.

Future directions

This study suggests that a highly intensive balance intervention, such as a circus camp focused on balance, can improve postural control in children with DCD at the activity level of the ICF framework. Since this is the only study to address all aspects of postural control, further research is needed to replicate and expand upon these findings. Future studies should include larger sample sizes and investigate whether improvements in postural control led to enhanced participation and daily functioning, which aligns with the ICF model. Future research should examine whether the observed effects persist over time. This study mainly focused on medium-term follow-up, leaving the long-term impact of improvements unclear.

Conclusion

The study suggests that a highly intensive intervention, such as a circus camp, improves motor skills in children with DCD. In the short term, the intervention had a negligible effect on the total score of the Kids-BESTest-2 and the TGMD-3. However, there was a clear improvement in motor performance in the medium term. Children with lower baseline scores on the Kids-BESTest-2 and the TGMD-3 showed the most significant motor progress. In the mixed model with Kids-BESTest-2, age and baseline scores were significant factors in the total score of the Kids-BESTest-2. This result suggested that older children and children who had higher baseline scores generally performed better.

Apart from the motor findings, no significant correlations were present between the motor outcome measures and self-perception. Nevertheless, a positive trend was noticeable, which requires further investigation. The only significant differences between responders and non-responders were age and baseline score on the Kids-BESTest-2. Other differences were not significant.

The results of this study provide valuable information for clinicians seeking innovative, intensive, and child-friendly treatment methods for children with DCD. However, given the study's small sample size, further research is still needed to confirm these finding

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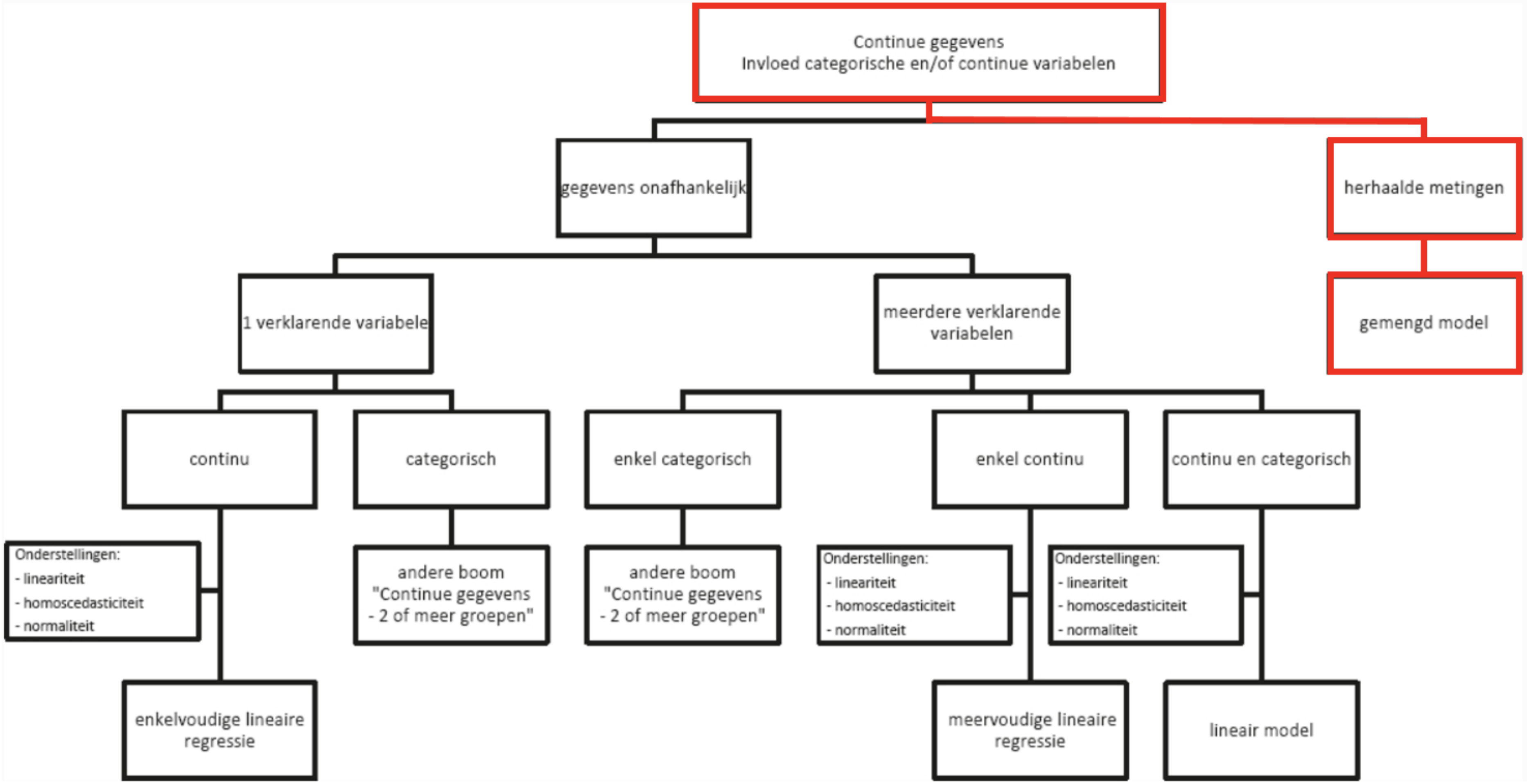
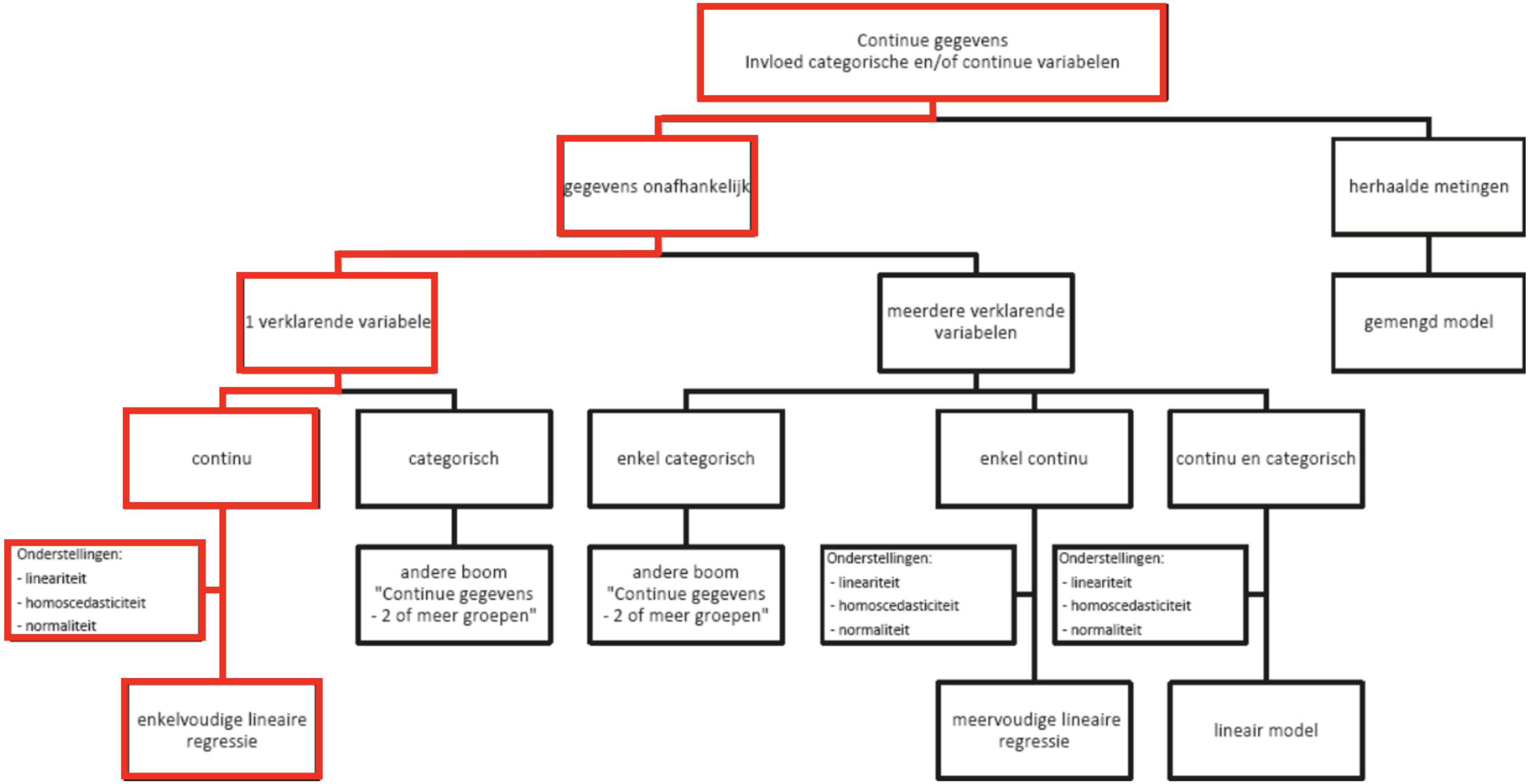
Appendix

Appendix A



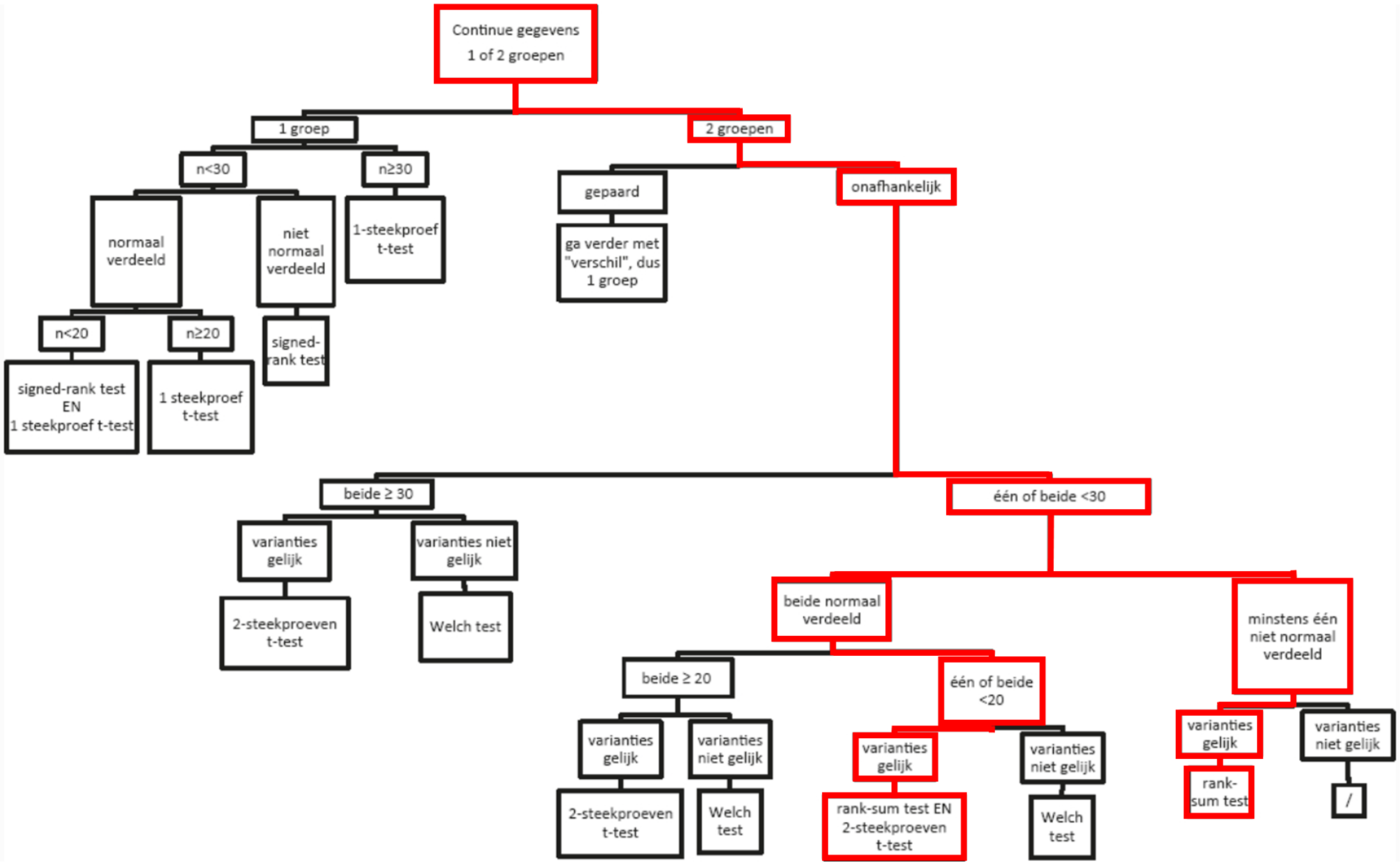
Continue gegevens
Invloed categorische en/of continue variabelen
gegevens onafhankelijk
herhaalde metingen
1 verklarende variabele
meerdere verklarende variabelen
gemengd model
continu
categorisch
enkel categorisch
enkel continu
continu en categorisch
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
andere boom "Continue gegevens - 2 of meer groepen"
andere boom "Continue gegevens - 2 of meer groepen"
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
enkelvoudige lineaire regressie
meervoudige lineaire regressie
lineair model

Appendix B



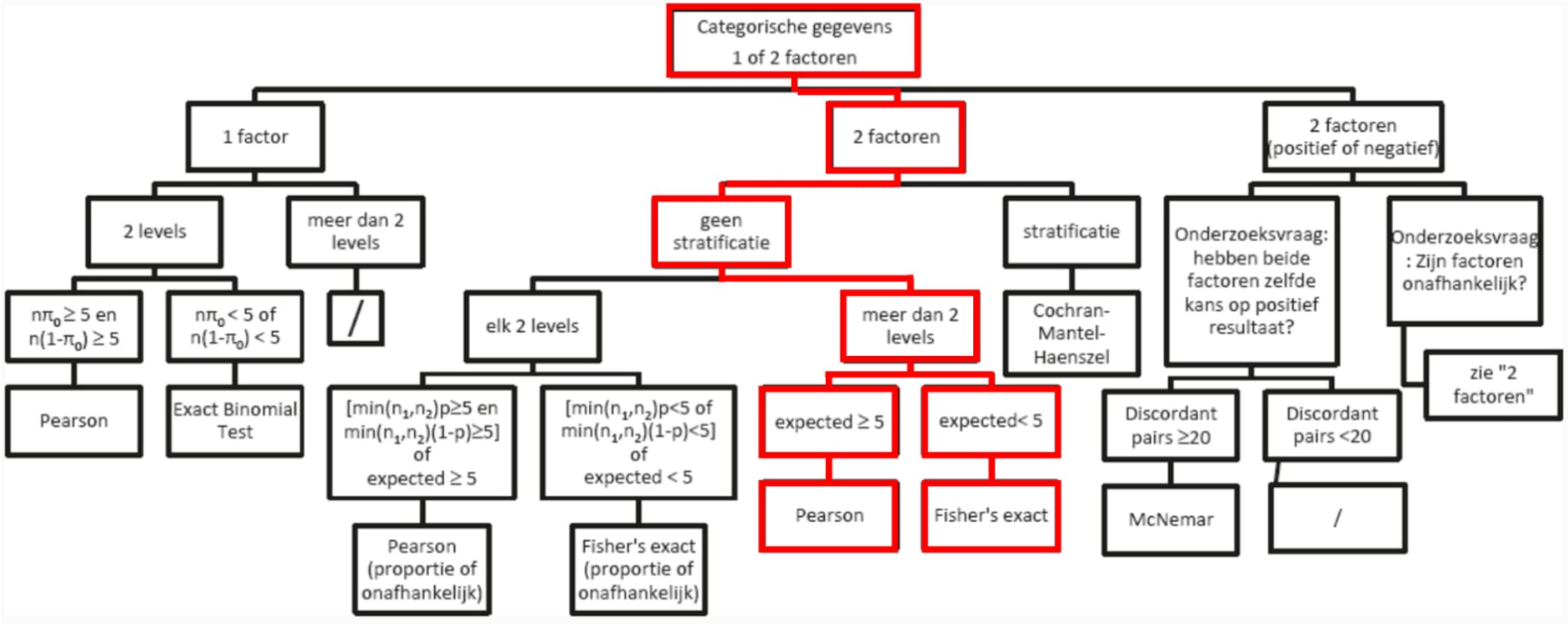
Continue gegevens
Invloed categorische en/of continue variabelen
gegevens onafhankelijk
herhaalde metingen
1 verklarende variabele
meerdere verklarende variabelen
gemengd model
continu
categorisch
enkel categorisch
enkel continu
continu en categorisch
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
andere boom "Continue gegevens - 2 of meer groepen"
andere boom "Continue gegevens - 2 of meer groepen"
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
enkelvoudige lineaire regressie
meervoudige lineaire regressie
lineair model

Appendix C1



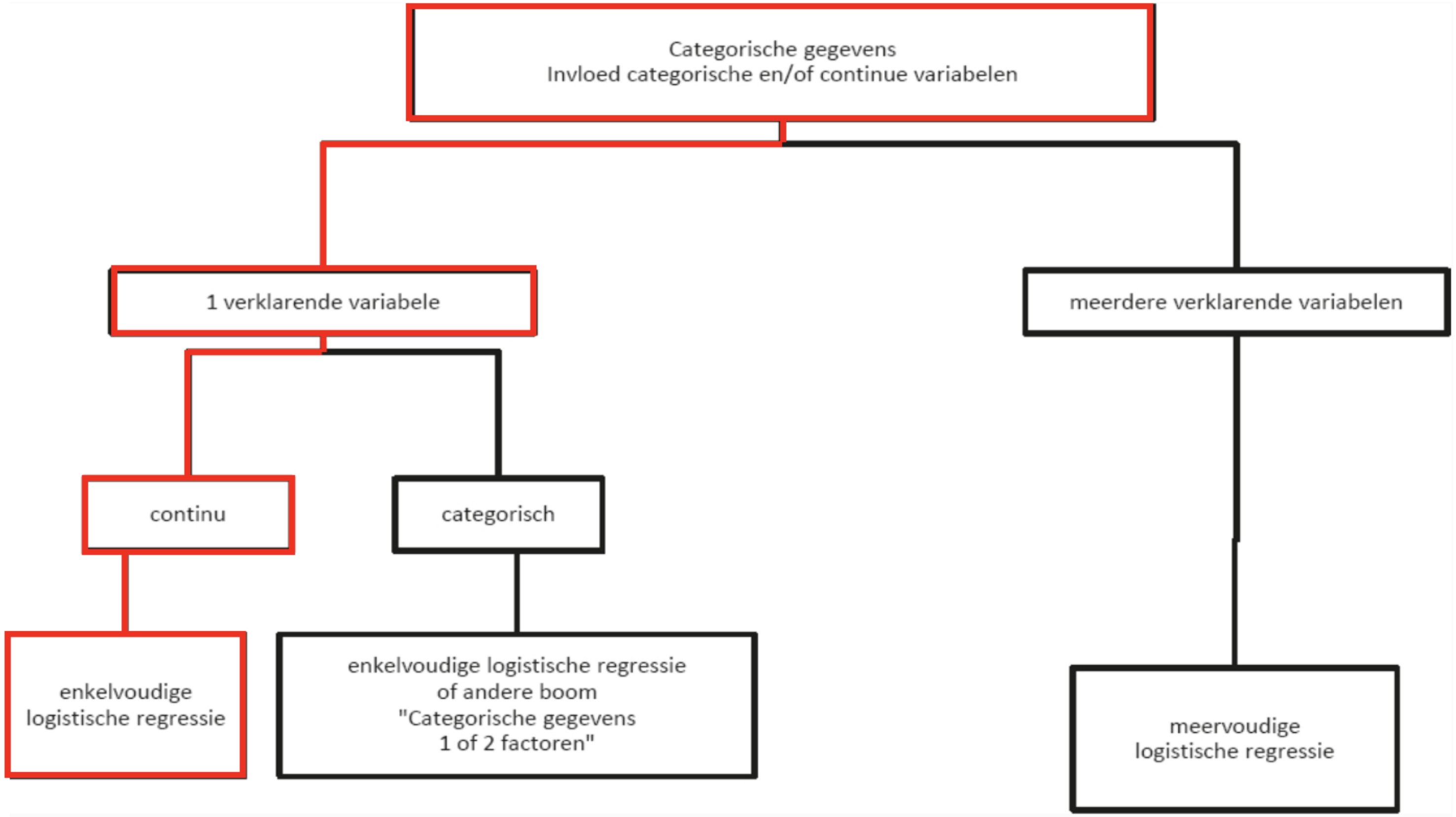
Continue gegevens
1 of 2 groepen
1 groep
2 groepen
n<30
n≥30
normaal verdeeld
niet normaal verdeeld
1-steekproef t-test
n<20
n≥20
signed-rank test
signed-rank test EN 1 steekproef t-test
1 steekproef t-test
gepaard
ga verder met "verschil", dus 1 groep
onafhankelijk
beide ≥ 30
één of beide <30
varianties gelijk
varianties niet gelijk
2-steekproeven t-test
Welch test
beide normaal verdeeld
minstens één niet normaal verdeeld
beide ≥ 20
één of beide <20
varianties gelijk
varianties niet gelijk
2-steekproeven t-test
Welch test
varianties gelijk
varianties niet gelijk
rank-sum test EN 2-steekproeven t-test
Welch test
varianties gelijk
varianties niet gelijk
rank-sum test
/

Appendix C2



Categorische gegevens
1 of 2 factoren
1 factor
2 factoren
2 factoren
(positief of negatief)
2 levels
meer dan 2 levels
$n\pi_0 \geq 5$ en $n(1-\pi_0) \geq 5$
$n\pi_0 < 5$ of $n(1-\pi_0) < 5$
/
Pearson
Exact Binomial Test
geen stratificatie
stratificatie
elk 2 levels
meer dan 2 levels
Cochran-Mantel-Haenszel
$[\min(n_1,n_2)p \geq 5$ en $\min(n_1,n_2)(1-p) \geq 5]$ of expected ≥ 5
$[\min(n_1,n_2)p < 5$ of $\min(n_1,n_2)(1-p) < 5]$ of expected < 5
Pearson (proportie of onafhankelijk)
Fisher's exact (proportie of onafhankelijk)
expected ≥ 5
expected < 5
Pearson
Fisher's exact
Onderzoeksvraag: hebben beide factoren zelfde kans op positief resultaat?
Onderzoeksvraag: Zijn factoren onafhankelijk?
zie "2 factoren"
Discordant pairs ≥ 20
Discordant pairs < 20
McNemar
/

Appendix D



Categorische gegevens
Invloed categorische en/of continue variabelen
1 verklarende variabele
meerdere verklarende variabelen
continu
categorisch
enkelvoudige logistische regressie
enkelvoudige logistische regressie
of andere boom
"Categorische gegevens
1 of 2 factoren"
meervoudige logistische regressie