


Emma Childrens Hospital
Amsterdam UMC

Neuroscience @ KNVB

The sport-related concussion clinic

Dr. Marsh Königs, [@marshkoning](#)
Emma Neuroscience Group, Emma Children's Hospital, Amsterdam UMC, University of Amsterdam



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Bio

Dr. Marsh Königs

Tenure Track Traumatic Brain Injury

- Amsterdam UMC, Emma Children's Hospital

Embedded Scientist: Concussion Management

- Royal Dutch Soccer Association (KNVB)
- AFC Ajax Amsterdam

Scientific Director

- Daan Theeuwes Center for Intensive Neurorehabilitation








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Neuroscience @ KNVB



Concussion Management Heading Concussion Clinic

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Concussion Management




KNVB national teams

- Pre-tournament baseline testing
- Neurocognitive screening after concussion
- Advice to optimize recovery
- Gradual return to play
- Talent identification?

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Heading




- Societal attention for potential negative effects
- US ban on heading for youth
- UK heading guidelines

NRC (2021, 2022)
MLS (2015)
FA (2020-2022)

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Heading



Scottish professional players; increased risk of neurodegenerative disease at death
- Especially for defenders


Mackay et al. (2019) NEJM
Russell et al. (2021) JAMA Neurol

- Relation with heading not investigated
- Lower risk of cardiovascular disease
- Higher age at death

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Heading



Effects of heading on postural control, electrophysiological and cognitive functioning

- N = 19, 20 rotational headers in 10 minutes @ 38 km/h

Di Virgilio et al. (2016) *EbioMedicine*

Ecological validity?

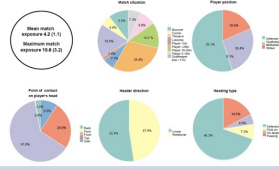
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Heading

Heading Exposure in Elite Football (Soccer): A Study in Adolescent, Young Adult and Adult Male and Female Players

- Development of video registration tool with comprehensive context recording
- Heading registration in 116 full matches of KNVB teams
 - U15 up to AXI
 - Male and female



Langdon, Goedhart, Oosterlaan, Königs, (In press), *Medicine & Science in Sport & Exercise*

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Sport-related Concussion Clinic



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Background

- 54-60 million individuals sustain traumatic brain injury (TBI) each year¹
- 90% concerns mild TBI, or concussion²
- Significant contribution from sports (45% in children)³
- ~10% of cases has persisting symptoms⁴



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1 Flegal et al. (2015) *The Lancet Neurology*,
2 Cunningham (2015) *CDC Prevention*,
3 Sporeman (2015) *Monthly Monthly Weekly Report*
4 Oosterlaan et al. (2015) *Journal of Neurotrauma*

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Royal Dutch Football Association's Concussion Clinic

Sports Medical Center, FIFA Medical Center of Excellence

Chief Medical Officer, Edwin Goedhart





Shari Langdon, PhD Candidate

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KNVB Concussion Clinic - Journey

Clinimetrics

- Sensitive, objective and continuous measures
- Structured in time and content
- Routine Outcome Monitoring

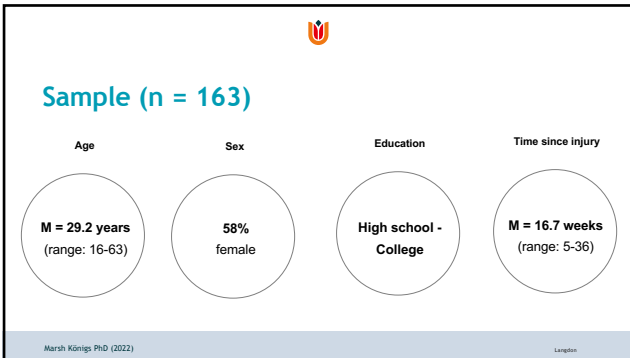
Assessments

- Pre-intake
- Intake
- Follow-up at 6-weeks
- ...
- Discharge

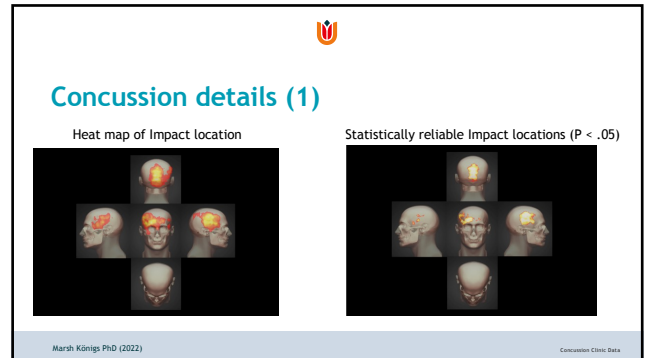


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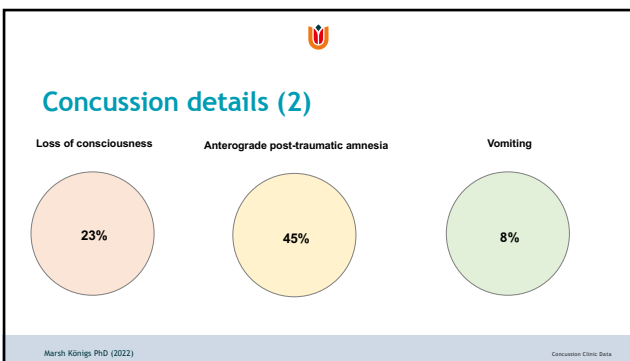
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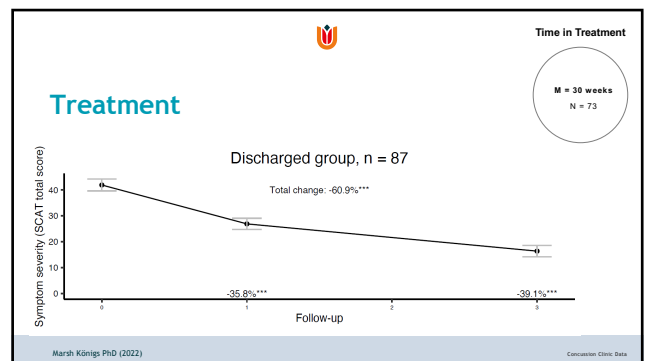
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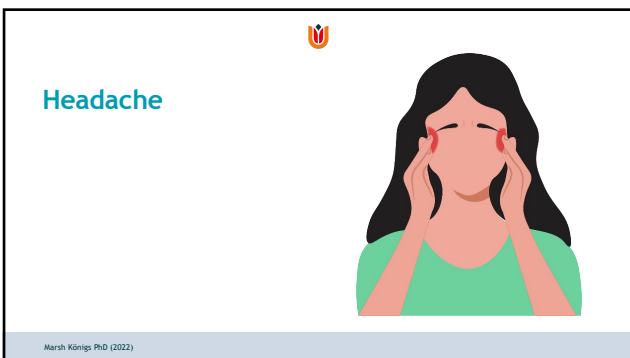
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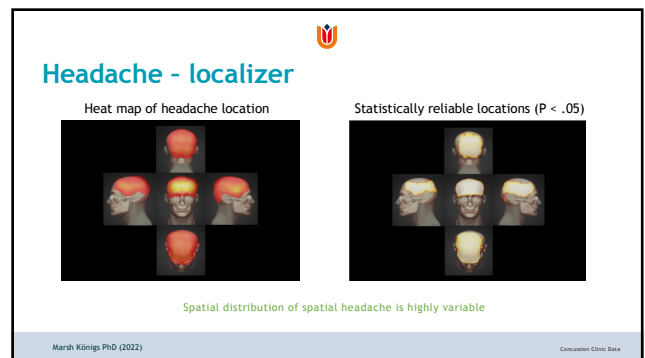
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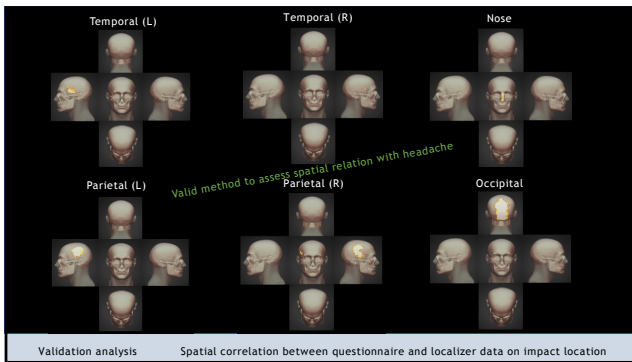
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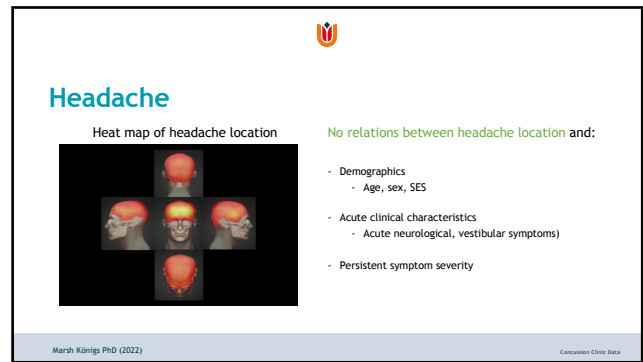
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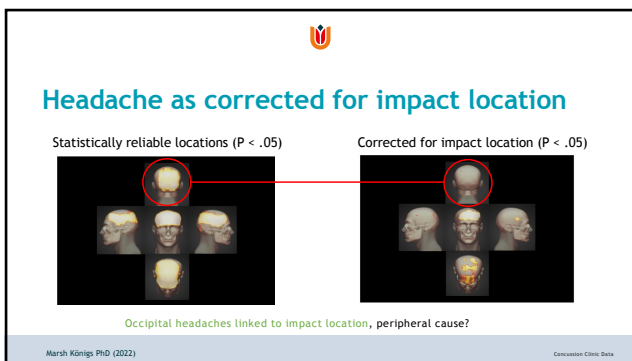
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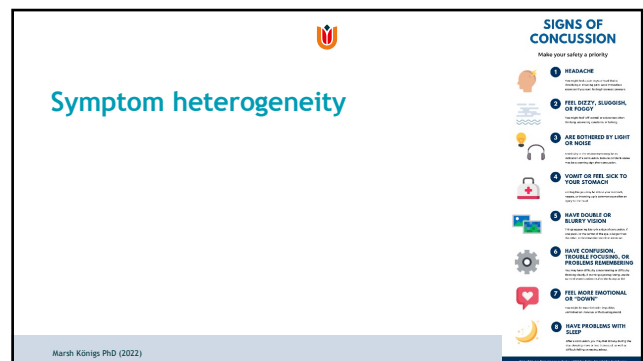
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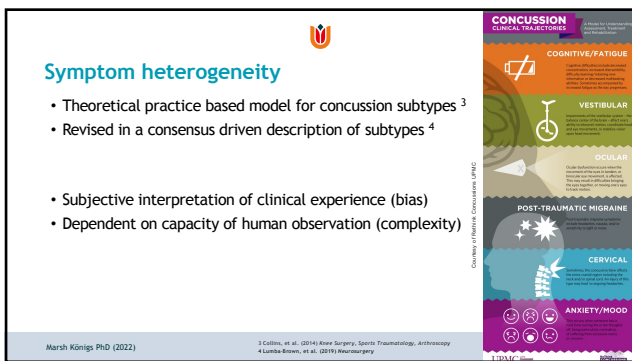
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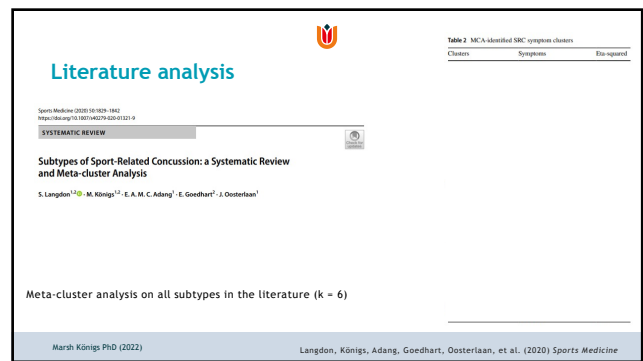
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Literature analysis

k = 19 studies found evidence for relations between symptom subtypes and clinical outcome

Clusters reported in the literature mapped to

- migraine subtype 24%
- sleep-emotional subtype 21%
- cognitive-emotional subtype 19%
- neurological subtype 2%
- undefined feelings subtype 0%

Strongest relations were found between migraine subtype and clinical outcome

- Prolonged recovery duration k = 4
- Cognitive and balance deficits k = 1
- Neuroimaging parameters k = 1
- Greater symptom severity k = 1
- Heart rate recordings k = 1

No studies on persistent symptom subtypes

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Persisting symptom subtypes

STEP 2: SYMPTOM EVALUATION

Please Check: Baseline Post-Injury

Please hand the form to the athlete

	None	Mild	Moderate	Severe			
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Spin headlight"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Cold/flu	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6

Principal Component Analysis of SCAT-5 Symptom Scale
Varimax rotation, extraction 6 subtypes, R² = 85%

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Symptom subtypes

Persistent symptoms cluster in 6 subtypes

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Symptom subgroups

Data partitioning based on Manhattan distance

Extraction of 4 symptom subgroups

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Symptom subgroups

Dominance
Contribution of subtype symptoms severity

* P < .05, ** P < .01, *** P < .001

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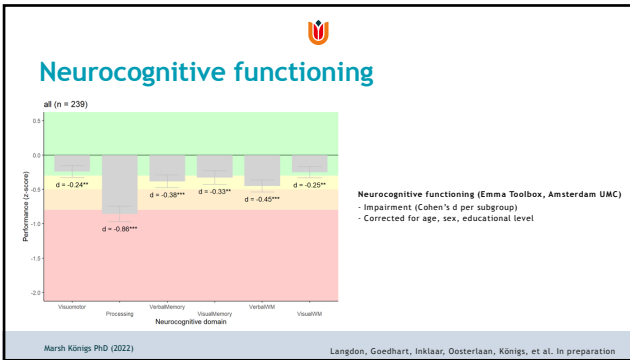
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SRC patient subgroups

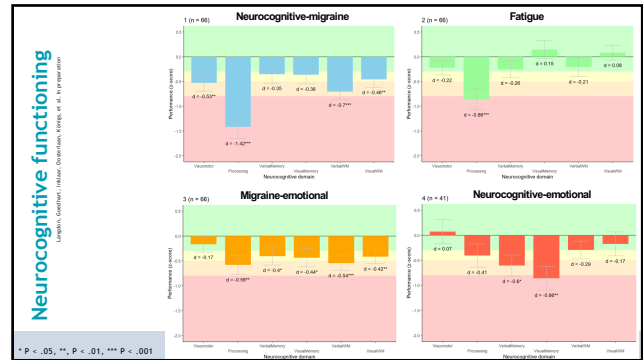
Figure 3. Overview of significant group differences between SRC patient subgroups on pre-injury characteristics, personality characteristics, SRC characteristics and symptom severity. Note: Color coding refers to severe (i.e. red) or better (i.e. green) socio-economic status, LOC = Loss of consciousness, SCAT = Sport Concussion Assessment Tool 5, SES = socio-economic status, SIPP-SF = Severity Index of Personality Problems Short Form.

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Conclusions Headache

Spatial distribution of headache is highly variable

- > No relations with demographics, clinical parameters or persistent symptoms
- > Occipital headaches linked to impact location; peripheral cause?

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Conclusions Literature

Concussion symptoms cluster into symptom subtypes

- > Meta analytic evidence for at least five subtypes
 - Migraine, sleep-emotional and cognitive-emotional most prevalent in literature
- > Relevance for functional outcome
 - Especially the migraine subtype

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Conclusions Persistent symptoms

- > Persistent symptoms after concussion cluster in subtypes
- > Patients cluster in symptom subgroups based on symptom subtype profiles
- > Symptom subgroups differentiate on
 - Demographic, clinical parameters, personality structure > predisposition
 - Symptom severity > prognosis
 - Type of neurocognitive impairment > underlying mechanism?

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General conclusions

- > Concussion subgroups have clinical relevance regarding
 - > Personalizing Prognosis
- > Indicates potential need to personalize treatment

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Future directions

➤ Personalizing the prognosis of sport-related concussion recovery using machine learning



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Future directions

➤ Neurochemical changes during natural heading exposure




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Project team




Edwin Goedhart




Melanie Inklaar



Marsh Königs




Shari Langdon



Jaap Oosterlaan

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Persisting Symptoms of Sport-Related Concussion

Clinical relevance of a data-driven approach

Dr. Marsh Königs, <https://www.uva.nl/en/research/research-teams-and-institutes/emmaneuroscience>
Emma Neuroscience Group, Emma Children's Hospital, Amsterdam UMC, University of Amsterdam



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