Biomechanics and Assistive Technologies Research Group

University of Defence
Military Faculty of Medicine

FACULTY OF BIOMEDICAL ENGINEERING CTU IN PRAGUE

Current State and Design Recommendations of Wearable Systems in Military Applications

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Who we are

A multidisciplinary team focused on research, design and development:

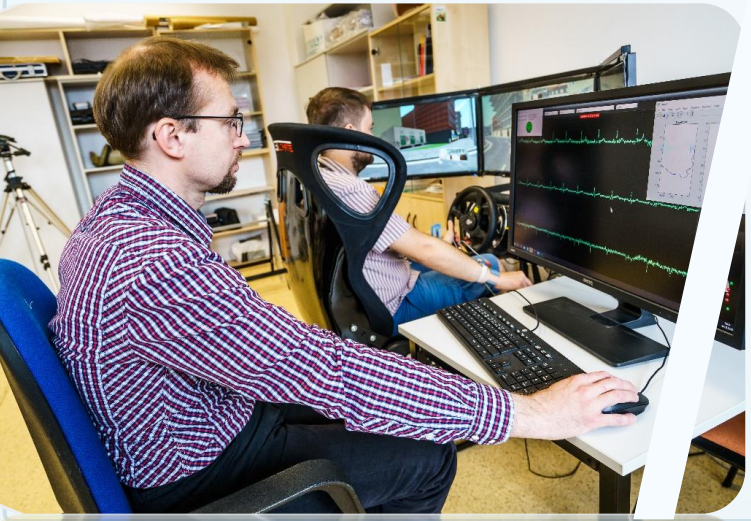
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Methodologies

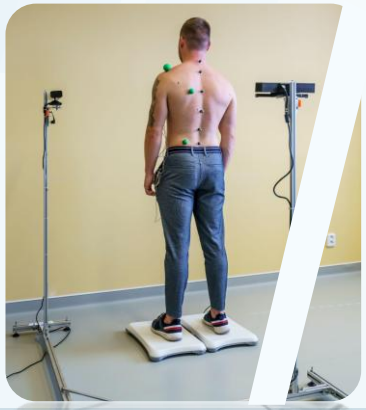
Software

Electronic systems

for measuring and evaluating physiological, motion and image data.









Research challenges



Operating in hazardous environments



Real vs. simulated environments (VR, AR, ...)



Screening and assessing individuals and teams



Training planning and readiness assessment



Optimizing the working environment



Optimizing individual wearable equipment

Introduction and motivation

Military operations involve high physical
and mental demands in unpredictable environments.



- Physical exertion and fatigue
- Psychological stress
- Time pressure
- Unpredictable conditions (hazards, terrain, weather)

Continuous physiological monitoring can support safer and more effective military operations.

Research design

From literature to user requirements and practical evaluation.



1
Literature overview

2
Questionnaire
(First responders)
n = 114

3
Pilot testing
(Military training)
n = 10

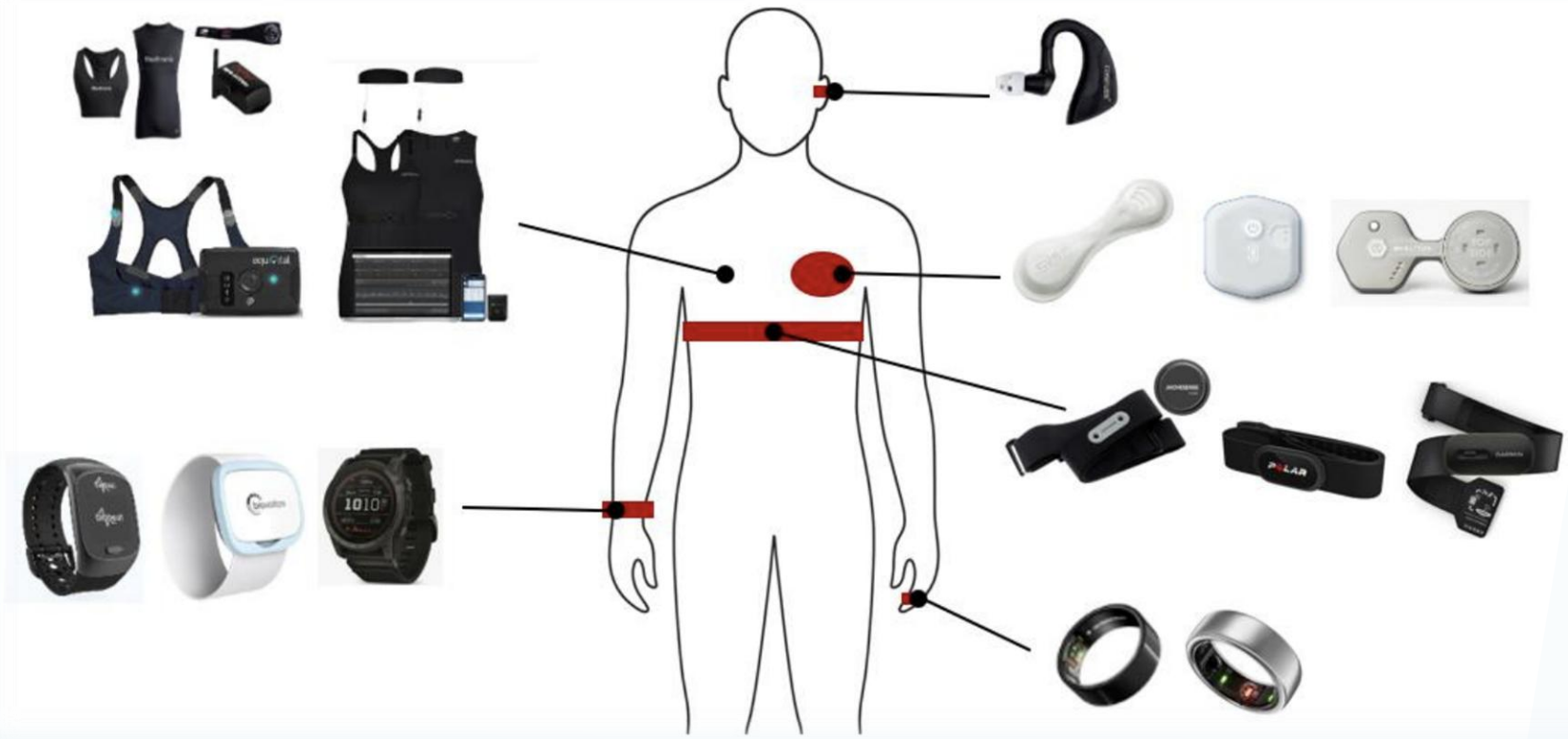
4
User evaluation
(Usability and applicability)

5
Design recommendations

Thematic literature overview + user preferences + practical feedback

Current state of wearable systems

Classification depends on function, body placement and architecture.



Body placement

- Head
- Torso
- Upper limbs (e.g. wrist)
- Lower limbs (e.g. ankle)

Architecture

- On-body systems
- In-body systems

Function

- Monitoring
- Medical support
- Communication
- Alerts

Three implementation approaches

From standalone devices to fully integrated solutions.

1 Commercial devices



Smart T-shirt, chest straps, smartwatches, etc.

2 Multimodal Systems



Combination of multiple sensors (e.g., ECG, EMG, PA, etc.)

3 Integrated into equipment



Smart vests and uniforms.

Application areas in military environments

Six application domains identified in the literature review.



External risk detection

Hazards and exposure



Passive health protection

Physiological status



Localization and tracking

Position and activity



Treatment and rehabilitation

Recovery and biofeedback



Personnel preselection

Response to workload

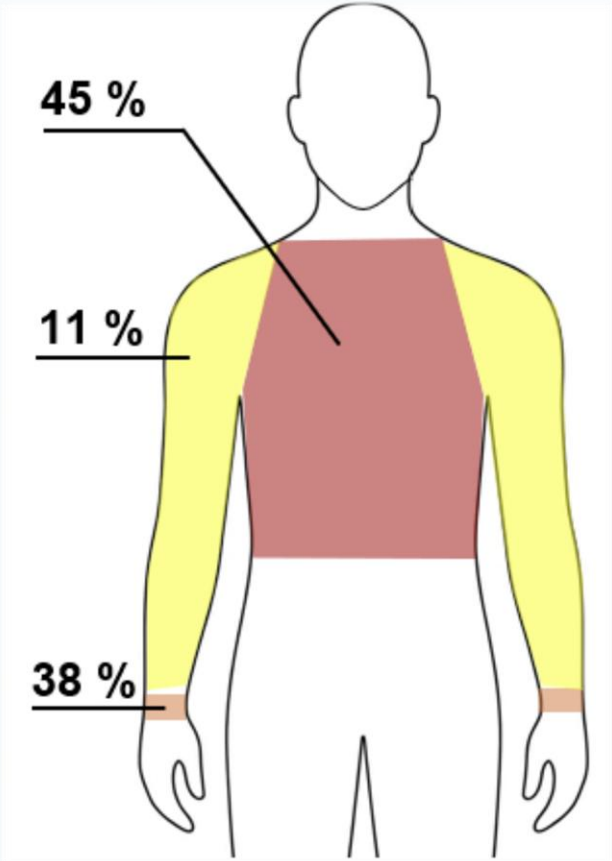


Training and education

Performance assessment

Questionnaire survey – first responders

n = 114 respondents (military, police, fire and rescue, emergency services)



Preferred placement on the body

Most preferred monitored parameters

Heart rate	31 %
Respiration	26%
Other	23%

≤ 150 g

Preferred device weight (majority of respondents)

Pilot testing in tactical training

Testing of a CTU-developed wearable system.



Participants

10 students
(University of Defence)

Measured signals

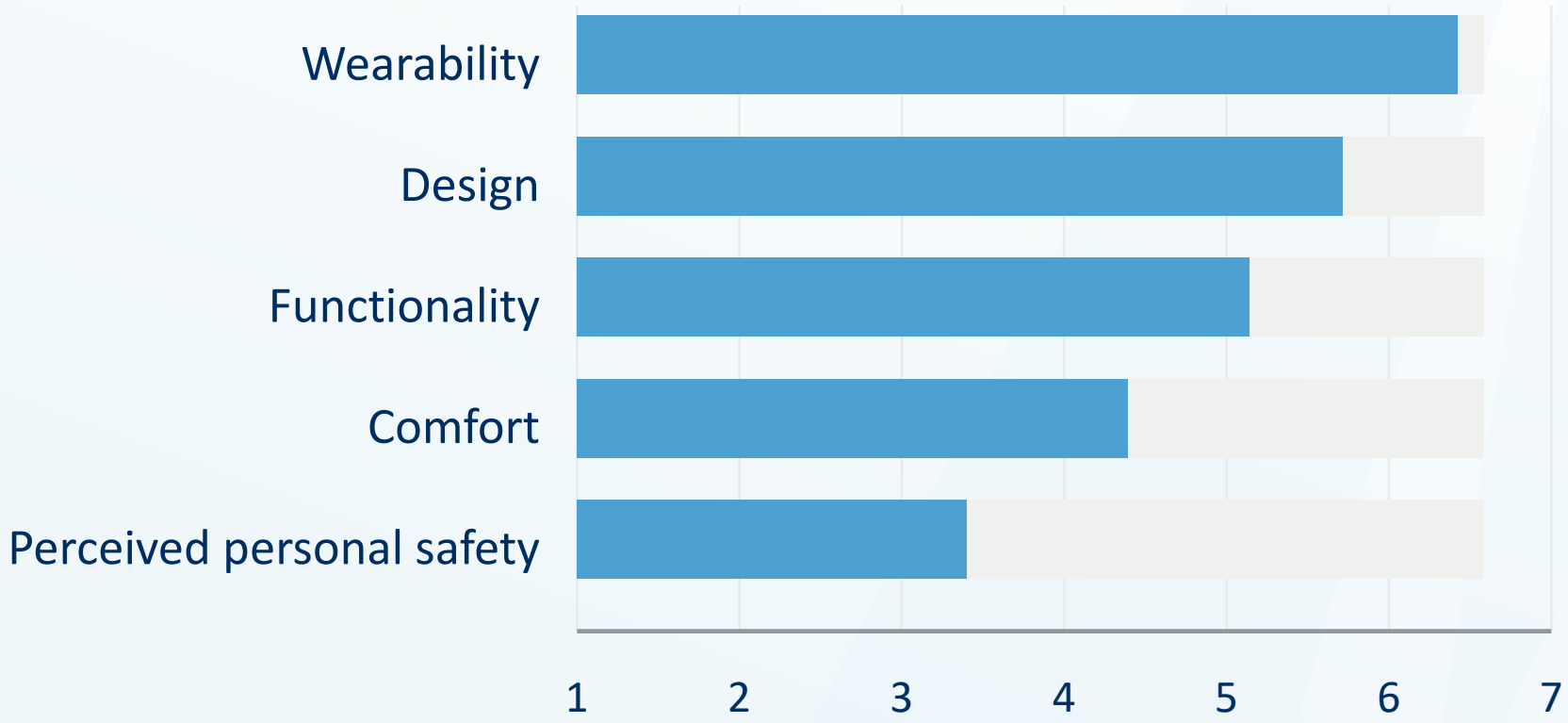
Heart activity (ECG)
Respiratory aktivity
Physical activity

Practical setting

Tactical training activities
Equipment worn during real movement

User evaluation – applicability and usability

Assessment of the wearable system during military training.



	Median	IQR
Wearability	5.5	4.8 – 6.0
Design	5.0	4.0 – 5.8
Functionality	4.5	3.8 – 5.3
Comfort	4.0	3.0 – 5.0
Perceived personal safety	3.0	2.0 – 4.0

Pilot evaluation, n = 10; descriptive statistics.

Practical limitations and user feedback

Technical functionality does not automatically guarantee operational usability.



- Discomfort during wear
- Impractical placement of recording unit
- Restrictive cabling
- Ergonomic limitations during movement
- Need for better integration with equipment

Design recommendations

Based on literature review, user preferences and pilot evaluation.

Technical reliability

- Resistance to water, dust, shock
- Operational temperature −40 to +40 °C
- Reliable skin contact
- Battery autonomy ≥ 24 h

Data and communication

- Data encryption
- Local data recording
- Suitable interfaces
- Communication requirements

Human factors

- Low weight (≤ 150 g)
- Comfort and ergonomics
- Minimal restriction of movement
- Compatibility with equipment
- Easy maintenance

Conclusions

Significant potential

Wearable systems can support physiological monitoring in military applications.

Operational requirements

Technical design must reflect real deployment conditions.

End-user validation

Practical testing is essential to identify ergonomic and usability limitations.

Further validation with larger samples and in different operational conditions is required.

Thank you for your attention

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