Effects of postural changes on airway resistance and pulmonary diffusing capacity in gymnasts: an exploratory study

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# Abstract

Background

Methods

*Inclusion:* 12 healthy gymnasts aged 18-40 years

*Exclusion:*Any known heart or lung disease

*Design:* Exploratory, randomised cross-over study

*Intervention*: Over the course of two study days, airway resistance and pulmonary diffusing capacity will be measured in following postures: upright standing, handstand, supine, and prone.

Sample size: 12

*Statistical design*: Linear mixed effect model and pairwise testing of estimated marginal means.

**Regulatory considerations:** This study will be sent for approval to the Regional Ethical Committee (file no. H-XXXXXX).

Perspective:

# Introduction and background

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# Aim

To exploratively determine whether and how lung function is affected by changes in the direction gavitational vector relative to the lung by means of extreme postural.

# Methods

## 

## Study design and recruitment

### Overall design

Airway resistance and pulmonary diffusing capacity will be measured in 12 gymnasts in four postures (two per study day) in a randomised order: upright standing, handstand, supine, and prone.

On Visit 0, a medical health interview and examination (including auscultation and blood pressure measurement) will be performed. After this, the individual participant will draw four notes (with upright, handstand, supine, and prone written on hem) to determine the sequence of postural changes. To ensure that the first measurements are not obtained during handstand, the handstand note will be added after the first note has been drawn.

On Visit 1, measurements will be obtained in the first two postures. IOS will be performed first, followed by two to three diffusion capacity manoeuvres. All measurements will be performed after 1 minute in the given posture, and with a four minute break between each measurement where the participant is placed in the sitting position. There will be an approx. 1-hour break between the first and second posture.

On Visit 2, measurements will be obtained in the last two postures, following the same procedure as on Visit 1.

## Eligibility criteria

### Inclusion criteria

* Active gymnasts that can perform a 2-minute handstand against a wall
* Men and women
* 18-40 years

### Exclusion criteria

* Symptoms of disease within 2 weeks prior to the study
* Pregnancy

## Outcomes

Between posture differences in DL,CO, and IOS-based resistance (Rrs, R5-R20) and reactance (Xrs, X5)

### Primary outcome:

DL,CO

### Secondary outcome:

IOS-based resistance (Rrs, R5-R20)

### Exploratory outcomes

reactance (Xrs, X5)

## Experimental procedures

### Recruitment and collection of ethical approval

Participants will be recruited from the ODK Gymnastics Union and ODK Gymnastics Union in Copenhagen and Frederiksberg. We will obtain name, e-mail, and phone number from interested gymnasts. If the inclusion criteria are fulfilled, written information about the project will be forwarded, and a meeting will be set up where the potential participant is informed in detail about the study. Given that the potentia participant provides both oral and written informed consent (within three days), a premedical exam including a medical health interview and examination (blood pressure, heart rate, pulmonary and cardiac auscultation) by one of the study physicians (Visit 0, 30 minutes). If the patient is deemed eligible, the following Visits 1 and 2 (each lasting 2 hours) are booked. If the participant wishes and if logistically possible, the medical interview and examination can take place on the same day as the informed consent is provided. No information is obtained from the participant’s health record.

### Lung function testing

IOS permits the passive measurement of lung mechanics, as sound waves are superimposed on normal tidal breathing, and the disturbances in flow and pressure caused by the external waves are used to calculate parameters describing the resistance to airflow and reactive parameters that mostly relate to efficient storage and return of energy by the lung. It requires minimal participant cooperation. An impulse consisting of a mixture of sound waves of different frequencies is generated by the loudspeaker at the mouth. As this wave passes into the lungs, it causes changes in pressure as well as in the flow of air. The frequencies of the waves delivered in IOS ranges from 5 to 30 Hz, which causes no discomfort. A pressure transducer and a pneumo-chromatograph are present at the mouthpiece, to measure the pressure and flow, respectively. The patient breathes normally, and the measurement takes 20-30 seconds. Pulmonary diffusing capacity is measured by a portable handheld device and is performed in accordance with consensus guidelines (1–3). Up to three maneuvcres are perfomred per posture, each of which takes approx. 30 seconds.

### Other measurements

Heart rate, non-invasive blood pressure, as well as pulse oximetric arterial oxygen saturation is alos measured in each posture.

## Biological material and biobank

No biological material is obtained in the present study.

## Sample size

The effect size is unknown, and a sample size of 12 is pragmatically chosen as based on current recommendations for pilot and exploratory studies (4), such that the reported means and standard deviations may inform future hypothesis-testing studies.

## Statistical procedure

Statistical analysis will be done in an updated version of RStudio(5), using the LMMstar package(6). The statistical code for the analysis will be publicly available on Github (<https://github.com/Malte-Lund/LungPosture>).

Analysis of the effect of posture on the outcome will be performed using a linear mixed model using an unstructured covariance pattern to account for repeated measures in the same subject. Sex (assigned at birth, male or female), height (numerical), age (numerical), order (categorical 1 to 4), posture (categorical: upright, handstand, supine, prone) and the interaction between order and posture will be included as fixed effects. Missing data will be handled implicitly by maximum likelihood estimation in the linear mixed model.

Models will be assessed for goodness of fit graphically by assessing the qq-plot and the residual vs. predicted values.

## Multiple testing and significance

The primary end point (DL,CO)will not be adjusted for multiplicity testing. All secondary and exploratory outcomes will be adjusted by false discovery rate(FDR) in the method developed by Benjamini and Hochberg(7). Adjusted p-values less than 0.05 will be considered statistically significant.

# Ethical considerations

## General information

This study is novel as provides mecahnistic insoights into the factors that may impair pulmonary gas exchange in different postures; this is noot only relevant for gymansts that are interested in understanding how different postures affect theiur breathing, but also in the clinical setting where different postures, such as pronng, are often introduced to improve pulmonary gas exchange. This study will be conducted in accordance with the regional ethical committee and the Declaration of Helsinki. Informed consent will be obtained from all study participants before enrolment.

## Dissemination

The results of the study, whether positive, negative, or inconclusive, will be published. The manuscript will then be submitted to peer reviewed scientific journals. Authorships will be assigned according to the Vancouver rules as determined by the PI Ronan M. G. Berg.

## Radiation exposure

None.

## Risks of adverse events during the study

The risk of discomfort or dizziness during the different postures and measurements is minimal; it must be noted that the included population are well ackuanted with all these postures. There are no risks associated with the different lung function tests.

## Reporting of adverse events during the study

There are no anticipated adverse events associated with enrolment in the study. However, in the unlikely event an adverse event does occur, all adverse events (AEs) will be recorded on adverse event form (Appendix A). These forms will include a description and classification of the event, date of onset, date resolved, whether the event was serious or not (ICH criteria), relationship of the event to the study (1=none, 2=unlikely, 3=possible, 4=probable, 5=definitely), action taken, and whether the study was suspended or not. All serious adverse events (SAEs), regardless of causation, will be reported to the Regional Ethical Committee of Copenhagen.

## Ensuring integrity and privacy of the participant

The study falls under the Danish Data Protection Decree (‘Databeskyttelsesforordningen’) and the Danish Data Protection Law (‘Databeskyttelsesloven’). The protocol is approved by the Regional Ethical Committee of Copenhagen and the Danish Data Protection Agency. Confidentiality of the participants will be maintained by assigning subjects a study number, keeping identifiers separate from the data and storing data in a locked file and secure computer database. Scientific reports generated from the study will not contain information that would identify the participants.

## Compensation

Participants will be reimbursed for transportation and loss of income, up to a total of 1000 DKK.

## Insurance

The study falls under the Danish worker's compensation law (‘Lov om Arbejdsskadesikring’) as it includes healthy volunteers The Danish Patient Insurance Association (‘Patientskadeerstatningen’) will cover any injury that may occur to the participants due to the study program.

# Study location, feasibility and organization

## Facilities available

The experiments will be performed at a The Department of Clinical Physiology and Nuclear Medicine at Rigshospitalet, where all the measurements are routinely performed. The investigators have vast experience with exercise studies and high-level expertise with all the described techniques. All equipment necessary for a successful completion of the study is available, and all techniques are well established. The PI, Ronan Berg, is a board-certified specialist in clinical physiology and nuclear medicine. Therefore, the study is feasible.

## Funding

The study is initiated by the investigators. There are no financial or other conflicts of interest associated with this study. The costs associated with the study are covered by The Department of Clinical Physiology and Nuclear Medicine at Rigshospitalet at Rigshospitalet.

# Time schedule

The study will be initiated as soon as it has been approved by the Scientific Ethical Committee and will expectedly take 4 months to complete. Data analysis and subsequent manuscript writing for publication in a peer-reviewed scientific journal will be performed immediately hereafter.

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# Appendix A. Adverse event reporting guidelines

Reporting of adverse reactions (in health scientific research projects not involving medicinal products)

Serious unexpected adverse reactions or events:

The chief investigators must immediately inform the committee if suspected unexpected serious adverse reactions or serious events occur during the project. The report must include comments on any outcomes for the concerned trial.  
  
Reporting must take place no later than 7 days after the sponsor or the chief investigator became aware of any such adverse reactions or events.  
  
In case of serious adverse reactions or serious events resulting from the project, the chief investigator must make available any information requested by the committee.  
  
The report can be made using a particular [form](http://www.dnvk.dk/forskere/~/media/Files/cvk/forskere/Indberetning%20af%20bivirkninger/skemaalvorligbivirkn.ashx) prepared by the committee system. The form is in Danish and downloadable from (<http://www.dnvk.dk/English/Reporting%20of%20adverse%20reactions.aspx>). The form and attachments can be submitted electronically to the regional research ethics committee using digital signature.  
  
**Annual report:**

Once every year and throughout the trial period, the chief investigator must submit a list of all serious expected and unexpected adverse reactions and all serious events having occurred in the period. Enclosed with the report must be an assessment of the trial subjects' safety.   
  
The reported material can be in either Danish or English.  
  
The report must be made using a [form](http://www.dnvk.dk/forskere/~/media/Files/cvk/forskere/Indberetning%20af%20bivirkninger/skemarligbivirkningsindberetning.ashx) prepared by the committee system. The form is in Danish and downloadable from

(<http://www.dnvk.dk/English/Reporting%20of%20adverse%20reactions.aspx>).

The form and attachments can be submitted electronically to the regional research ethics committee using digital signature.

# Appendix B: Letter to possible participants

Kære XXXX,  
  
På Center for Aktiv Sundhed på Rigshospitalet vil vi undersøge, hvordan træning påvirker lungerne. For at kunne gøre dette, skal vi undersøge en ny måle metode.

Forsøget foregår på Rigshospitalet, hvor vi vil undersøge din diffusionskapacitet, altså din evne til at få ilt fra lunge til blodbane, mens du sidder roligt på en stol og efterfølgende mens du cykler på en cykel hvor der samtidig trækkes blod fra et plastikkateter i et blodkar i håndleddet . Udover det besøg vil du først skulle møde til en besøgsdag hvor vi gennemgår dit helbred, hvilket inkluderer en udvidet læge undersøgelse, en udvidet lungefunktions undersøgelse, en undersøgelse af din kropssammensætning og en konditionstest.

Vedhæftet dette brev, finder du en uddybet beskrivelse af vores forskningsprojekt som du skal være velkommen til at læse. Vi vil herefter kontakte dig telefonisk inden for de næste 14 dage, hvor vi vil vi informere dig om forsøget og muligheden for deltagelse, hvis det har din interesse.

Mvh,  
COPDEX projektgruppen

Tryghedsfondens Center for Aktiv Sundhed, Rigshospitalet