
Heading, Brain Health & Heart Rate Variability

Studying Football Heading in Finnish Top-Level Female Players

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Faculty of Sport and Health Sciences · University of Jyväskylä · Spring 2026

Master's Thesis Seminar

Heading: A Routine with Unknown Consequences

- Football is a unique sport → players deliberately use their heads to play the ball
- Repeated sub-concussive head impacts from heading are increasingly linked to long-term brain health risks and raise long-term health concerns (cognitive, neurological)
- Each header delivers a measurable force to the brain — even without concussion symptoms
- Effects accumulate: training sessions add thousands of impacts over a career
- Effect on the autonomic nervous system (ANS) — the body's stress-recovery regulator — is largely unknown
- No study has examined training-related heading and HRV in adult elite female players

~10–30

headers per training session (typical)

1000s

of headers over a career at elite level

3

existing studies on heading & HRV globally

0

studies in adult elite female players

RESEARCH QUESTION

Is training-related repeated heading associated with changes in HRV?

Can HRV serve as a non-invasive window into heading's effects on the brain?

- Does heading count (frequency) matter?
- Does impact intensity (peak acceleration = g-force) matter?
- Do cumulative impacts across a session/sessions matter?



What is HRV — and Why Does It Matter?

The variation in time between consecutive heartbeats

- Reflects how well the autonomic nervous system balances stress and recovery
- Higher HRV = better recovery, lower fatigue
- Lower HRV = high training load, fatigue, illness or stress
- Used by elite clubs via Firstbeat, Polar, etc.

HIGH HRV

Well recovered · Ready to train hard
Autonomic nervous system in balance

LOW HRV

Under-recovered · High fatigue
More rest or reduced load needed

HRV as a Window into Brain Health

The brain controls the heart via the autonomic nervous system

- The brainstem and cortex regulate heart rhythm through the vagus nerve
- Head impacts that disrupt brain function can therefore alter heart rate variability
- After concussion, HRV changes are well documented (Blake et al. 2016 systematic review)
- The question: do repeated sub-concussive heading impacts produce the same signal at a smaller scale?

BRAIN IMPACT

Heading → sub-concussive
brain impact → potential
neurophysiological disruption



HRV SIGNAL

Disrupted ANS regulation
→ detectable change
in lnRMSSD / SDNN

How We Studied It

Study Design

- 35 players · 3 Finnish premier league teams (Kansallinen Liiga)
- 2-week monitoring blocks · up to 7 training sessions per block
- Data collected: June–August & September–October 2025
- Part of SUCCESS project — Universities of Jyväskylä & Helsinki

Head impacts

ACT Head Impact Tracker + video analysis per session

Training load

Firstbeat (session intensity covariate)

Post-session HRV

3-min Firstbeat recording immediately after training

Morning HRV

3-min recording next morning (next-day brain state)

No Detectable Neurophysiological Signal from Heading — At These Volumes

None of the heading exposure metrics (count, peak acceleration, or cumulative g-load) produced a statistically significant HRV change, at either post-session or next-morning timepoint.

Heading metric	Post-session HRV (lnRMSSD)	Morning HRV (lnRMSSD)	Interpretation
Heading count (per session)	$p = 0.27$	$p = 0.77$	<i>No ANS disruption detected</i>
Mean peak acceleration (g)	$p = 0.90$	$p = 0.27$	<i>No ANS disruption detected</i>
Cumulative g-load	$p = 0.20$	$p = 0.98$	<i>No ANS disruption detected</i>

Preliminary data: 2 of 3 teams · n = 17 players · Full dataset (3rd team) pending

- Consistent across all sensitivity analyses → robust null finding within this sample
- Effect sizes negligible: ≈ 1% change in RMSSD per additional header

What IS Driving the HRV Signal?

Training Load

Strongly suppressed post-session lnRMSSD
 $p < 0.001$ across all models

- Overall training stress — not head impact specifically — drives the HRV response
- Effect resolved fully by next morning, suggesting adequate overnight recovery
- HRV is sensitive to physiological load but not yet separating out the heading signal

Accumulation Across the Block

Post-session HRV declined progressively across sessions ($p = 0.002$)

- ~0.12 lnRMSSD drop per session — cumulative stress signature
- Morning HRV stable — brain-heart axis recovers well overnight in this sample
- Raises questions about longer training blocks with higher heading volumes

HRV detects the physiological load of training. The heading-specific neurophysiological signal, if it exists, is not yet separable from overall training stress at these volumes.

What Does This Mean for Football Organisations?

For clubs & performance teams

HRV monitoring captures training stress reliably. If heading were disrupting the autonomic nervous system, this methodology would be positioned to detect it.

Brain health monitoring in practice

This study shows HRV-based brain health screening during training is feasible at club level, without sending players to a lab. A scalable approach for ongoing monitoring.

On heading guidelines

National associations have moved to restrict heading in youth football. For adult elite women, the data are still sparse. This study contributes to that evidence base.

Important caveat

Null finding \neq no risk. These are training volumes over two weeks. Career-level cumulative exposure, or higher-intensity heading in matches, may produce different results.

Study Status and What Comes Next

PRELIMINARY | These results are based on 2 of 3 teams (n = 17 players). Full dataset including the 3rd team is pending.

Current limitations

- 17 players — underpowered to detect small neurophysiological effects
- 3-min HRV recordings are short; head impact effects may need longer windows
- Two different training load instruments across teams (Firstbeat vs Polar)
- Only training heading captured, not match heading
- Observational: no causal inference

Next steps

- Add 3rd team data → 31 players total
- Re-run full analysis
- Consider additional biomarkers alongside HRV for brain health screening

What this study tells us — so far

1

HRV is a feasible tool for tracking heading-related brain health effects

The methodology works in real training environments. If heading disrupts the autonomic nervous system, this approach is positioned to detect it.

2

At training volumes studied here, no neurophysiological HRV signal was detected

Heading count, intensity, and cumulative load showed no significant association with HRV — but sample size limits what we can rule out.

3

Training load — not heading — is the dominant driver of HRV

Session intensity suppresses post-session HRV acutely; this resolves overnight. The brain-heart axis recovers well in this sample.

4

The question remains open — and important

With 31 players and the full dataset, we will be better placed to detect small neurophysiological effects. This is a field that needs research.