Monitoring stress and fatigue in first responders in action

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VisionGroup
looking at healthcare

First Responders

First Responders

Who are the first responders?

First Responders

- Emergency medical technicians (EMTs)
- Emergency physicians
- Nurses
- Paramedics
- Police
- Firefighters

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- **Firefighters**

BOMBEIROS VOLUNTÁRIOS AMARANTE

1316
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1117

A dream job ...

… with fresh environments…

... challenging ...

... no pressure ...

... without hurries ...

... it feels just like a vacation ...

... but it has some risks.

Stress and fatigue

Stress

- over the last decades the term has increased popularity
- it is difficult to define the concept, at least in simple terms

"a situation that taxes or exceeds one's personal resources or threatens the person well-being has the potential to cause stress" (R. S. Lazarus and S. Folkman)

Stress

- Psychological self-report measures (e.g., questionnaires) fulfilled in paper several hours after the event

- Skin conductance measurements to detect emotional or physiological arousal

Stress

- ECG is commonly used to measure stress in human beings
- R-R variability is the main technique used for this purpose
- For this measure to be effective, we need to have a simple and effective way of long-term monitoring (at least one working day) of diagnosis quality ECG.
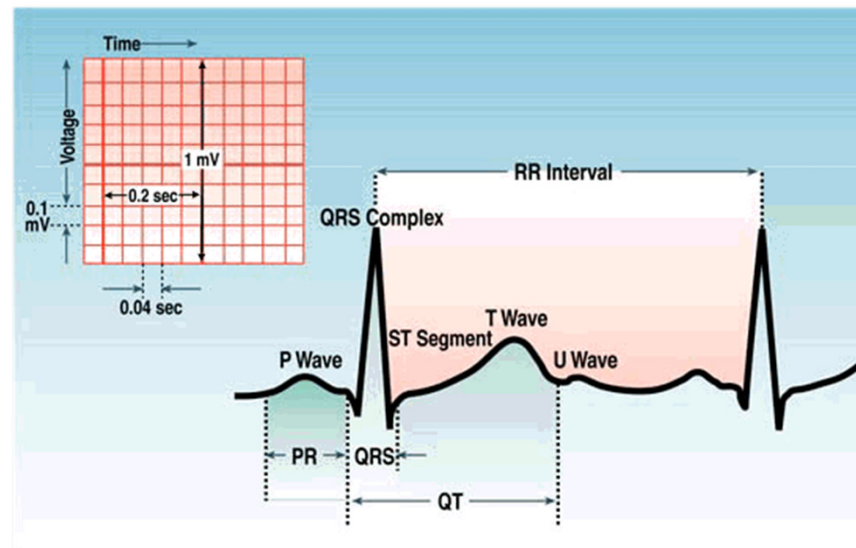
Fatigue: Motivation

- In real time
  - To evaluate if a person is capable to perform is work in perfect conditions
  - To evaluate if a person should be advised to rest

- Long time analysis
  - To understand the harms that it is provoking to a person health
  - To evaluate the evolution of fatigue in a person

Fatigue

- Can be physical and/or psychological

- Is a sensation that is noticed by the patient

- Hard to describe or measure

Fatigue

Physical fatigue (lack of muscle strength)

- Two states:
  - True: force exerted by the muscles is less than expected
  - Perceived: you feel more effort than expected

- Can be:
  - Central: overall energy deprivation
  - Peripheral: muscle-specific incapacity to work
  - Neural: can be both

Fatigue

Psychological fatigue

- Can be confused with perceived fatigue

- Main causes:
  - Worries and stress
  - Lack of sleep
  - Emotional shock
  - Everyday difficulties
  - …

- To find the reason for this kind of fatigue the patient needs to guide the physician through his daily life

Fatigue: SoA

There is a general lack of consensus around the definition

- Usually the studies define first what they want to access:
  a) subjective quantification of fatigue,
  b) subjective distress because fatigue,
  c) subjective assessment of impact of fatigue on activities of daily life,
  d) certain widely recognized correlates of fatigue, and
  e) key biological parameters

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Monitor physiological signals

Sensors commonly used

- Electrocardiogram (ECG)
- Electromyography (EMG)
- Temperature thermistors;
- Galvanic skin response;
- Infrared emitter/receiver systems;
- Accelerometers;
- Gyroscopes;
- …

- They are usually wireless and tend to use low energy spent protocols (bluetooth low energy, ZigBee …)

Vital Jacket

The "silver bullet" is provided by a high-tech company named Biodevices, which together with researchers at the University of Aveiro developed a suite of non-intrusive wearable technologies, as inconspicuous as a t-shirt, capable of gathering relevant information about the individual.

Sensors on the jacket:

- ECG
- GPS
- Accelerometer

Possibel future sensors / features:

- Temperature sensor
- O_2 sensor
- Skin conductance sensor
- Comunicaction system
- Video input/output

Vicon

Shimmer

- Kinematics Development Kit
- Cardio Development Kit
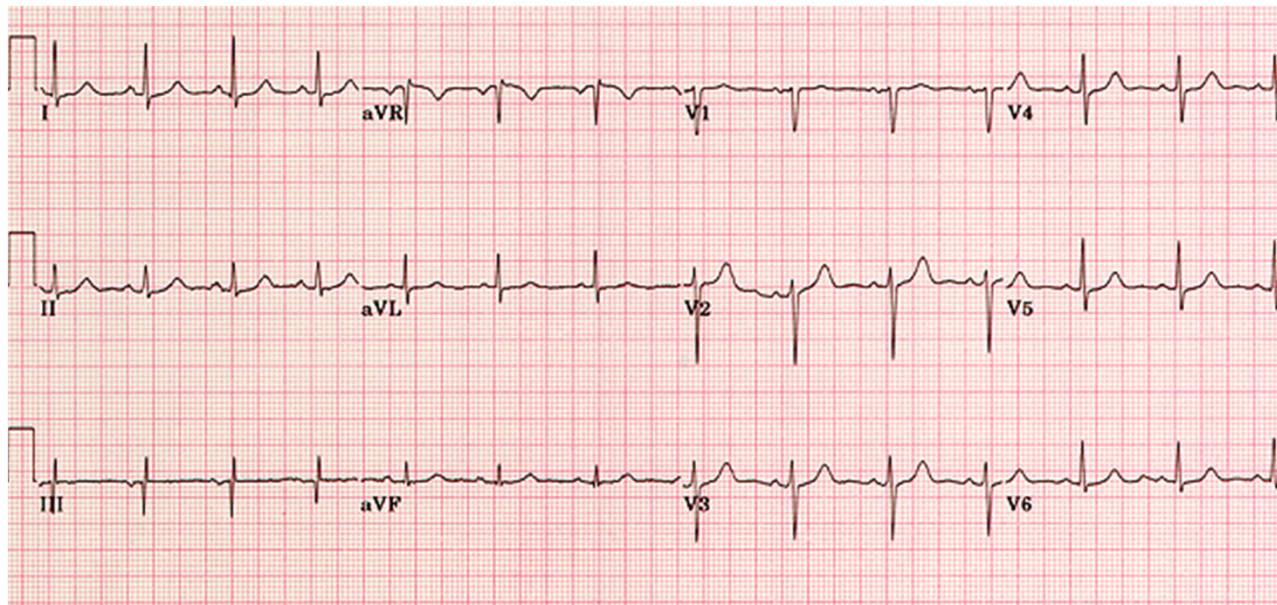- EMG Development Kit
- GSR Development Kit

Vital Analysis

Context and Annotation

- A physiological signal without context or annotation can be analyzed?

# Contextual studies

Observations

- Need for portability
- Focus during an event
- Size of the team
- Roles during the event
- The trips
- Voice over anything
- Actions are rarely predictable
- The impacts are different for each FF

Methodologies

- Stress Annotation
  - Cooperations with Faculdade de de Psicologia e Ciências da Educação do Porto

- Event-driven Annotation
  - Framework workflow

- Voice Annotation
  - "break the glass"

Framework
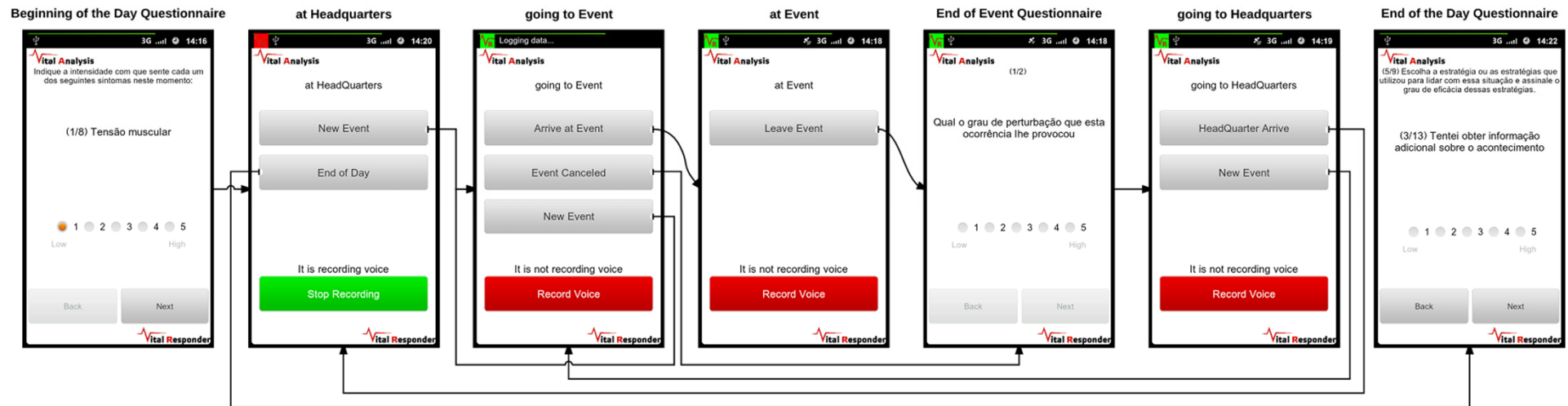
Results

RESULTS FROM THE USABILITY EVALUATION, COMPILED FROM THE DATASET COLLECTED FROM THE FIREFIGHTERS (FF). WE HAVE ANALYSED ALL EVENTS (TOTAL), AS WELL AS WHEN ONLY A SPECIFIC AMOUNT OF FF WHERE PRESENT (COLUMNS 1FF..5FF), AND WHEN MORE THAN A SPECIFIC AMOUNT WAS PRESENT (COLUMNS >1FF..>3FF)

	Total	1FF	2FF	3FF	4FF	5FF	>1FF	>2FF	>3FF
Nr. of Events	454	259	151	29	6	6	192	41	12
% of Events with Annotation	53,5%	38,2%	69,5%	82,8%	83,3%	100,0%	72,9%	85,4%	91,7%
% of Events with good Annotation	64,2%	57,6%	68,6%	29,2%	40,0%	83,3%	61,4%	40,0%	63,6%
% of Annotated Events with Audio	14,8%	11,1%	10,5%	41,7%	20,0%	50,0%	17,9%	40,0%	36,4%
% of Questionnaires with Audio	20,2%	19,2%	13,3%	33,3%	40,0%	50,0%	19,3%	37,1%	45,5%

Results

MEAN AND STANDARD DEVIATION (SD) VALUES OF THE STRESS APPRAISAL FOR EACH EVENT CATEGORY WHERE 0 IS MINIMUM AND 4 THE MAXIMUM.

| Event categories	Mean	SD	Min	Max
Fire	1,23	1,002	0	4
Accident	1,40	0,857	0	3
Infrastructure/communications	0,50	0,798	0	2
Pre-hospital assistance	1,11	0,813	0	4
Legal conflict	0,80	0,837	0	2
Technological/Industrial	0,50	0,548	0	1
Services	1,01	1,033	0	3
Activities	0,77	0,725	0	2
Total	1,10	0,918	0	4

Gait Analysis

Gait

Gait analysis is the study of patterns in the movements produced by the limbs of animals during locomotion

- Is mainly characterized by:
  - Movements patterns
  - Velocity
  - Forces
  - Kinetics and energy cycles
  - Contact with different surfaces

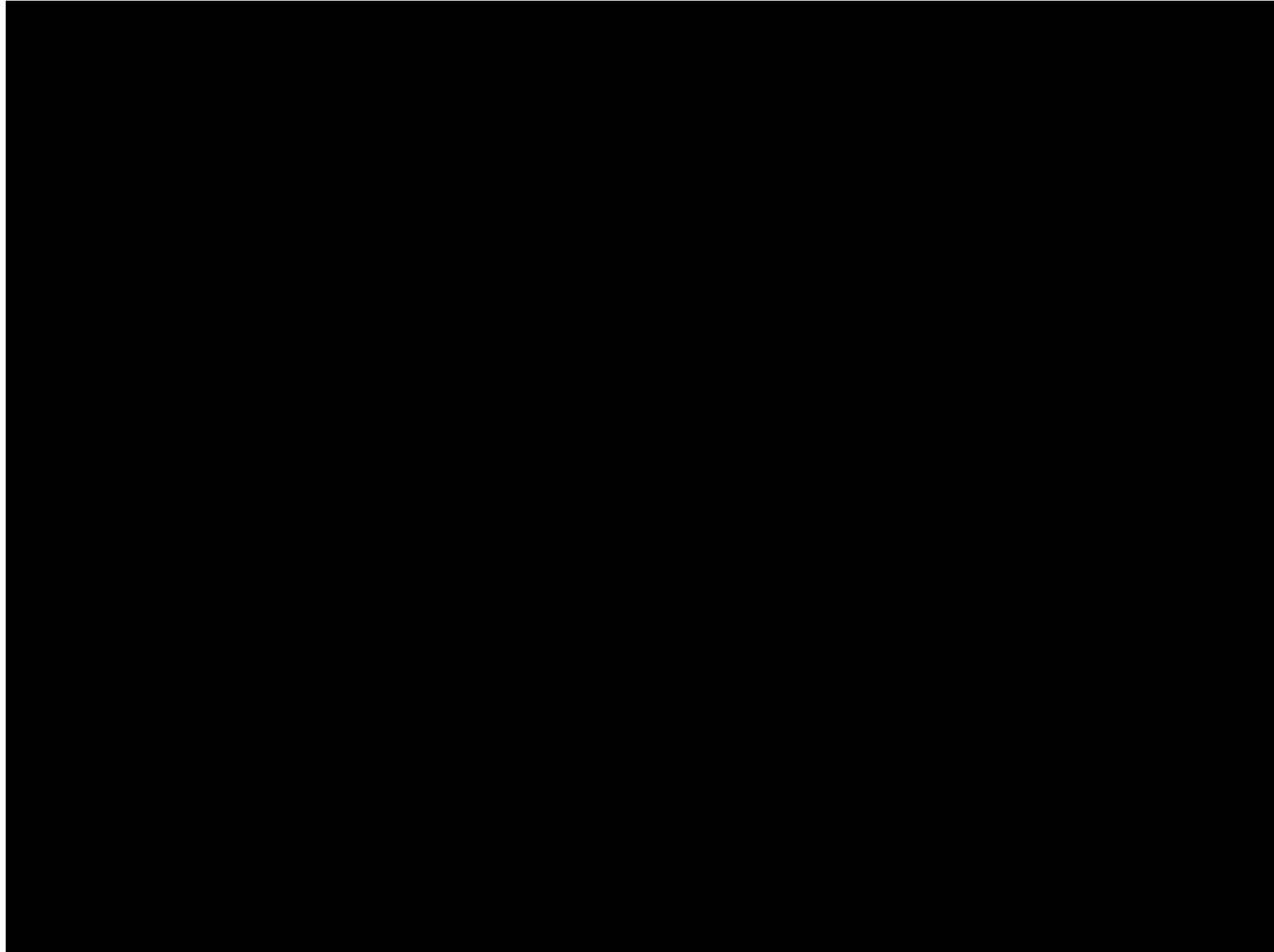# Gait Cycle
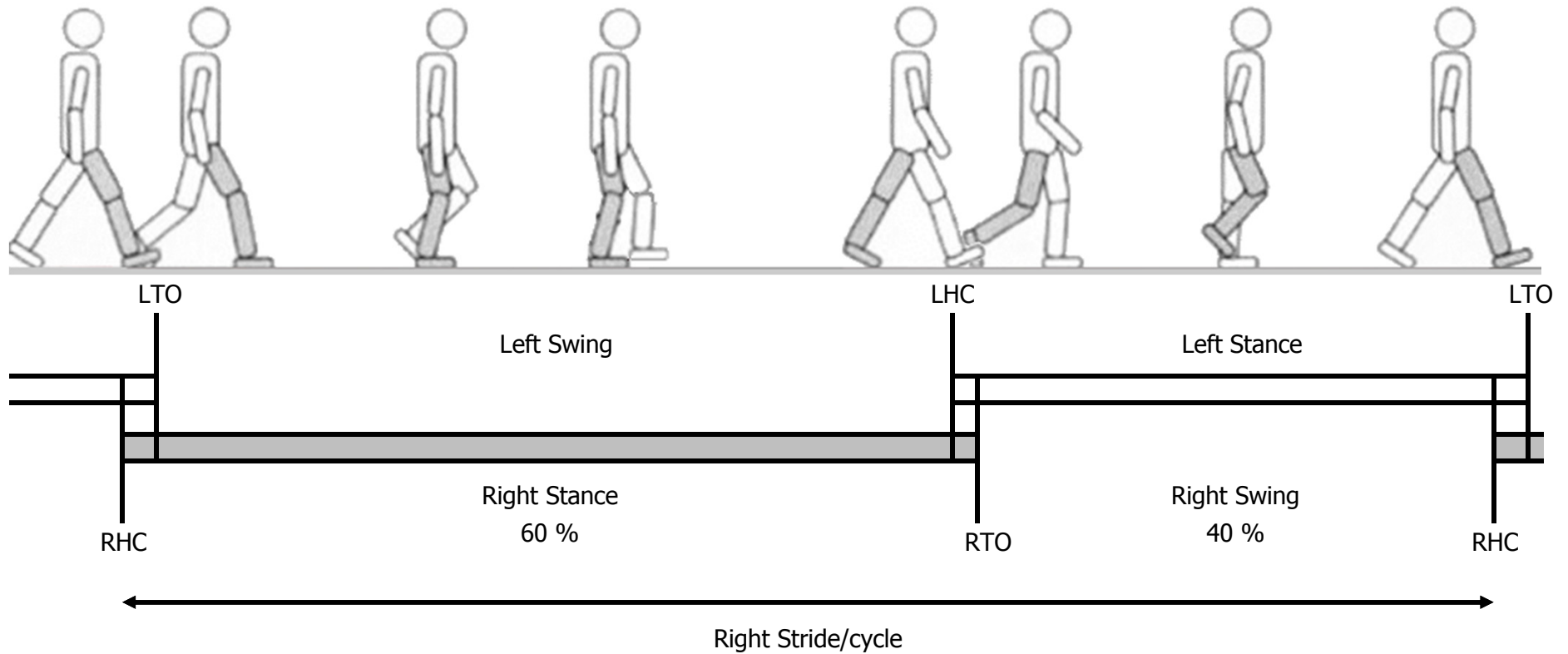
Gait Cycle
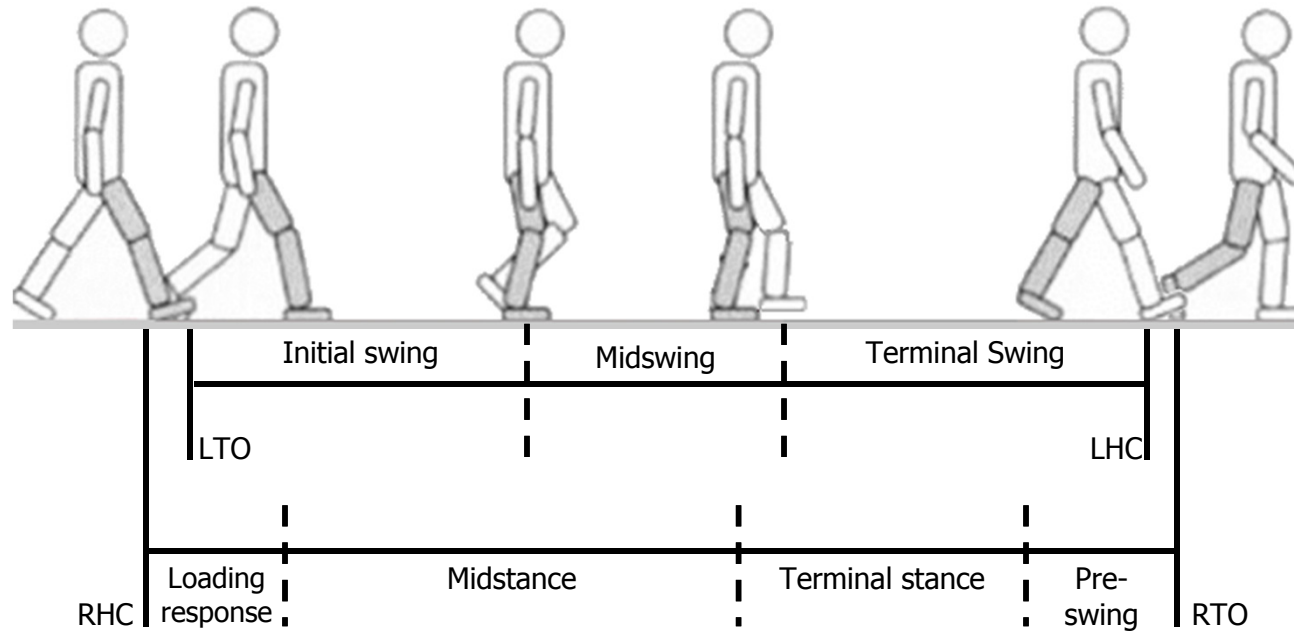
Gait

We know that:

- Fatigue affects the way we walk
  - Start to walk slowly, sloppier, ….

- Each human has is own way to walk (Gait)
  - Like a signature
  - Cycling patterns

Gait Analysis Laboratory

Can a gait laboratory be used in …

… an **uncontrolled** life environment?

... or in a real life environment?

Gait Analysis

Estimate fatigue through the analysis of patterns, abnormalities or correlations of gait in real life using wearable devices.
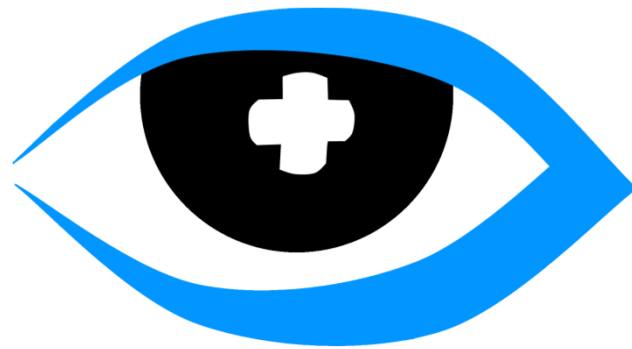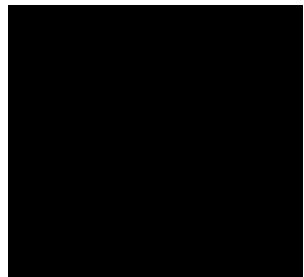
Adidas: miCoach Speed_Cell

Applications in real life ....

In real life ….

- First Responders

- Sports
  - To evaluate the condition of a player

- Elderly monitoring
  - Monitoring the fatigue levels of elders can help physicians to better evaluate their physic condition and to advice specific work plans

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