Difficulties in motor skills of children at different stages of life
The critical path based upon today’s standards

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Pediatrician and Pediatric Neurologist
Contents

• Diagnostics of Developmental Coordination Disorder (DCD)
• The critical path of reconizing motor difficulties in health care
• Developmental research program of children at risk in HYKS
• Thoughts for the future
Diagnostic classification

- ICD-10 International Statistical Classification of Diseases and Related Health Problems (WHO)
  - Used nation wide in Finnish medical report system
  - F82 Developmental disorder in motor skills

- DSM-5 (American Psychiatric Association, APA)
  - Psychiatrists also use the DSM-5 classification
  - 315.4 Developmental Coordination Disorder

- EACD 2019 DCD recommendation based on the DSM-5 classification
ICD-10: F82 Developmental disorder of motor skills

- The code of diagnosis includes:
  - Developmental dyspraxia
  - Developmental coordination disorder
  - The clumsy child syndrome
  - Mirror movements
Clinical symptom picture

• The developmental disorder in motor skills includes deficiency in the coordination of muscles, which cannot be explained by mental retardation, nor by a neurological disorder. Neither it is due to direct sensory problems (deficiency in sight or hearing).

• There are signs of under developed nervous system; choreatic limb movements, mirror movements (soft signs) and other similar developmental difficulties, as well as deficiency in the adjustment of movements requiring fine- and gross motor skills

• The tendon reflexes can be initiated or subsided but never asymmetrically
Choreatic-, associated- and mirror movements
Examination of child with minor neurological dysfunction
Touwen, 1979; Hadders-Algra, 2010
Clinical depiction

• In anamnesia, there can be perinatal complications like low birth weight or considerable prematurity

• Young children are clumsy or stiff when taking steps and they learn slowly to run, jump and walk the stairs

• Reaching achievable goals late
Clinical depiction

• The symptom picture varies
• The child can be clumsy performing fine and/or gross motor movements, dropping things, stumbling, walking into objects or he/she can have difficulties in writing.
• Drawing skills can also be poor, as well as skills in making puzzles, playing with toys, ball games and understanding maps.
• Also, difficulties in tying shoelaces and in dressing up
Clinical depiction

• In addition, there can be challenges in speech, especially in pronunciation
• Often related with deficiency in completing visuospatial cognitive tasks
• Some of the children might have learning disabilities, which can at times be difficult
• Also social-, emotional-, and behavior disorders do occur
ICD-10:  
F82 Developmental disorder in motor coordination

• **Diagnostic Criteria**

A. In the standardized test, the number of points, taking in consideration the chronological age of the child, is at least 2 SD's below the expected value

B. Interferes considerably with learning and everyday activities

C. No neurological disease is diagnosed

D. IQ is not under 70 in the standardized test
**DSM-5: 315.4 Developmental coordination disorder**

<table>
<thead>
<tr>
<th>A</th>
<th>The acquisition and execution of coordinated motor skills is substantially below that expected given the individual’s chronological age and opportunity for skill learning and use. Difficulties are manifested as clumsiness (e.g., dropping or bumping into objects) as well as slowness and inaccuracy of performance of motor skills (e.g., catching an object, using scissors or cutlery, handwriting, riding a bike, or participating in sports).</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>The motor skills deficit in Criterion A significantly and persistently interferes with activities of daily living appropriate to chronological age (e.g., self-care and self-maintenance) and impacts academic/school productivity, prevocational and vocational activities, leisure, and play.</td>
</tr>
<tr>
<td>C</td>
<td>Onset of symptoms is in the early developmental period.</td>
</tr>
<tr>
<td>D</td>
<td>The motor skills deficits are not better explained by intellectual disability (intellectual developmental disorder) or visual impairment and are not attributable to a neurological condition affecting movement (e.g., cerebral palsy, muscular dystrophy, degenerative disorder).</td>
</tr>
</tbody>
</table>

*DSM-5: Diagnostic and Statistical Manual of Mental Disorders Fifth edition*

doi:10.1371/journal.pone.0140470.t001
How does the DCD affect everyday life?

DCD in ICF context
(International Classification of Functioning, Disability and Health, ICF)

Body structure & function
- Alterations in the brain structures
- Slowness, imprecision and clumsiness fine- and gross motor skills

Performance
- Slow at running and poor at ball games

Participation
- Difficulties in participating with age peers

Environmental factors
- Not chosen to games
- Being bullied

Individual factors
- Disappointed, ’I am a failure/stupid, poor self-esteem
Diagnosing DCD
EACD (European Academy of Childhood Disability) recommendation 2012, 2019

• DCD diagnosis is based on:

  1. **Clinical evaluation**
     • Examination by a physician

  2. Evaluation of performance of daily activities
     • Structured inquiry for parents/nursery school/elementary school

  3. **Testing the skill level of performing motor activities**
     • Standardized test

• Diagnosis can be given after the child is 5 year old

• Some children who have a developmental delay, may reach their peers later on
How is DCD diagnosed?

• **1. Clinical examination**
  • *From Anamnesis* diseases of the family, risks in early development, somatic diseases, medication, neurological symptoms, injuries and other possible developmental issues are investigated
  • *Somatic and neurological examination* (differential diagnosis, exclusion of diseases such as cerebral palsy, muscular disease, periferic disease of the nervous system, sensory impairment, syndromes, musculoskeletal system disease, structure differences, rheumatism, obesity)
  • *Additional examination* Laboratory research (if needed), MRI of the brain, neurophysiological examination, neuropsychologist’s examination
How is DCD diagnosed?

• **2. Evaluation of functional ability in every day life**
  
  Evaluation of independent activity skills, progress at school, handwriting
  
  • Which everyday life motor activities do the difficulties affect,
  
  • At what level do the motor difficulties hinder the child from taking part in activities, games, physical action and hobbies, typical for his/hers age, in and outside of home
  
  • Feedback from kindergarten or school offers information about the skills and development of the child compared to his/hers peers, and of participating in group activities
  
  • Structured questionnaires alongside an interview with the parents
    
    • HYVE_4v, Viivi (5-15v), Observation form for motor abilities
    • DCDQ-R (recommendation of DCD professionals), Little DCDQ
  
  • VIIVI-questionnaire of development and behavior, provides information about concentration, social skills and emotional development, a profile of development and behavior
How is DCD diagnosed?

• **3. Motor testing**
  - DCD-diagnosis requires the use of standardized motor test
  - **Movement-ABC-2-test, MABC-2** (3–16-year old children) (physiotherapist)
  - **Bruininks–Oseretsky-test, BOT-2** (4–21-years old children) measures fine motor coordination as well as strength and agility (occupational therapist)

• **DCD threshold in MABC-2 test <16 percentile (1SD)**
The objective of the critical path in developmental problems

• Clarification of the division of labor in early recognition, diagnosis, treatment, rehabilitation and observation so that the necessary and well timed support is provided in order to support the development of the child and prevent the negative ramifications.

• Based on the needs of children, focus on managing in everyday life

• Division of actions between different professionals (primary health care vs. special care)

• Ensure the knowledge and the skills of the professionals

• Ensure the coherent procedure (criteria for the additional examination and access for care equal to everyone)
How does ‘the care chain’ work in DCD?

• **Primary health care**

• **Concern / Suspicion / Early recognition**
  - Regular health checks at the Child health centre: doctor and a public health nurse
  - Observations at the Childcare (special kindergarten teacher)
  - Medical check-up at the School health service: doctor and a public health nurse.
  - Observations of the teacher and the special education teacher
  - Observations of the parents

• → Instant intervention (guidance for the parents to support the development at home, supportive actions of the child care and school, rearrangements of the operational environment, training)

• →+ consulting the physiotherapist and occupational therapist (evaluation and screening)

• →+ child health centre/school doctor: Identifying the problem → how much and what kind of support is needed: counseling visits, motor-group, individual therapy periods

• The primary health care holds the primarily responsibility of the care
How does the care chain work in DCD?

• ➔ Referral to special health care (Paediatric neurology/Paediatric medicine)

• Diagnostics / Differential diagnosis

• Wide range of difficulties

• Plan for the rehabilitation (multidisciplinary team: doctor, primary nurse, physio-, occupational-, speech therapist, neuropsychologist, social worker)

• Monitoring
Child Welfare Clinic Model
At school age also
Groningen
Motor Observation
MOQ-T-FI for teachers annually
1., 5., 8. class
VANE: Assessment tool for Infant's Neurological Development

• From 6 weeks to 18 months
• Qualitative and quantitative tasks
• Items
  • Interaction skills
  • Play and language development
  • Vision and hearing
  • Perceptual-motor skills (posture, muscle tonus, movements, turning, sitting, walking, graping and griping)
• If there is abnormal development in one area, further assessment is needed, as well as evaluation of support need
LENE: Assessment Tool of Neurological Development of 2.5 to 6 year old children

Vision
Hearing
Gross motor skills
Coordination tests
Exceptional movements
Interaction skills
Attention
Receptive language skills
Language comprehension
Auditory perception
Prereading skills
Eye-hand coordination
Visual perception play
Self care skills

Mustonen et al 2000, SLL
LENE 4 - year old version

• Gross motor
  • Walking
  • Tip-toe walking in line
  • One-leg balance
  • Jumping over rope
  • Throwing and catching the ball

• Exceptional movements

• Eye-hand coordination
  • Copying figures
  • Making a bridge using three blocks
  • Threading beads
  • Cutting, use of scissors
<table>
<thead>
<tr>
<th>LENE 6-year old version</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gross motor skills</strong></td>
</tr>
<tr>
<td>• Walking backwards</td>
</tr>
<tr>
<td>• One leg balance</td>
</tr>
<tr>
<td>• One leg jump</td>
</tr>
<tr>
<td><strong>Eye-hand coordination</strong></td>
</tr>
<tr>
<td>• Copying figures</td>
</tr>
<tr>
<td>• Cutting by using scissors</td>
</tr>
<tr>
<td>• Pencil grip</td>
</tr>
<tr>
<td>• Handedness</td>
</tr>
<tr>
<td><strong>Exceptional movements</strong></td>
</tr>
<tr>
<td><strong>Coordination tests</strong></td>
</tr>
<tr>
<td>• Diadokokinesia</td>
</tr>
<tr>
<td>• Finger-nose –test</td>
</tr>
</tbody>
</table>
Hyve - Estimation of Child’s Motor skills according to Early Childhood educators

- **Motor skills at the age of 4**
- Fundamental movement skills
  - Walking, running, hopping
- Good postural control
- Holds pencil correctly
- Dresses independently
  - E.g., zipper or buttons
- Knows body parts
Hyve - Estimation of child’s Motor skills according to Early Childhood educators

• When should you be worried?
• Manual dexterity and eye-hand coordination are difficult for the child (threading beads, buttoning, drinking from the mug)
• Dual motor tasks are difficult for the child (descending the stairs and carrying and object simultaneously)
• Child stumbles and falls easily
• Child cannot model movements or postures
• Childs jumping is not elastic, supple
Hyve - model: Estimation of child’s self-care skills according to Early Childhood educators

- **At the age of 4 the child independently**
  - Goes to toilet
  - Washes and dries hands
  - Gets dressed
    - (Except shoelaces)
  - Uses cutlery, at least the fork
  - Pours drink
  - Butters bread
Total score of LENE at the age of 4 and 5
Valtonen, Ahonen, Lyytinen 2004, SLL

<table>
<thead>
<tr>
<th>Vision</th>
<th>Normal</th>
<th>Slight delay</th>
<th>Clear delay</th>
<th>Refuses</th>
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<tr>
<td>Hearing</td>
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<td>Slight delay</td>
<td>Clear delay</td>
<td>Refuses</td>
</tr>
<tr>
<td>Gross motor</td>
<td>Normal</td>
<td>Slight delay</td>
<td>Clear delay</td>
<td>Refuses</td>
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<td>Interaction</td>
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<td>Attention</td>
<td>Normal</td>
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<td>Refuses</td>
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<td>Receptive language</td>
<td>Normal</td>
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<td>Refuses</td>
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<td>Comprehension</td>
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<td>Auditory perception</td>
<td>Normal</td>
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<td>Refuses</td>
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<tr>
<td>Eye-hand coordination</td>
<td>Normal</td>
<td>Slight delay</td>
<td>Clear delay</td>
<td>Refuses</td>
</tr>
<tr>
<td>Play</td>
<td>Normal</td>
<td>Slight delay</td>
<td>Clear delay</td>
<td>Refuses</td>
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<td>Self-care skills</td>
<td>Normal</td>
<td>Slight delay</td>
<td>Clear delay</td>
<td>Refuses</td>
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</table>

Taulukko 1. Lene-kokonaisarvio 4-vuotisarkastuksessa (n = 434).

<table>
<thead>
<tr>
<th>Osio (kokonaisarvio)</th>
<th>Normaali kehitys %</th>
<th>Lievää viivästymä %</th>
<th>Selvä viivästymä %</th>
<th>Kielätytystä %</th>
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<tbody>
<tr>
<td>Nääkö</td>
<td>94,4</td>
<td>3,6</td>
<td>0,2</td>
<td>3,8</td>
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<td>Kuulo</td>
<td>98,8</td>
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<td>Karkeamotoriikka</td>
<td>81,5</td>
<td>10,5</td>
<td>8,0</td>
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<tr>
<td>Vuorovaikutus</td>
<td>90,7</td>
<td>8,1</td>
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<td>Tarkkaavaisuus</td>
<td>85,6</td>
<td>13,0</td>
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<td>Puheen tuottaminen</td>
<td>86,5</td>
<td>11,3</td>
<td>2,1</td>
<td>1,9</td>
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<td>2,3</td>
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<td>Kuullun hahmotettainen</td>
<td>91,6</td>
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<td>Silmän ja käden yhteistyö</td>
<td>74,6</td>
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<td>Leikki</td>
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<td>Omatoimisuus</td>
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Taulukko 2. Lene-kokonaisarvio 5-vuotisarkastuksessa (n = 411).

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<thead>
<tr>
<th>Osio (kokonaisarvio)</th>
<th>Normaali kehitys %</th>
<th>Lievää viivästymä %</th>
<th>Selvä viivästymä %</th>
<th>Kielätytystä %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nääkö</td>
<td>92,6</td>
<td>3,9</td>
<td>3,4</td>
<td>0,3</td>
</tr>
<tr>
<td>Kuulo</td>
<td>92,5</td>
<td>7,3</td>
<td>0,3</td>
<td>2,0</td>
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<tr>
<td>Karkeamotoriikka</td>
<td>70,6</td>
<td>14,6</td>
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<td>1,5</td>
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<td>Koordinatiokoe</td>
<td>86,0</td>
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<td>Tarkkaavaisuus</td>
<td>84,7</td>
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<td>Puheen ja kielen valmiudet</td>
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<td>1,9</td>
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<tr>
<td>Lumiikko-testi</td>
<td>Normal</td>
<td>Slight delay</td>
<td>Clear delay</td>
<td>Refuses</td>
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<tr>
<td>Visualinen hahmotettainen</td>
<td>82,2</td>
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<tr>
<td>Silmän ja käden yhteistyö</td>
<td>71,9</td>
<td>16,6</td>
<td>11,5</td>
<td>0,0</td>
</tr>
</tbody>
</table>

Vision
Hearing
Gross motor
Coordination
Attention
Speech and language readiness
Visual perception
Eye-hand coordination
F82 diagnoses at Helsinki University Hospital (HYKS)
Child Neurology in 2018

- **Children/youth under 15 yrs. in 2018** (National Statistics Service)
  - Helsinki, Espoo, Vantaa, Kirkkonummi, Kauniainen
  - <7 yrs  n= 93000
  - 7-14 yrs  n=104000

- **DCD<5 percentile (1.8%) presumption  7-14 yrs  n=1900**

- At HYKS Child Neurology (ULS, Jorvi, Peijas) main diagnose F82  in 2018
  - <7 yrs  n=131  (0.1% of all)
  - 7-14 yrs  n=114  (0.1% of all / 6% of presumption)
Evaluating the treatment protocol from the viewpoint of motor difficulties

• **Strengths**
  
  • Good basic structure (possibilities for observation in different settings, co-operation between home, daycare and healthcare, frequent contact with maternity clinic/children’s healthcare, structured assessment)
  
  • Expert professionals in an active role

• **Weaknesses**
  
  • “High threshold of intervening /sending with indication to difficulties in gross motor skills”, after reaching independent walking
  
  • Knowledge of DCD is inadequate
  
  • Motor difficulties are secondary, when there are other developmental problems (e.g. language disorder)
  
  • School-aged children are dropouts in healthcare, if no other problems
  
  • Physiotherapy / functional therapy resources inadequate
  
  • Use of diagnostic indicators is random
  
  • Inequality even within municipalities
Follow-up program of the development of children at risk, in the HYKS Children’s Hospital

- Newborn prematurity intensive care unit developmental follow up clinic
  - 3 m, 6 m, (9 m), 12 m →
  - neonatologist, child neurologist, physiotherapist (joint reception)
  - speech therapist, functional therapist, when needed
  - rehabilitation professional, social worker, dietician
  - ophthalmologist

- Child neurology reception
  - (18m), 24m (adjusted age), 3-4yrs, 5-6yrs
  - School-aged; if learning difficulties are observed, reading remediation or neuropsychological rehabilitation is considered
  - Child neurologist
  - Physiotherapy, speech therapy, functional therapy, neuropsychologist, social worker, when needed
Follow-up program of the development of children at risk

Measures

- Newborn prematurity intensive care unit developmental follow up clinic
- 3m, 6m, (9m), 12m → 
- Griffiths
- Hammersmith Infant Neuro (HINE)
- Alberta Infant Motor scale (AIMS)
- Sensory Profile (SP)-questionnaire

- Child neurology clinic
- (18m), 24m (adjusted), 3-4yrs, 5-6yrs
- Griffiths (2yrs)
- Hempel, Touwen neuro
- MABC2 (5-6yrs)
- WPPSI-R, NEPSY (5-6yrs)
- SP, MCDI (Early communication and language development), Viivi (5-15)-questionnaires
Important to observe / intervene during the first year

• At 3 months the control of intermediate position of head and body, symmetry of movements
  - social interaction, gaze, observing, reaching
Important to observe / intervene during the first year

- Sitting position—eye-hand coordination, play
Important to observe / intervene during the first year

• Transitions between stances, moving
Important to observe / intervene during the first year

- Pincer grasp, specificity of fine motor skills
  - fine motor skills, dexterity, pencil skills
Premature nervous system development cohort (Kekeke) (under 28 rweeks)

- Prematurely born in 2006-2008 (EPT), N=78/85 survived intensive care during newborn period
- 6-7 year follow-up study
  - N= 68 prematurely born children (EPT)
  - N= 36 control group (FT)

<table>
<thead>
<tr>
<th></th>
<th>EPT</th>
<th>FT (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuro (Touwen)</td>
<td>CP</td>
<td>8.8%</td>
</tr>
<tr>
<td>EPT n=68</td>
<td>MNDc</td>
<td>22.1%</td>
</tr>
<tr>
<td></td>
<td>MNDs</td>
<td>36.8%</td>
</tr>
<tr>
<td>MABC2</td>
<td>&lt;5 percentile</td>
<td>7.5%</td>
</tr>
<tr>
<td>EPT n=53</td>
<td>5-15 percentile</td>
<td>13.2%</td>
</tr>
</tbody>
</table>
Child Welfare Clinic Model
A delay in developmental milestones is a late manifestation of abnormal motor function!

Observing qualitative abnormalities in motor function is always possible even before recognizing a delay in motor development!
Motor skills are a ground stone of an individual's development, on which an understanding of the surrounding physical and social world is built.

→ cascade influence to perception, social and motor skills

( Libertus & Hauf 2017 )
Lastenneuvolakäynnit Espoossa

Child Welfare Clinic Model
Summary

• Motor development is the basis of all other development domains
• When perceiving motor difficulties, intervention should be immediate and early
• In our healthcare, there are well functioning structures and expert professionals for recognizing motor difficulties
• Knowledge on the developmental coordination disorder and its meaning for a child’s everyday life is inadequate
• DCD-diagnose is not commonly used in our country