Study protocol

TESTING OF PERSONAL PROTECTIVE EQUIPMENT (PPE)
FOR A BSL 4 ENVIRONMENT

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Abstract
The aim of the study is to identify how the wearing of personal protective equipment (PPE) over a longer period of time under different temperature conditions affects physical performance, individual feeling, power of concentration and error ratio. Two different PPE systems are compared while carrying out typical laboratory work in two different temperature conditions. To be able to develop adequate working conditions for future laboratory workers in high security laboratories, it is necessary to identify previously mentioned parameters as well as indicators that duly indicate overload and error ratio. Based on these measurements a maximum reasonable working time under given circumstances shall be established. The study is conducted within the framework of the EU project „European Research Infrastructure on Highly Pathogenic Agents (ERINHA)“ where a pan-European solution for the collection of pathogenic samples should be developed.

Administrative structure

| Function                     | Name                        | Profession         |
|------------------------------|-----------------------------|--------------------|
| Principal Investigator Analysis | Univ. Prof. Dr. Kurt Zatloukal | Pathologist       |
| Study Coordination Data Management | Mag. (FH) Sandra Hagauer | Health Management PhD student |
| Sample Management Analysis | Mag. Martina Loibner | Microbiologist PhD student |

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Introduction
Within the framework of the Campus project of the Medical University of Graz a joint laboratory for working with biological agents in risk group 3 is designated for the Institutes of Pathology, Hygiene, Microbiology and Environmental Medicine and Biobank. In the context of healthcare and medical diagnostics the mentioned unit should enable a safe and immediate execution of autopsies and sample collection to research pathogen-host-interactions. To be able to work on pathogens causing diseases with pandemic potential as well as therapy resistant pathogens whose risk group is unknown, the laboratory should additionally be equipped with a mobile isolation unit (glovebox) and should furthermore include increased personal protection. This kind of sample collection is currently not organised but is highly relevant to determine whether mortality can be traced back to the agent or to co-morbidities when diseases caused by pathogens are occurring. Furthermore important information concerning the organ specificity of pathogens, pathogenic mechanisms, as well as the body’s infection defense reactions can be gained.

The establishment of such a sample collection centre takes place within the framework of a pan-European infrastructure initiative of the European Commission (ERINHA = European Research Infrastructure on Highly Pathogenic Agents). One of the tasks linked to this project is the establishment of a master plan for an all-purpose sample collection during autopsy. This concept should be set up at the interface between the health system and high security laboratory and should be an appropriate mock-up solution for all of Europe. For this reason a mobile solution especially applicable in countries with a warmer climate (e.g. South-East-Europe, Africa) is required. The planning takes place in close collaboration with the High Infectious Disease Transport Team (HITT) of the Red Cross Styria, as well as the the Provincial Health Directorate Styria and the Department of Civil Protection Styria.

Beside safeguarding human beings and environment from unintentional disposal of pathogenic agents it is important to protect laboratory staff from infections. To ensure sufficient protection the following safety precautions are intended:

1. Spatial infrastructure: laboratory with security level 3
2. Room setup: gloveboxes with negative pressure and material lock, manlocks with opportunity for decontamination
3. Personal protective equipment: virus-tight-whole-body protective suits, respiratory devices with HEPA filters, virus-tight gloves and boots

Objective of the study
This study focuses predominantly on barrier level 3. Aim of the study is to identify how wearing PPE over a longer period of time in different temperature conditions affects physical performance, individual feeling, power of concentration and error ratio (elevated environmental temperature could pose a limiting factor while working with increased personal protection). Furthermore it raises the question of which possible maximum working time is feasible. It is to assume that raising the time limit implicates higher error ratio, followed by the fact that protective provisions can’t be met, which furthermore highly increases risk of injury. For this reason it is important to identify indicators that point out loss of concentration in a timely manner.
Study design

This study is planned as a monocentric, randomised cross-over study. During the course of the study, two protective suits will be compared under two different temperature conditions. This study serves to determine the bodily performance, the concentration levels, error rates, and subjective well being during laboratory work in protective suits. A pilot phase is planned, in order to optimise the simulated laboratory work in glove boxes, to define the most meaningful simulated conditions (e.g., how many pipetting steps are possible in a given time, testing the logistics during the procedure), as well as to determine the relevance of the planned measurements. In the pilot phase, between 5-7 voluntary test subjects will be included. Based on the evidence from published studies regarding testing of personal protective equipment, a participant number of maximally 20 is assumed, although, due to the relatively long time required for the study, a dropout rate of about 50% is to be expected.

Estimated time schedule

| PILOT PHASE                  | End date     |
|-----------------------------|--------------|
| Recruiting of subjects      | mid May      |
| Testing series              | mid May      |
| Evaluation                  | End of May   |

| EXECUTION PHASE             | BIS          |
|-----------------------------|--------------|
| Recruiting of subjects      | mid May      |
| Module I a / b ~10 subjects | Beginning of June |
| Interim analysis            | mid June     |
| Module I a / b ~10 subjects | id June      |
| Evaluation module I         | End of June  |
| Module II a / b ~10 subjects| End of June  |
| Interim evaluation          | mid July     |
| Module II a / b ~10 subjects| mid July     |
| Evaluation module II        | End of July  |
| Final evaluation            | End of August|

Study population

The study is split into a pilot and execution phase, where 5-7 voluntary subjects are included in the pilot phase and a maximum of 20 voluntary subjects are included in the execution phase. The recruiting for the trial is exclusively carried out on a voluntary registration base through announcements at KAGES, the Medical University of Graz, the Karl-Franzens University and the University of Applied Sciences JOANNEUM, mainly focused on students and employees from the above mentioned institutions. The inclusion and exclusion criteria below are taken into consideration.

Inclusion criteria:
- sex: female / male
- age: 18-65 years
- good mental and physical capacity
Exclusion criteria:
- age: <18 years; >65 years
- pregnancy, allergy against latex or PVC, claustrophobia, hypotension (tendency to collapse), infectious diseases, affinity to thrombosis
- untreated chronic condition, for example asthma, COPD, other pulmonary diseases, cardiovascular diseases, epilepsy
- participation in another study

Methods
Each participant tested two PPE systems:

a) system A: full-body suit including respirator
   - e.g. Tychem F protective suit including socks
   - e.g. 3M™ reusable light cap S-655
   - e.g. 3M™ Jupiter™ cooling unit
   - e.g. Sempermed surgical gloves (optional)
   - e.g. boots

b) System B: full-body suit with fully integrated ventilation system (positive pressure)
   - e.g. 3M™ JS-series Typ 3 Respiratory Protective Suit (CRPS)
   - e.g. Sempermed surgical gloves (optional)
   - e.g. boots

at two different climate zones (module I: ~ 20°C / module II: ~ 28°C) on two different days. On each testing day between two and four subjects perform the series of testings listed below. Each subject is assigned through a system of randomisation called http://www.randomizer.at/, which decided with which PPE system the subject is supposed to start the testing series.

The test series described below are run in succession where the test persons start in a time-delayed fashion. After 15 minutes, they change to the next test. Between the various tests, there is a five-minute recreation break. Tests 1-3 are repeated until the test person cannot tolerate the conditions any more or stops for another reason. During the test phases the following parameters are measured and recorded regularly: heart rate, heart rate variability, oxygen saturation and body temperature. Immediately before and after the separate modules urine and saliva specimens are taken in order to create a metabolite profile, and the weight of the body and the equipment are measured in order to be able to calculate the loss of fluids.

In addition to the measurements mentioned above an extensive instruction, explanation and anamnesis will happen before the study starts. The test persons are encouraged to comment on their subjective feelings during the test series, furthermore there is an hourly survey by way of a structured questionnaire (including a continuous record on the communications system).

**MODULE I a/b (environmental temperatures ~ 20°C)**

| Test | Task | Type (?) | body position |
|------|------|----------|---------------|
| 1    | Laboratory tutorial I
- screwing together tubes with screwtop
- arranging tubes in a box following a certain pattern | simulated glovebox | sitting |
| Test | task | Type | body position |
|------|------|------|---------------|
| 1    | Laboratory tutorial I - screwing together tubes with screwtop - arranging tubes in a box following a certain pattern | simulated glovebox | sitting |
| 2    | Laboratory tutorial II - pipetting liquids (e.g. water) following a defined amount | simulated glovebox | standing |
| 3    | Power of concentration test | computer or handwritten | sitting |

**MODULE II a/b (environmental temperatures ~ 28°C)**

| Parameter                  | Measurement device | Unit | Before testing | During testing | After testing |
|----------------------------|--------------------|------|----------------|----------------|---------------|
| Body height                | measuring tape     | cm   | X              |                |               |
| Body weight                | personal scale     | kg   | X              | X              |               |
| Body-Mass-Index            | calculator         | BMI  | X              |                |               |
| Blood pressure             | blood pressure meter | mm/Hg | X              | X              |               |
| Urine                      | NMR* (outsourced)  |      | X              | X              |               |
| Saliva                     | NMR* (outsourced)  |      | X              | X              |               |
| Heart rate/Variability (HR/HRV) | heart rate monitor pulse oximeter ECG-monitor | beat per minute | X | X | X |
| Oxygen saturation (SpO2)   | pulse oximeter     | %    | X              | X              | X             |
| Core temperature           | thermometer (tba)  | °C   | X              | X              | X             |
| Dehydration                | personal scale     | g    |                | X              |               |

*Nuclear Magnetic Resonance (developing a metabolite profile)*

**Process of the study** (description of a typical experimental procedure)

**I PILOT PHASE**
a) Recruiting of subjects
   Calling for tender: MUG, KAGES, KFU, FH JOANNEUM
   Generating a contact database for interested persons
   Invitation for an informational event
   Informational event (alternative date if required)
     - presenting the trial
     - conducting an informed consent discussion
     - completing the case history
     - distributing the informed consent
   Evaluation of case histories
   Collecting signed informed consents
   Inclusion into the pilot phase / trial
   Appointment coordination for the pilot phase
   Appointment coordination for the different modules

b) Executing the pilot phase
   Testing of the different PPE systems
   Testing of the different laboratory tutorials / the power of concentration tests
   Evaluation based on subjective judgement

c) Optimizing the study protocol based on the results of the pilot phase
II EXECUTION PHASE

a) Conducting module I a/b + II a/b

Preparation
- Issuing a subject-ID
- Issuing the randomly assigned PPE system
- Short introduction
  -> Only for the first appointment (getting dressed, explaining the testing series,...)

Initial measurements (immediately before starting the testing series)
- Anamnesis (regarding the module)
- Collecting saliva samples -> refrigerated storage
- Collecting urine samples (total bladder emptying) -> refrigerated storage
- Measuring HR (recording in the database)
- Measuring oxygen saturation (recording in the database)
- Measuring body temperature (recording in the database)
- Measuring blood pressure (recording in the database)
- Measuring body weight (without PPE system)
- Measuring weight of PPE system
- Installing the HR-monitor/pulse oximetry
- Installing the thermometer
- Getting dressed with the protective suit
- Measuring the total weight (subject including the protective suit)

Conducting the testing series

Series I
- Laboratory tutorial I (duration: 15 minutes + recovery period: 5 minutes)
- Laboratory tutorial II (duration: 15 minutes + recovery period: 5 minutes)
  -> Recording measured data (HR, oxygen saturation, °C)
  -> Power of concentration test (duration: 15 minutes + recovery period: 5 minutes)

Series II
- Laboratory tutorial I (duration: 15 minutes + recovery period: 5 minutes)
- Laboratory tutorial II (duration: 15 minutes + recovery period: 5 minutes)
  -> Recording measured data (HR, oxygen saturation, °C)
  -> Power of concentration test (duration: 15 minutes + recovery period: 5 minutes)

Series III
- Laboratory tutorial I (duration: 15 minutes + recovery period: 5 minutes)
- Laboratory tutorial II (duration: 15 minutes + recovery period: 5 minutes)
  -> Recording measured data (HR, oxygen saturation, °C)
Power of concentration test (duration: 15 minutes + recovery period: 5 minutes)

Series IV
Laboratory tutorial I (duration: 15 minutes + recovery period: 5 minutes)
Laboratory tutorial II (duration: 15 minutes + recovery period: 5 minutes)
Recording measured data (HR, oxygen saturation, °C)
Power of concentration test (duration: 15 minutes + recovery period: 5 minutes)

Series V (only module I)
Laboratory tutorial I (duration: 15 minutes + recovery period: 5 minutes)
Laboratory tutorial II (duration: 15 minutes + recovery period: 5 minutes)
Recording measured data (HR, oxygen saturation, °C)
Power of concentration test (duration: 15 minutes + recovery period: 5 minutes)

Series VI (only module I)
Laboratory tutorial I (duration: 15 minutes + recovery period: 5 minutes)
Laboratory tutorial II (duration: 15 minutes + recovery period: 5 minutes)
Recording measured data (HR, oxygen saturation, °C)
Power of concentration test (duration: 15 minutes + recovery period: 5 minutes)

Final measurements (immediately after finishing the testing series or after quitting the testing series)
- Measuring the total weight (subject including the protective suit)
- Taking off the protective suit
- Measuring body weight (without PPE system)
- Measuring weight of PPE system
- Removing the HR-monitor/pulse oximetry
- Removing the thermometer
- Collecting saliva samples -> refrigerated storage
- Collecting urine samples -> refrigerated storage
- Measuring HR (recording in the database)
- Measuring oxygen saturation (recording in the database)
- Measuring body temperature (recording in the database)
- Measuring blood pressure (recording in the database)

b) Data interpretation
- Exporting coded subject data from Microsoft Access to Microsoft Excel
- Forwarding the coded data to the statistician
- Interpreting the generated data
- Developing the publication
- Releasing the publication to a scientific journal / dissertation
Study dropout
Each subject is able to quit the study any time (reasons are not required, but can be mentioned). Module I with an environmental temperature of about 20°C automatically ends after a maximum 6 hours. Module II with an environmental temperature of about 28°C automatically ends after a maximum of 4 hours.

Therapy safety
There is neither a benefit nor a risk for subjects included into the trial. Due to the water tightness of the protective suits used in the study strains like heat accumulation and fluid loss through heat generation inside the suit could lead to cardiovascular problems (e.g. to collapse) under certain circumstances. For this scenario a medical doctor on call-duty is contacted immediately. Apart from that, there is no further risk to be expected for the described trial.

Data management
Data management of the subject’s data is exclusively made in a coded way with help of an access database, built up on the following scheme:

| Anamnesis                                      |
|-----------------------------------------------|
| subject-ID                                    |
| sex                                           |
| date of birth                                 |
| date of anamnesis                             |
| time                                          |
| body height                                   |
| body weight                                   |
| BMI                                           |
| HR (resting)                                  |
| SpO₂ in % resting                             |
| body temperature in °C resting                |
| systolic blood pressure resting               |
| diastolic blood pressure resting              |
| notes                                         |

| Module I a          | Module I b          | Module II a         | Module II b         |
|---------------------|---------------------|---------------------|---------------------|
| Date of examination| Date of examination| Date of examination| Date of examination|
| Start of testing series| Start of testing series| Start of testing series| Start of testing series|
| End of testing series| End of testing series| End of testing series| End of testing series|
| Total testing time  | Total testing time  | Total testing time  | Total testing time  |
| Protective suit system| Protective suit system| Protective suit system| Protective suit system|
| Room temperature    | Room temperature    | Room temperature    | Room temperature    |
| notes               | notes               | notes               | notes               |

| Regular measurements during testing series |
|---------------------------------------------|
| time                                        |
| HR                                          |
| SpO₂                                         |

|                  |                  |                  |                  |
|                  |                  |                  |                  |
|                  |                  |                  |                  |
|                  |                  |                  |                  |
| Initial / final measurements |
|-----------------------------|
| **Body temperature °C**    |
| Systolic blood pressure    |
| diastolic blood pressure   |
| Body weight in g           |
| Weight of suit system in g |
| Total weight in g          |
| dehydration in g           |
| **Body temperature °C**    |
| Systolic blood pressure    |
| diastolic blood pressure   |
| Body weight in g           |
| Weight of suit system in g |
| Total weight in g          |
| dehydration in g           |
| **Body temperature °C**    |
| Systolic blood pressure    |
| diastolic blood pressure   |
| Body weight in g           |
| Weight of suit system in g |
| Total weight in g          |
| dehydration in g           |
| **Body temperature °C**    |
| Systolic blood pressure    |
| diastolic blood pressure   |
| Body weight in g           |
| Weight of suit system in g |
| Total weight in g          |
| dehydration in g           |

To guarantee a regular contact with the study subjects (for the different testing series) contact details in connection with a subject-ID are recorded in a separate, password protected database.

| contact data |
|--------------|
| subject-ID   |
| title        |
| surname      |
| family name  |
| Email address|
| phone number |
| notes        |

**Ethical aspects**

Regarding benefit or risk for the subjects, see Therapy Safety above. For clarification of all ethical aspects an application to the ethical commission of the Medical University of Graz is made. All subjects are instructed at an informal meeting (repeated if required) where the informed consent paper is provided.

**Data protection**

Individual-related information connected with data generated within the study is exclusively saved in a coded way in a database with restricted access and own passwords. For contacting the subjects a separate contact data base with restricted access and own password is established. The generated data for analysis, publications and exchange with the collaboration partner is exclusively used in a coded way. Furthermore it is ensured that results of the trial (e.g. performance of the testing series) has, where appropriate, no influence on a current employment relationship or studies.
Estimated number of cases

The number of cases of about 20 subjects is estimated on the basis on findings of previous trials regarding testing of PPE. Due to a relatively high time requirement to go through the trial a drop out rate of about 50% is expected.

Reporting

The outcome is intended to be published in scientific journals, in a dissertation, as well as to be presented at congresses.

Literature

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**Annex**
Proposal to the ethics commission  
Information for study population / declaration of consent  
Proof of qualification of auditor  
Declaration of conflict of interests  
Call for tender  
Compensation for testing persons

Signature:……………………………….  
(Auditor)