ISRCTN14521276 https://doi.org/10.1186/ISRCTN14521276

Effects of breathing on brain, body and their coupling in elite adolescent ice hockey players

Submission date 18/06/2026	**Recruitment status** Recruiting	[ ] Prospectively registered [ ] Protocol [ ] Statistical analysis plan [ ] Results [ ] Individual participant data [X] Record updated in last year
Registration date 24/06/2026	**Overall study status** Ongoing	
Last Edited 22/06/2026	**Condition category** Other	

Plain English summary of protocol

Background and study aims

There is a lack of evidence in current research literature containing acute effects of breathing on neurophysiological mechanisms, especially on elite level athletes. Also, this study builds a neurophysiological foundation to more comprehensively understand the synchronization of brain – body connection for deeper research of human performance in the future.

The purpose of this study is to investigate the effects of controlled breathing on brain activity, autonomic function, and their coupling in ice hockey players. The study aims to identify neurophysiological mechanisms how breathing phases are coupled with brain activity in different brain regions, especially alpha power (8-12 Hz) & beta (12-30 Hz) and how breathing may enhance subjective emotional regulation, attentional balance, and physiological recovery.

Who can participate?

35 healthy male volunteers aged 15–20 years will be recruited for the study. All participants will be elite junior ice hockey players competing at the highest/ second highest national level in Finland. All participants will receive standardized information about the study.

What does the study involve?

Each participant will complete two experimental conditions during a single session: normal spontaneous breathing and a guided slow breathing condition. The order of conditions will be randomized to control for sequence effects. Guided breathing will be self-paced and characterized by a longer exhalation than inhalation, without external pacing (e.g. metronome), to enhance ecological validity and preserve natural breathing patterns. Both conditions will be performed in the same seated posture with eyes open. Participants will sit approximately 2.5 meters from a wall-mounted fixation cross to control visual input. Total duration of study is 1,5h.

What are the possible benefits and risks of participating?

Very low to no risk of irritation with use of electrode gel. There will be no direct benefit to participants as the devices will not be used diagnostically.

Where is the study run from?
All measurements will be conducted at Xamk's Active Life Lab and Vierumäki Sport Institute (Finland).

When is the study starting and how long is it expecting to run for?
May 2026 to December 2026.

Who is funding the study?
Study is funded by South Eastern University of Applied Sciences (XAMK) (Finland).

Who is the main contact?
Jaakko Heikkilä, jaakko.heikkila@xamk.fi

Contact information

Type(s)
Public, Scientific, Principal investigator

Contact name
Mr Jaakko Heikkilä

ORCID ID
https://orcid.org/0009-0001-6480-2083

Contact details
Raviradantie 22
Mikkeli
Finland
50100
+358 504755926
jaakko.heikkila@xamk.fi

Additional identifiers

Study information

Scientific Title
Effects of breathing on brain, body and their coupling in elite adolescent ice hockey players

Study objectives
The purpose of this study is to investigate the effects of controlled breathing on brain activity, autonomic function, and their coupling in ice hockey players. The study aims to identify neurophysiological mechanisms how breathing phases are coupled with brain activity in different brain regions, especially alpha power (8-12 Hz) & beta (12-30 Hz) and how breathing may enhance subjective emotional regulation, attentional balance, and physiological recovery.

Ethics approval required
Ethics approval required

Ethics approval(s)

Approved 10/04/2026, Ethics board of South Eastern University of Applied Sciences (Patteristonkatu 3D, Mikkeli, 50100, Finland; +358 405469262; johanna.hirvonen@xamk.fi), ref: 2 /2026

Primary study design
Interventional

Allocation
Randomized controlled trial

Masking
Open (masking not used)

Control
Active

Assignment
Crossover

Purpose
Basic science

Study type(s)

Health condition(s) or problem(s) studied
Effects of deep breathing on brain activity, autonomic nervous system function, affective wellbeing, and brain–body coupling in healthy adolescents.

Interventions
Methodically this study will use EEG-measurements for brain signal oscillations (frontal, central, parietal, occipital), ECG for measuring cardiac signal, heart rate variability (HRV) and breathing will be monitored by piezoelectric respiration belt. All equipment will be connected to Enobio 20ch EEG device and analyses conducted in Python (Jyputer notebook, MNE)

Within design study, participants will have two consecutive nose breathing conditions (natural vs. deep) in computer randomized order with washout period (2min) between conditions. Both condition phases include 3min stabilization phase, 5min intervention and 5min follow-up phase (total 13min). State questionnaires (Warr, VAS) after both conditions, trait questionnaires (backround, IPIP-20, MAIA-2) before, after and during washout.

Respiration phase-dependent modulation of EEG alpha power (8–12 Hz) will be quantified using the modulation index (MI). This will be complemented by respiration-specific metrics (e.g., peak-to-trough difference, phase-binned alpha power) and integrated with cardiac variables (HR, RMSSD, HF, LF, SDNN) to characterize brain–body coupling.

Intervention Type
Behavioural

Primary outcome(s)

1. EEG alpha power (8–12 Hz) and the strength of brain–autonomic coupling between alpha power and autonomic responses (respiratory rate and HRV) measured using EEG, ECG, respiration belt at natural and deep breathing conditions (480 seconds)

Key secondary outcome(s)
1. Cardiac variables (HR, RMSSD, HF, LF, SDNN) measured using ECG at natural and deep breathing conditions (480 seconds)

2. Self-perceived mood, stress, attention, alertness, focus, interoception and personality trait measured using questionnaires (WARR scale 0-10, IPIP-20 scale 1-5, MAIA-2 scale 0-5, VAS scale 0-10) at before and/or after conditions

3. Beta activity (12-30 Hz) across all four brain regions (frontal, central, parietal, occipital) measured using EEG at natural and deep breathing conditions (480 seconds)

Completion date
31/12/2026

Eligibility

Key inclusion criteria
1. Healthy volunteer
2. Male or female
3. Adolescent 15-20 years old
4. Elite ice hockey players (highest or second highest junior league in Finland)

Healthy volunteers allowed
Yes

Age group
Mixed

Lower age limit
15 Years

Upper age limit
20 Years

Sex
All

Total final enrolment
0

Key exclusion criteria
1. Chronical arrhythmia or user of medicines that will affect on heart rate (diabetes care containing insulin, thyroxine, psychotropic drugs, tricyclic antidepressants, clozapine)
2. Participants will be informed to reduce caffeine and nicotine intake 3h, intensive sports 12h and alcohol 24h before measurement
3. Participants which don’t understand clearly Finnish or English will be excluded from the study

Date of first enrolment
05/05/2026

Date of final enrolment
31/08/2026

Locations

Countries of recruitment
Finland

Study participating centre
Mikkeli
Raviradantie 22
Mikkeli
Finland
50100

Study participating centre
Vierumäki Sport Institute
Pihkalantie 3
Vierumäki
Finland
19120

Sponsor information

Organisation
South Eastern Finland University of Applied Sciences

ROR
https://ror.org/051v6v138

Organisation
University of Chieti-Pescara

ROR
https://ror.org/00qjgza05

Funder(s)

Funder type

Funder Name
South-Eastern University of Applied Sciences

Results and Publications

Individual participant data (IPD) sharing plan

IPD sharing plan summary
Not expected to be made available

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Participant information sheet	in Finnish		22/06/2026	No	Yes