FACULTEIT GENEESKUNDE EN GEZONDHEIDSWETENSCHAPPEN

Psychometric properties of the Flemish Little Developmental Coordination Disorder Questionnaire (L-DCD-Q-VL).

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Promotor: Prof. Dr. Hilde Van Waelvelde
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List of abbreviations

AIMS: Alberta Infant Motor Scales

Beery-VMI: Beery-Buktenica Developmental Test of Visual-Motor Integration

BMI: Body Mass Index

BOTMP: Bruininks-Oseretsky Test of Motor Proficiency

BSID-II: Bayley Scales for Infant Development-II

ChAS-P/T: Children Activity Scales for Parents/Teachers

CSAPPA: Children's Self-Perceptions of Adequacy in and Predilection for Physical Activity

DCD: Developmental Coordination Disorder

DCD-Q: Developmental Coordination Disorder Questionnaire

DTVP-2: Developmental Test of Visual Perception-2

EACD: European Academy for Childhood Disability

EYMC: Early Years Movement Skills

ICC: intraclass correlation coefficient

L-DCD-Q-Vl: Flemish Little Developmental Coordination Disorder Questionnaire

M: median

M-ABC-2: Movement-Assessment Battery for Children-2

MC: motor coordination

N: number of children

Pc: percentile

ROC: Receiver operating characteristics

VMI: visual motor integration

VMVK: Vragenlijst voor Motorische Vaardigheden van Kleuters

VP: visual perception

WHO: World Health Organization

WRAVMA: Wide Range Assessment of Visual Motor Ability

Y: year

Abstract (English)

BACKGROUND: With a prevalence of 1,8% to 6% in school-aged children and the known secondary complications, DCD is a minor neurodevelopment coordination disorder affecting numerous children in multiple ways (ADL-activities, psycho-social, emotional, physical fitness). Those fine and gross motor problems preschool children may experience, can be identified with the parental questionnaire L-DCD-Q-Vl.

OBJECTIVES: The aim of this study is to evaluate psychometric properties of the L-DCD-Q-Vl and to develop Flemish norm references for the L-DCD-Q-Vl.

METHODS: Three hundred and five questionnaires completed by parents of three- to five-year old preschool children were handed in on which norm references were calculated. Of those 305 children, 90 children were assessed with the Movement Assessment Battery for Children-2 Test (M-ABC-2), the Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery-VMI-6), the Vragenlijst voor de Motorische Vaardigheden van Kleuters (VMVK) and a BMI-measurement. Internal consistency of the L-DCD-Q-Vl was measured by Cronbach's alpha. Applying factor analysis, the construct validity was determined. Spearman correlations were administered to investigate concurrent validity between L-DCD-Q-Vl and M-ABC-2, Beery-VMI, VMVK and BMI. Also, sensitivity, specificity and percentages of agreement were calculated to determine validity of the questionnaire.

RESULTS: Seven out of 305 children (2,30%) scored equal to or below the cut off of percentile 2 (= raw score 49). High internal consistency was determined (Cronbach's alpha = 0,901). Three factors were revealed by factor analysis (fine motor skills, gross motor skills and ball skills). Significant and moderate correlations were found for M-ABC-2 and VMVK, a significant and low correlation was found between the L-DCD-Q-Vl and the Beery-VMI and no significant correlation was found for BMI. Compared to a M-ABC-2 score at or below the 16th percentile, sensitivity of 18,8% and specificity of 77,3% were calculated for the L-DCD-Q-Vl.

CONCLUSION: The L-DCD-Q-Vl cannot be recommended as screening tool for DCD for Flemish children between 3 and 5 years old.

Keywords: DCD, L-DCD-Q-Vl, psychometric properties, validity, norm references

Abstract (Dutch)

ACHTERGROND: Development Coordination Disorder (DCD) is een milde neuromotore stoornis die 1,8 % tot 6% van de lagere schoolkinderen treft en invloed heeft op verschillende vlakken (dagdagelijkse activiteiten, psycho-sociaal, emotioneel en fysieke fitheid). De L-DCD-Q-Vl, een vragenlijst voor ouders, werd ontwikkeld om de motorische problemen die kleuters in het dagdagelijkse leven kunnen ervaren, in kaart te brengen. Op die manier zou de L-DCD-Q-Vl als screeningsinstrument kunnen gebruikt worden voor het opsporen van DCD op kleuterleeftijd.

DOELSTELLINGEN: Deze studie heeft als doel de psychometrische eigenschappen van de L-DCD-Q-Vl te onderzoeken en de normering van de L-DCD-Q-Vl te bepalen.

METHODE: Driehonderdenvijf bruikbare vragenlijsten ingevuld door ouders over hun 3- tot 5-jarige kinderen, werden terugbezorgd en werden gebruikt om normgegevens op te stellen. Uit deze populatie werden vervolgens 90 kinderen random geselecteerd en onderzocht met een testbatterij bestaande uit de Movement Assessment Battery for Children-2 Test (M-ABC-2), de Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery-VMI-6), de Vragenlijst voor de Motorisch Vaardigheden van Kleuters (VMVK) en een BMI-meting. De interne consistentie van de L-DCD-Q-Vl werd gemeten met Cronbach's alpha. Aan de hand van de factoranalyse werd de constructvaliditeit bepaald. Spearman correlaties werden gebruikt om de concurrente validiteit tussen de L-DCD-Q-Vl en de M-ABC-2, Beery-VMI, VMVK en BMI te onderzoeken. Ook werden sensitiviteit, specificiteit en percentages van overeenkomst berekend om de validiteit van de vragenlijst te bepalen.

RESULTATEN: Zeven van de 305 kinderen (2,30%) scoorden op of onder de grenswaarde van percentiel 2 (= ruwe score 49). Hoge interne consistentie werd gevonden (Cronbach's alpha = 0.901). Drie factoren kwamen naar voren door factoranalyse (fijne motoriek, grove motoriek en balvaardigheden). Een significante en matige correlatie werd gevonden tussen de L-DCD-Q-Vl en de M-ABC-2. Significante en lage correlaties werden gevonden tussen Beery-VMI en VMVK, terwijl er geen significante correlatie gevonden werd voor BMI. In vergelijking met een M-ABC-2 percentielscore van 16 of kleiner dan 16, werden de sensitiviteit en specificiteit van de L-DCD-Q-Vl respectievelijk gemeten op 18,8% en 77,3%.

CONCLUSIE: De L-DCD-Q-Vl wordt niet aangeraden als een screeningsinstrument voor DCD voor een populatie van Vlaamse kinderen van drie tot en met vijf jaar oud.

Keywords: DCD, L-DCD-Q-Vl, psychometrische eigenschappen, validiteit, normering

1. Introduction

Children with Developmental Coordination Disorder (DCD) have difficulties with the movement coordination quality and motor planning of fine and/or gross motor tasks (1). Those specific difficulties often start to be recognized in the 'golden age' of motor development, since children between three and five years old develop many fundamental motor skills in this period. Motor skills such as running, jumping, throwing, catching, painting, closing and opening zippers and buttons… can appear to be executed slower, less coordinated, more inattentive and hence not as fluent as their peers (2). This delayed motor development interferes with participation in activities in the playground, in daily living activities at home and in achievements at school (3). Difficulties experienced within the coordination of fine or gross motor tasks in absolute absence of clear neurological or intellectual disorders can be indicative for DCD (4). Similar to peers, children with DCD will succeed in learning new motor skills such as riding a bike, swimming or writing, although their movements will probably remain less precise, more inaccurate and will often happen at a slower speed. The prevalence of DCD is estimated at 1,8% (5) to 6% (6) in school-aged children with a male-female ratio of 3:1 (4).

The difficulties that children with DCD experience, can also go beyond the motor domain resulting in physical, socio-emotional and behavioral problems. The delayed motor skills affect the daily living activities which may result in the emerge of psychosocial consequences. The secondary problems may start in some children already in preschool age and persist often into adolescence and adulthood (7) (8). Zwicker et al. (9) highlight the impact on psychological and social domains in children with DCD reporting lower self-efficacy, larger symptoms of depression and anxiety, more externalizing behaviors and more social problems. Adolescents, in particular, experience poorer social support and lower self-worth (10). Besides the psychosocial consequences, reduced physical fitness and physical inactivity are also noticed with subsequently increased risk for obesity (higher BMI)(11). Poor perception of physical fitness (7), reduced motivation to participate in teamplays and sports, less contact with peers and lack of practicing the skills they need for teamplays are described as causes (12). If not approached, the obesity or overweight are important predictors for overweight in adulthood, which can eventually be associated with important cardiovascular diseases (13).

Although DCD belongs to the category of 'minor neurodevelopmental disorders', an effort to minimize the above mentioned major negative outcomes in adolescence and adulthood should be made (14). Early detection and diagnosis are imperative in order to improve motor skills and prevent secondary problems towards DCD (e.g. health, psychosocial and academic complications). Since receiving a DCD diagnosis can

take a long time, the diagnostic procedure is frequently described as very stressful by parents (15). A lot of stress and dissatisfaction are consequently involved in multiple cases. Frustrations about the lack of consistency in and the duration of the diagnostic process should be evaded by developing a reliable screening instrument with the purpose of referring the children at risk to the appropriate professionals.

To enable (early) diagnostics, a reliable and valid screening instrument is required. Moret, Pirson and Van Der Massen suggested two motor assessments with satisfactory predictive values and thus considered to be reliable instruments in predicting minor developmental disorders in children aged under the age of three: AIMS and BSID-II (16). Likewise, for the population of preschool children aged three to five years old, no golden standard in Flanders has currently been developed to either diagnose children with DCD or to screen for children at risk for DCD. A possible explanation can be that according to the European Academy for Childhood Disability (EACD) guidelines, DCD is generally not diagnosed before the age of five (17). However the Bruininks-Oseretsky test of motor proficiency (BOTMP) or the Movement-Assessment Battery for Children (M-ABC) are capable of objectifying criterium A of the DCD diagnoses in children of three years old, significant problems exist for the diagnosis of children below the age of five (18). Children below the age of five show larger differences in rates of development, possible delayed development with spontaneous catch up, more fluctuations in motivation and cooperation while being assessed. To fulfill all the established diagnosis criteria, the used (screening)measurement needs also to esteem and scale the functional impact of DCD on activities at home and at school. Parent-report measurements/questionnaires are considered to add important information about this functional impact to the assessment of a child and hence seem to have valuable interests in objectifying criterium B (19). Several questionnaires for parents and teachers (M-ABC checklist (20), the ChAS-P/T (21), CSAPPA (22), the EYMC (23), DCD-Q (24), VMVK (25) and L-DCD-Q (26)) are available to survey the motor skills of children at home or in class. Up to now, only the M-ABC checklist and VMVK are available in Dutch. However, the M-ABC checklist is only available for children who are at least six years old, while the VMVK is a Dutch questionnaire specifically developed for teachers. No Dutch parental questionnaire is obtainable to be applied as a screening instrument for the Flemish population of three- to five-year-old children. Recently the L-DCD-Q has been translated into Flemish *(Appendix 1)* which could be a first step into the development of a Dutch parental questionnaire, although the psychometric properties and consequently the appropriateness to be a valid screening instrument remain to be determined.

The origin of the L-DCD-Q-Vl is situated in Canada where the DCD-Q was developed in 2000 as *"A parent-report questionnaire that assists health care practitioners in the identification of DCD."* (24, 27). Children

and adolescents between eight years and fourteen and a half years were the targeted population. Afterwards, in 2009 the DCD-Q was revised in Canada and extended to a lower age range: five to seven years (28). In 2010 Rihtman et al. (26) developed in Israel the L-DCD-Q to screen preschoolers from three and four years old for DCD. Both Dutch (29) and Canadian (30) researchers translated the L-DCD-Q to their native language and evaluated the psychometric properties of their adapted questionnaire. By evaluating the psychometric properties in Flanders, this study aims to evaluate the validity of this checklist, specifically for the Flemish region and compares results cross-culturally and especially with the Dutch neighbours from the Netherlands (29).

The L-DCD-Q has already been translated into Dutch and some psychometric properties were recently investigated (29). This study aims to investigate the validity of the L-DCD-Q-Vl in Flanders, replicate and elaborate the evaluation of the internal consistency and validity and develop norm references for Flanders. Data about the L-DCD-Q are already described in seven countries: Canada (24, 30), Israel (26), South-Africa (31), Switzerland/France (32), Taiwan (33), the US (34) and The Netherlands (29). By developing and evaluating the L-DCD-Q-VL this study will, first of all, meet the recommendations of the EACD which concluded that the DCD-Q is as yet the better-evaluated questionnaire (17). Furthermore, the study also answers the recommendations of the World Health Organization (WHO), which says that cross-cultural translation of already developed instruments is faster, cheaper and contributes to cross-cultural information exchange (35). The aim of this study, the development of Flemish norm references of the L-DCD-Q-Vl and the determination of its psychometric properties, is consequently an important contribution to the spectrum of screening instruments for young children, aged three- to five-years old.

2. Methods

2.1 Participants

After acquiring approval of the Ethics Committee of UZ Ghent, a total number of 1287 children and their parent(s) of 13 Flemish schools were invited to participate in the study. Parents were asked to complete the Little Developmental Coordination Disorder Questionnaire – Flemish version (L-DCD-Q-Vl) and sign the informed consent. A total of 344 completed L-DCD-Q questionnaires were handed in (26,73%). The inclusion criterion was: (1) children aged between 3 years 0 months and 5 years 11 months 30 days. Exclusion criteria were: (1) parents did not give approval to participate in further scientific research, (2) the child was already diagnosed with a medical condition that can affect motor development (e.g. CP, neuromuscular diseases, …), (3) one or more missing answers in the returned questionnaire.

To develop Flemish norm references, all of the returned questionnaires, were submitted to the in- and exclusion criteria. Twenty-seven children appeared to be too young or too old, parents of seven children did not give approval, five questionnaires were not completed and no children were diagnosed with neurological disorders such as CP, DCD, ASS… Eventually, the total population-based sample of this research consisted of 305 preschool children. The flowchart of this selection process is depicted in Figure 1.

Starting from those 305 completed questionnaires included for the development of norm references, 90 children were randomly selected to analyze the psychometric properties of the L-DCD-Q-Vl. Before randomizing, 18 children (5,9%) were excluded for the evaluation of the psychometric properties because their parents did not give approval to participate in this part of the study. Also, children whose questionnaire was filled in or submitted too late were excluded (18,4%). The remaining questionnaires (n=231) were subdivided in six groups, according to age and gender: males 3y (n=32), females 3y (n=49), males 4y (n=41), females 4y (n=34), males 5y (n=41) and females 5y (n=34). To carry out a random selection, each child received a code. Out of each group 15 codes were selected by means of *Research Randomizer.* To limit the workload for the participating teachers, a maximum of four children of the same class could be selected.

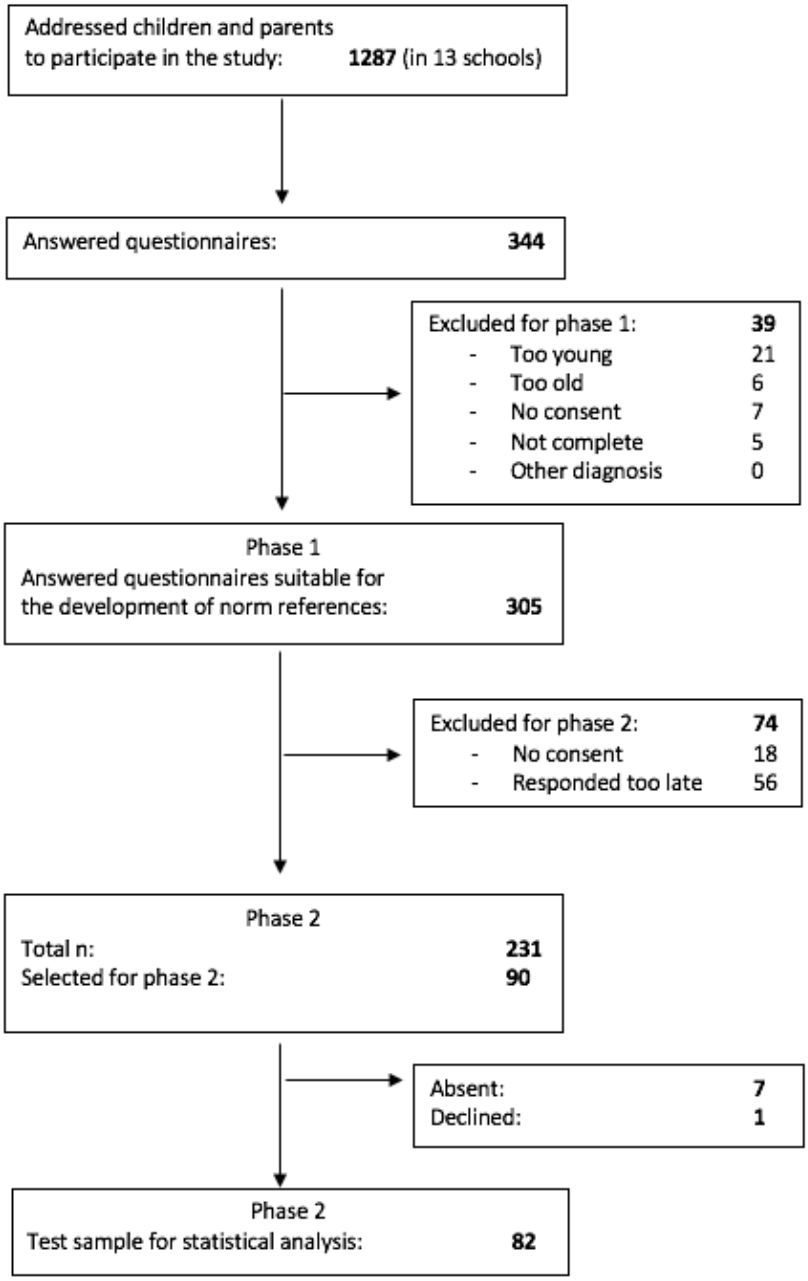

Figure 1: Flowchart of the selection of the participants

2.2 Measurements

2.2.1 Little Development Coordination Disorder Questionnaire - Flemish (L-DCDQ-Vl)

The L-DCD-Q-Vl is an inexpensive and easy to complete instrument used to describe specific motor coordination features of young preschool children (29). In 15 questions, parents are asked to compare their child's movement coordination quality with those of children of the same age and rate their performance on a 5-point Likert scale, with 1 = absolutely not relevant to my child and 5 = absolutely relevant to my child. A total score of 75 can be obtained: the closer the added score to 75 points, the better the performance and quality of motor coordination of the child.

The L-DCD-Q and original DCD-Q were already translated and analyzed for psychometric properties in seven countries. All of the studies measured a Cronbach's alpha-value higher than 0,7 which confirms an excellent homogeneity of all questions (36). Test-retest-reliability of the L-DCD-Q, developed in Israel, showed good to ideal reliability. An ICC (intraclass correlation coefficient) of 0,96 was reported in Canada by Wilson et al. (95% CI; 0,82 - 0,98; $p<0,001$). Likewise, the Chinese version of the L-DCD-Q confirmed the findings of other studies by measuring a good test-retest-reliability ($r=0,97$). Moderate correlations with the M-ABC-2 were calculated in Taiwan ($r=0,52$; $p<0,001$), the Netherlands ($r=0,36$; $p<0,001$) and South-Africa ($r=0,29$).

2.2.2 Movement Assessment Battery for Children-2nd edition (M-ABC-2) (37)

The M-ABC-2 is a standardized, norm-referenced motor assessment developed for children from three to sixteen years old. In each of the three age ranges, eight items measuring manual dexterity, aiming and catching and balance should be performed and assessed by each child to screen for potential motor problems. The first age range assesses the motor skills of children from three to six years and hence applied by the researchers of the present study to examine the development of motor abilities of preschool children. After assigning raw scores to each tested item, the standard scores can be valued. In turn, the total test score can be converted into a percentile rank. The possibility of categorizing children depending on the acquired scores is an advantage of using percentile ranks. According to the M-ABC-2 manual a child who scored between the 5th and 16th percentile is at risk for developing a motor problem. A score below the 5th percentile suggests a motor impairment.

2.2.3 Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery-VMI-6) (38)

The Beery-VMI assesses in one core task and two supplemental tasks the visual-motor abilities of children and adults aged two to hundred years old. The core task or the Visual Motor Integration (VMI) evaluates

the process from visual integration to the motor outcome. A sequence of 21 geometric figures needs to be copied using pencil and paper. The two supplemental tasks evaluate the visual perception (VP) and motor coordination (MC) separated from each other by respectively assessing the ability to point out two similar figures and connecting dots within the provided boxes. Since the Beery-VMI is a standardized, norm-referenced measurement, raw scores on individual items can be converted to standard scores, percentile scores and age equivalents.

The authors of the test measured an internal consistency of 0,82 (VMI), 0,81 (VP) and 0,82 (MC) which indicates an acceptable homogeneity of all items in the age range of 2y-18y. Likewise, excellent interscorer reliability was indicated with values of 0,93 (VMI), 0,98 (VP), 0,94 (MC). Low to moderate correlation were respectively measured between the VMI task and the Drawing subtest of the Wild Range Assessment of Visual Motor Abilities (WRAVMA) and between the VMI and a copying subtest of the Developmental Test of Visual perception (DTVP-2).

2.2.4 Vragenlijst voor de Motorische Vaardigheden van Kleuters (VMVK) (25)

The VMVK surveys the motor abilities of a three-, four- or five-year-old child by asking the teacher to score 28 daily activities from 1 to 4 (1= child can perform the task without failing; 4= child cannot perform the task at all). The total test score is the sum of all item scores. The higher the score, the less daily motor activities are acquired yet.

In 2007 the psychometric properties of the VMVK were evaluated by D'Hondt & Severius. A Cronbach's alpha of 0,97 was found as measure for internal consistency. An ICC of 0,94 for the test-retest reliability and 0,80 for the interscorer reliability indicate a good reliability of the VMVK. However, an ICC of 0,40 was calculated in the age category of five-year-old children, indicating the need for a cautious interpretation in this age range. Weak to strong correlations were reported for the concurrent validity between the VMVK and the M-ABC-2 (3y: r=0,70; 4y: r=0,40).

2.2.5 Body Mass Index (BMI) (39)

Whether a child has overweight or is obese, can be determined by calculating the Body Mass Index. The formula applied in this study to measure the BMI of children is weight/height^2. Since weight can be a confounding factor, measuring the BMI could add useful information to the present study (29).

2.3 Data analysis

Analyses were performed using the Statistical Package for Social Science version 25 (SPSS-25).

Normality was computed with Q-Q plots and the Shapiro-Wilks test. Non-parametric tests were applied for this research, since significant evidence of the Shapiro-Wilks test indicated no normal distribution. Box-plots were set up to detect any outliers. In term of descriptive statistics, the median and the associated range will be described.

Cronbach's alpha was computed to investigate the internal consistency of the L-DCDQ-Vl. High values (>0.80) indicate high reliability or high internal consistency. An alpha level <0.50 indicates insufficient reliability. Generally, a scale with a value of >0.70 is considered acceptable (36).

To assess concurrent validity, Spearman correlations were calculated between the L-DCD-Q and the M-ABC-2, the Beery VMI, the VMVK and the BMI. Standard scores of the M-ABC-2 and the Beery VMI were used in order that no bias could occur between the different age groups. For the VMVK, difference scores between the expected and obtained scores for that age were applied.

A further analysis of validity was conducted by evaluating the percentage of agreement within the different tests using contingency tables. The concurrent validity between two tests measures whether the children could be similarly categorized by two different assessments. Since the M-ABC-2 is known as golden standard to identify children at risk for DCD with a cut-off score at Pc16, this research applied the similar cut-off score for M-ABC-2. Comparably cut-off scores at Pc15 were applied for the Beery-VMI, VMVK and L-DCD-Q-Vl.

The significance of this concurrence was verified with the Fisher-exact-test. A significant difference suggests a larger agreement between the results of two motor assessments than expected based on coincidence, which is automatically expected in case of high concurrence. Sensitivity and specificity for L-DCD-Q-VL were determined based on the M-ABC-2 using the same cut-off scores as mentioned above. Sensitivity or the ability to correctly identify children at risk for DCD, is significant at a value of 80%. Specificity is significant at a value of 90% (31).

To describe the factor structure of the L-DCD-Q and classify the different questions to one or more central factors, a factor analysis was carried out (40), more specifically a factor analysis with Principal Axis Factoring as extraction method and Varimax with Kaiser Normalization as rotation method. A factor loading above 0,40 was considered acceptable to include a particular item into a factor (41).

3. Results

3.1 Participants

The population-based sample of this study consisted of 305 children (147 males, 158 females; median age: 53 months (36m-70m)) of whom 100 five-year-old, 103 four-year-old and 102 three-year-old).

Of the 90 randomly selected children, seven were ill at the moment of testing and 1 refused to participate. In consequence, 82 children were tested effectively (42 males, 40 females; median age: 56,5 months (36m-71m) of whom 30 five-year-old, 26 four-year-old and 26 three-year-old.) A standard score of 102 is the median standard score obtained for the Beery-VMI (79 - 218), a mean standard score of 10 was calculated for the M-ABC-2 (SD=2,75), a positive median difference score of 4 for the VMVK (-47 - 24) and a median of 15,98 for the measured BMI.

3.2 Norm references

Since a significant Shapiro-Wilks test ($p<0.0001$) showed that the population was not normally distributed, the median and the associated range for the L-DCD-Q-Vl on the total sample-based group were set up (n=305; m=72; [43-75]). The total sample-based group included 100 five years old (m=72; [43-75]), 103 four years old (m=72; [44-75]) and 102 three years old (m=71; [49-75]).

In this study, percentile 2, corresponding to a raw score of 49, was selected as cut-off score for the L-DCD-Q-Vl. Children who scored below Pc 2 should be categorized as children at risk for DCD. The choice for a low cut-off was made to minimize the number of false positives this screening instrument would indicate. In this study sample, seven children (male=6; female=1) of the total population-based sample scored equal to (n=1) or below (n=6) a score of 49 at the L-DCD-Q-Vl. A discrepancy between two sexes can be seen below percentile 2 as well as between the median scores of girls (m=72; [49-75]) and boys (m=71; [43-75]). However, this discrepancy is not found to be significant (p=0.057).

3.3 Psychometric properties of the L-DCD-Q-Vl

3.3.1 Internal consistency

A Cronbach's alpha of 0.901 was measured for the L-DCD-Q-Vl in a population-based sample of 305 children. Alpha-values of 0.892, 0.908 and 0.902 were respectively found for the three-, four- and five-year-old children. An acceptable internal consistency is determined with an alpha-value of 0,70 or higher (36). A high reliability of measuring one main subject, namely movement coordination quality in ADL-activities, with 15 different questions is subsequently indicated for the L-DCD-Q-Vl in all age categories.

3.3.2 Concurrent validity

Spearman correlations were calculated to evaluate validity of the L-DCD-Q-Vl (*Table 1*). The Little DCD-Q-Vl scores were significant and moderate correlated with the scores of M-ABC-2 (r=0.371) and the VMVK (r=0.320). A Significant, but low correlation was found between the L-DCD-Q-Vl and the Beery-VMI (r=0.290). However, the total scores of the L-DCD-Q-Vl did not correlate significantly with the measured BMI (r= -0.203).

Table 1: Spearman correlations between X and Y in (N=82)

	L-DCD-Q-Vl (total score)	
	Correlation coefficient	**P-value**
Beery-VMI (standard score)	0.290	0.008
M-ABC-2 (standard score)	0.371	0.001
VMVK (difference score)	0.320	0.004
BMI	-0.203	0.068

Additional important validity information was determined by using contingency tables. An agreement of 78% was accounted between the L-DCD-Q-Vl and the Beery-VMI. Sixty-four out of 82 children were classified in the same percentile category by the screening instrument and the visuomotor test. A Fisher-exact value of 0.116 was calculated which means the agreement of classification between the two tests is not better than was expected based on coincidence. The agreement between the VMVK and the L-DCD-Q-Vl was 77.8% (n=63) with a significant Fisher-exact value of 0.039, which could be interpreted as a better agreement in classification of the two tests than expected, based on coincidence.

Sensitivity and specificity of the L-DCD-Q-Vl could only be measured based on cut-off scores of the M-ABC-2, since its reputation as golden standard to diagnose DCD. Percentile 15 (Pc 16 for the M-ABC-2), corresponding with the cut-off of 61, was applied to categorize the assessed children in two categories for each test. A contingency table (*Table 2*) was set up to measure sensitivity and specificity, which amounted to 18.8% and 77.3% respectively. An agreement of 65.9% was found between the categorization of the M-ABC-2 and the L-DCD-Q-Vl with a non-significant Fisher-exact value of 1.00.

Table 2: contingency table between M-ABC-2 and L-DCD-Q-Vl in (N=82)

		M-ABC-2		
		≤ Pc 16	**> Pc 16**	**Total**
L-DCD-Q-Vl	**≤ Pc 15**	3	15	18
	> Pc 15	13	51	64
Total		16	66	82

3.3.3 Factor analysis

Factor analysis was performed in the total population-based sample (n=305) and resulted in three factors with an eigenvalue larger than one *(Table 3)*. These three factors explained 50.6% of the variance. Factor 1 included eight items and measured *fine motor skills*. Factor 2 included three items measuring *gross motor skills* and factor 3 included three items measuring *ball skills*. Factor loadings between 0.422 and 0.854 occurred *(Table 3)*. Item 12 of the L-DCD-Q-Vl did not load on any factor (<0.400).

Table 3: factor loadings by item in (N=305)

Item*	**Factor 1: fine motor skills**	**Factor 2: gross motor skills**	**Factor 3: ball skills**
1			0.636
2			0.714
3			0.558
4		0.706	
5		0.854	
6	0.616		
7	0.774		
8	0.652		
9	0.581		
10	0.422		
11	0.508		
12			
13		0.616	
14	0.484		
15	0.472		

**See appendix 1: L-DCD-Vl for questions*

4. Discussion

4.1 Summary of evidence

Since DCD is a minor neurodevelopmental coordination disorder with possible secondary problems affecting 1,8 to 6% school-aged children, early detection and intervention is important. The use of a valid parental questionnaire surveying motor coordination problems is indispensable in the identification of motor problems in preschool children. The aim of the current study was to evaluate the psychometric properties of the L-DCD-Q-Vl and create norm references for a population of three-, four- and five-year-old children.

Total test-scores of the L-DCD-Q-Vl, used to develop the norm references**,** showed a gender difference at low cut-off (Pc 2). Six boys and one girl appeared to be children at risk for DCD. Similarly, the median showed a difference in scores between the sexes, disadvantaging the boys. Considering the male-female disparity, Wilson et al. (30) generated separated gender cut-off scores with Receiver Operating Characteristic curves since gender seemed a good predictor of motor impairment according to that study. Equally, Livesey et al. (2007) (42) suggested specific gender norms for the M-ABC-2, while results in this study as well as in other studies (43, 44) indicate that differences in total test score between boys and girls are not significant and may also have no specific clinical relevance. Additionally, separated norms for sex do not seem to be imperative for motor assessments or screening instruments to meet their purpose (45). If identifying children with motor coordination problems is the main objective, a discussion can be raised whether the identification of children at risk should be made regardless whether the child is male or female. Another practical argument against developing gender specific norm references can be the disadvantage of halving the extent of the population group. Weaker statistical results and possible sampling errors would be described with a sample decreased by half. Consequently, similar to the original investigation of Rihtman et al. (26), no gender specific cut-offs for the L-DCD-Q-Vl were retained in this study. To develop norm references in this study, a cut-off was chosen at percentile 2, corresponding with a raw score of 49. However, other studies applied different manners of classifying their population into groups of typically developing children and children at risk. Contrary to the present study, Rihtman et al. (26) made a distinction between a group of children at risk and a control group, based on whether the child had been referred or was being treated for developmental delay at the time of the study or not. The study of Cantell et al. (29) divided the recruited participants in 2 groups using percentile scores of the M-ABC-2-Nl: a group of typically developing children (score at or below Pc 16) and an at-risk group (score above Pc 16). Similar to the study of Cantell et al., the study evaluating the Canadian L-DCD-Q described cut-off points while calculating sensitivity and specificity with ROC curves (29, 30). Since the ROC curves and their associated high cut-off points ensure an optimal sensitivity and specificity, those cut-off points

cannot be compared to the cut-off point of the present study. Venter et al. (31) used in their study the classification of Rithman et al. (26), which described the cut-off point for a possible DCD-diagnosis at two standard deviations from the average value of the group. Implementing this definition, Venter et al. calculated a raw score of 50 as cut-off point. No corresponding percentile was mentioned. However, since the present population of the study is not normal distributed, no mean score and standard deviation could be described, which implied that the cut-off point had to be calculated in a different way. Therefore, percentile 2, corresponding to a raw score of 49 was used in this study to decide whether a child is at risk for DCD or not. This raw score of 49 seems to be comparable to the cut-off value of 50 chosen by Venter et al. (31).

Consistent with other studies evaluating psychometric properties of the L-DCD-Q (29-31), homogeneity of the items of the questionnaire was confirmed with a high Cronbach's alpha-value (29-31). A good internal consistency is suggesting that all items are related to one main subject, namely movement coordination quality in ADL-activities. Nevertheless, a conscientious approach is needed because DCD is still known to be a heterogeneous condition. Different children at risk for DCD could show different patterns of deficits. Consequently, a screening instrument cannot claim to screen for one underlying phenomena of DCD, however they might have an enormous high internal consistency.

Unveiling the structure of the L-DCD-Q-Vl, a factor analysis was conducted. Three factors, fine motor skills (eight items), gross motor skills (three items) and ball skills (three items), were revealed explaining 50.6% of the total variance. Considering its low loading, *'Imitating body positions during games or sport activities.'* could not be loaded in any of the three factors. In fact, item 12 is the only question specifically assessing the quality of motor planning. Since children with DCD experience difficulties within planning complex movements (46), a suggestion can be made about adding more questions to the L-DCD-Q-Vl about motor planning. Motor planning is a feature frequently used in everyday tasks like brushing teeth, picking up a pencil and writing, putting on clothes… Developing and adding questions gauging the ability of considering the most appropriate way of performing a motor activity could consequently be an interesting additive to the questionnaire. The factor analysis of the current study has many similarities and yet some differences with the study of Cantell et al. (2019) (29). In the study of the L-DCD-Q-Nl, a factor loading above 0.30 was considered to be an acceptable level which resulted in 15 items divided in three factors (fine motor, locomotor and ball skills). Factor 3 included three items measuring 'ball skills', which is similar to the present study. Factor 1, fine motor skills, consisted of eight items in both studies, the same structure was found with two exceptions. At first, *'Good coordination'* loaded on the fine motor factor in the present study, while it is loaded on factor 2 in the study of Cantell et al.. A second difference was noticed within *'Imitates body positions'* loading on factor 1 in the factor analysis of the L-DCD-Q-Nl

and not loading on any factor in this study. The third factor was named differently in the present study, however consisting of the same three items in both studies.

To confirm whether the L-DCD-Q-Vl is a valid screening instrument, the questionnaire is expected to measure what it is purported to measure. Validity of the L-DCD-Q-Vl was evinced in multiple ways. Beginning with the correlation between L-DCD-Q-Vl and VMVK, initially both questionnaires, one for parents and one for teachers. However, both questionnaires measure a different connotation of motor performance, teachers are asked by the VMVK if a child performs a motor skill or not, while the L-DCD-Q-Vl asks parents if a child has features to perform motor skills as good as their peers. If a child cannot perform the daily activity enquired by the L-DCD-Q, although using similar patterns of movements as peers, the child can still score the maximum. Consequently, a significant but moderate correlation demonstrated, what was expected for this study.

Likewise, a moderate correlation with the M-ABC-2 was accounted. Similar results were found in previous studies of the L-DCD-Q in Canada (30), Taiwan (33), the Netherlands (29) and South-Africa (31). Considering the numerous amount of researchers using this motor assessment as 'golden standard' in their studies to correlate L-DCD-Q's with and the popularity of the M-ABC-2 in the context of diagnosing DCD, a moderate correlation of the L-DCD-Q-Vl with the M-ABC-2 demonstrates its capabilities as possible screening tool for DCD in preschoolers (47, 48).

While moderate correlations were described for VMVK and M-ABC-2, a low correlation was found between L-DCD-Q-Vl and Beery-VMI-6. This result was again expected for the questionnaire since the two assessments are originally developed to measure different aspects of motor coordination patterns. Several studies described DCD as a complex, heterogeneous condition and tried to subdivide DCD into different subtypes (49, 50). This differentiation proves that some children diagnosed with DCD may have problems with visual-motor integration tasks, while others do not experience those problems and thus will not be identified with DCD by using a Beery-VMI-6 test.

The last correlation inquired in the present study emerged to be a non-significant correlation between the L-DCD-Q-Vl and the BMI. Contrary to this result, the study researching validity of the L-DCD-Q-US described higher mean BMI percentiles in children with motor difficulties. An elucidation for this discrepancy can be found in the fact that only few high BMI's were measured in the population sample of this study. The results of those children were still moderate to good and thus their weight was not a limitation. Another explanation for the absence of similarity between the two studies may be the difference in characteristics of the inquired population. The prevalence of childhood obesity seems to be higher in the US compared to Europe (46% towards 38%), according to a study of Wang & Lobstein (2006) (51).

Further investigation of validity was focused on discriminating at risk children from not at-risk children. Since the purpose of the present study is to develop an early screening tool, high sensitivity is preferable to higher specificity causing identification of all those who are at risk for DCD (20). With the results of the present study, 18,8% sensitivity and 77,3% specificity, no compliance could be shown with the formulated statement. However, the non-significant association between the two classifications do not allow further interpretation. This is probably related to the low number of children scoring below the 16th percentile on the M-ABC-2 (19,5%), since this study investigated a population sample. Other studies included different population samples such as typical developing children, referred children and children at risk into their study resulting in higher sensitivity and discriminant validity (26, 30). Sensitivity and specificity of the L-DCD-Q were only in one study determined in the same way as the present study. The study of Venter et al. (2015) classified children in a DCD-group or non-DCD-group based on the total score obtained for the L-DCD-Q and the M-ABC-2. The low sensitivity calculated in the South-African population of three- to five-year-old children, is explained by the authors because of the difficulty for parents to recognize motor delays in children (31). Lack of knowledge about the typical development of a child and a possible atypical development can account for the low sensitivity rates of screening instruments. This elucidation could correspond to the EACD recommendations of not using questionnaires for population-based screening for DCD (17). However, no conclusions could be made regarding the calculated sensitivity and specificity in this study, important information about motor abilities of children compared to peers can be added by using the L-DCD-Q-Vl as a screening instrument.

4.2 Limitations

An important limitation of this study is that only a sample-based population was included, resulting in a non-significant association between a classification based on M-ABC-2 and L-DCD-Q-Vl. As a consequence, low sensitivity and specificity rates were measured in this study.

By inviting several Flemish schools to participate in this study, an attempt was made to select a representative sample. However, the low participation rate to the study can have restricted the generalizability of the result to the total population.

Since other studies seemed to have normal distributed populations included in their studies and administered other ways of calculating cut-off scores, comparing the cut-off score of the present study with others was difficult.

4.3 Conclusion

In summary, this study created norm references for the L-DCD-Q-Vl in a Flemish population of three-, four- and five-years old children resulting in a raw score of 49 (pc 2) as cut-off. Good internal consistency, moderate to low correlations for the M-ABC-2, VMVK and Beery-VMI and no significant associations with M-ABC-2 and Beery-VMI were found for the L-DCD-Q-Vl. Those data indicate an unsatisfactory grade of validity. However, interpretation of sensitivity and specificity is not legitimized since the low prevalence of children with DCD in the population group. Consequently, the L-DCD-Q-Vl cannot yet be recommended as a screening instrument in a population group of three- to five-year-old children.

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Appendix

Appendix 1: Little DCD-Q-Vl

Coördinatie Vragenlijst - Little DCD-Q - Vl

Datum: .....

Naam van het kind:..... Geboorte datum: ..... Geslacht: meisje/jongen (doorstreep wat niet past)

Ingevuld door..... Relatie tot het kind.....

De meeste van de motorische vaardigheden die in deze vragenlijst genoemd worden gaan over dingen die uw kind met zijn of haar handen doet, of over hoe hij/zij beweegt. Normaal gesproken wordt de coördinatie van een kind elk jaar beter zolang hij/zij groeit en zich ontwikkelt. Daarom vragen we u om tijdens het beoordelen van de beweringen hieronder te denken aan andere kinderen die u kent die **even oud zijn als uw kind** en de kwaliteit van de coördinatie van uw kind te vergelijken met die van deze leeftijdsgenootjes. Plaats a.u.b. achter elke bewering een kruisje in de kolom onder de beschrijving die het functioneren van uw kind het beste weergeeft.

	Is helemaal niet van toepassing op mijn kind 1	Is enigszins van toepassing op mijn kind 2	Is redelijk van toepassing op mijn kind 3	Is vrij goed van toepassing op mijn kind 4	Is helemaal van toepassing op mijn kind 5
1. Uw kind is in staat een grote bal naar een ander kind of een volwassene te gooien.					
2. Uw kind vangt een grote bal met beide handen als deze naar het midden van zijn of haar lichaam gegooid wordt van een afstand van 1.5 meter (leeftijd 3 - 4) of 2 meter (leeftijd 4 - 5).					
3. Uw kind schopt een bal, die naar hem/haar wordt toegerold, terug op een wijze die bij zijn/haar leeftijd past.					
4. Uw kind rent even snel en op dezelfde manier als leeftijdsgenoten van hetzelfde geslacht.					
5. Uw kind beweegt zich net zo goed van de ene naar de andere plek en wisselt net zo goed van lichaamspositie als leeftijdsgenootjes (bijv. de trap op en af klimmen, het bed in of uit klimmen, zelfstandig en met gemak in bad klimmen, meedoen met de stoelendans).					

[1] De Little DCD-Q - © Rihtman, T., Parush, S., & Wilson, B.N. - Aangepast door M.M. Schoemaker et al., 2009 – Aangepast door H. Van Waelvelde et al., 2010

	Is helemaal niet van toepassing op mijn kind 1	Is enigszins van toepassing op mijn kind 2	Is redelijk van toepassing op mijn kind 3	Is vrij goed van toepassing op mijn kind 4	Is helemaal van toepassing op mijn kind 5
6. Uw kind drinkt uit een beker zonder te knoeien en op een manier die bij zijn/haar leeftijd past.					
7. Uw kind kan eten met bestek (mes, vork, theelepel) en gebruikt het bestek net zoals andere kinderen van dezelfde leeftijd (kan het voedsel naar zijn/haar mond brengen).					
8. Uw kind houdt schrijfgerei (pen of kleurpotlood) net zo vast als leeftijdsgenoten en kan er mee krassen (leeftijd 3– 4) of eenvoudige lijnen en vormen mee natekenen (leeftijd 4-5).					
9. Uw kind kan grote kralen (leeftijd 3-4) of kleine kralen (leeftijd 4-5) rijgen.					
10. Uw kind kan stickers van een stickervel afhalen en ze op een voorgedrukte plek op een vel papier plakken.					
11. Uw kind is in staat constructiespelletjes uit te voeren op een wijze die bij zijn/haar leeftijd past (puzzels leggen, met LEGO spelen, een blokkentoren bouwen, blok- of LEGO figuren nabouwen).					
12. Uw kind kan de lichaamshouding van anderen imiteren tijdens bewegingsspelletjes of sportactiviteiten (*Klap eens in je handjes, Dirigentje, Schipper mag ik overvaren*).					
13. Uw kind gebruikt speeltoestellen op een wijze die bij zijn/haar leeftijd past (klimt in een klimrek, beklimt en glijdt van een glijbaan).					
14. De wijze waarop uw kind zich beweegt ziet er gecoördineerd uit (uw kind valt niet vaak gedurende de dag en heeft niet de neiging tegen personen en voorwerpen op te lopen).					
15. Wanneer uw kind langere tijd stil moet zitten, blijft het rechtop zitten (het raakt niet snel vermoeid of zakt in elkaar waardoor het lijkt alsof hij/zij uit de stoel valt).					

[1] De Little DCD-Q - © Rihtman, T., Parush, S., & Wilson, B.N. - Aangepast door M.M. Schoemaker et al., 2009 – Aangepast door H. Van Waelvelde et al., 2010

Abstract (lekentaal)

Achtergrond: Development Coordination Disorder (DCD) is een milde neuromotore stoornis die 1,8 tot 6% van de lagere schoolkinderen lijkt te treffen op verschillende vlakken (dagdagelijkse activiteiten, psycho-sociaal, emotioneel, fysieke fitheid). De fijn- en grofmotorische problemen die de kinderen kunnen ondervinden, kunnen opgespoord worden met de L-DCD-Q-Vl, een vragenlijst voor ouders.

Doelstellingen: Deze studie heeft als doel te bepalen of de L-DCD-Q-Vl een geschikt screeningsinstrument is opdat kinderen (3- tot 5-jarigen) met kans op DCD vroegtijdig opgespoord kunnen worden.

Methode: Er werden 305 bruikbare vragenlijsten over kleuters ingevuld door ouders. Uit deze werden vervolgens 90 kinderen random geselecteerd. Deze werden onderzocht met een testbatterij: (1) Movement Assessment Battery for Children-2 Test (M-ABC-2), (2) de Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery-VMI-6), (3) de Vragenlijst voor de Motorisch Vaardigheden van Kleuters (VMVK) en (4) een BMI-meting. Op de resultaten van de testbatterij werden verschillende statistische berekeningen gedaan om de sensitiviteit, specificiteit en percentages van overeenstemming (de validiteit) van de vragenlijst te bepalen.

Resultaten: Zeven kinderen van de totale populatie scoorden op of onder de vooropgestelde grenswaarde van score 49 op de L-DCD-Q-Vl. De vragenlijst kon ook onderverdeeld worden in 3 categorieën (fijne motoriek, grove motoriek en balvaardigheden). Een kleine positieve overeenstemming tussen verschillende tests werd enkel gevonden voor de L-DCD-Q-Vl en de M-ABC-2.

Conclusie: De L-DCD-Q-Vl kan niet aanbevolen worden als ideaal screeningsinstrument voor DCD voor kinderen tussen 3 en 5 jaar.

Etic committee

Afz.: Commissie voor Medische Ethiek

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  -Begeleidende brief voor ouders fase 2, versie 1
  -Begeleidende brief voor ouders fase 2 (incl. informering follow-up), versie 1
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Advies werd gevraagd door:
Prof. dr. H. VAN WAELVELDE ; Hoofdonderzoeker

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETHISCH COMITÉ BEOORDEELD. ER WERD EEN POSITIEF ADVIES GEGEVEN OVER DIT PROTOCOL OP 03/10/2018. INDIEN DE STUDIE NIET WORDT OPGESTART VOOR 03/10/2019, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEDIEND WORDEN.
Vooraleer het onderzoek te starten dient contact te worden genomen met Bimetra Clinics (09/332 05 00).

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE.A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 03/10/2018. IN CASE THIS STUDY IS NOT STARTED BY 03/10/2019, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.
Before initiating the study, please contact Bimetra Clinics (09/332 05 00).

DIT ADVIES WORDT OPGENOMEN IN HET VERSLAG VAN DE VERGADERING VAN HET ETHISCH COMITE VAN 16/10/2018
THIS ADVICE WILL APPEAR IN THE PROCEEDINGS OF THE MEETING OF THE ETHICS COMMITTEE OF 16/10/2018

* *Het Ethisch Comité werkt volgens 'ICH Good Clinical Practice' - regels*

ALGEMENE DIRECTIE
Commissie voor Medische Ethiek

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* *Het Ethisch Comité beklemtoont dat een gunstig advies niet betekent dat het Comité de verantwoordelijkheid voor het onderzoek op zich neemt. Bovendien dient U er over te waken dat Uw mening als betrokken onderzoeker wordt weergegeven in publicaties, rapporten voor de overheid enz., die het resultaat zijn van dit onderzoek.*
* *In het kader van 'Good Clinical Practice' moet de mogelijkheid bestaan dat het farmaceutisch bedrijf en de autoriteiten inzage krijgen van de originele data. In dit verband dienen de onderzoekers erover te waken dat dit gebeurt zonder schending van de privacy van de proefpersonen.*
* *Het Ethisch Comité benadrukt dat het de promotor is die garant dient te staan voor de conformiteit van de anderstalige informatie- en toestemmingsformulieren met de nederlandstalige documenten.*
* *Geen enkele onderzoeker betrokken bij deze studie is lid van het Ethisch Comité.*
* *Alle leden van het Ethisch Comité hebben dit project beoordeeld. (De ledenlijst is bijgevoegd)*
* *The Ethics Committee is organized and operates according to the 'ICH Good Clinical Practice' rules.*
* *The Ethics Committee stresses that approval of a study does not mean that the Committee accepts responsibility for it. Moreover, please keep in mind that your opinion as investigator is presented in the publications, reports to the government, etc., that are a result of this research.*
* *In the framework of 'Good Clinical Practice', the pharmaceutical company and the authorities have the right to inspect the original data. The investigators have to assure that the privacy of the subjects is respected.*
* *The Ethics Committee stresses that it is the responsibility of the promotor to guarantee the conformity of the non-dutch informed consent forms with the dutch documents.*
* *None of the investigators involved in this study is a member of the Ethics Committee.*
* *All members of the Ethics Committee have reviewed this project. (The list of the members is enclosed)*

Namens het Ethisch Comité / On behalf of the Ethics Committee

Prof. dr. D. MATTHYS
Voorzitter / Chairman

CC: De heer T. VERSCHOORE - UZ Gent - Bimetra Clinics
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