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STRESS MONITORING USING WEARABLE SENSORS FOR PEDESTRIAN WORKER RISK ANALYSIS

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Context

Pedestrian work often consists in:

- Carrying out several tasks on the road network (e.g., flaggers, school crossing guards, postmen);
- Being on foot for short periods of time, to ease traffic or to perform road repairs (e.g., blue collars or other construction workers, **police officers**);
- Alternating back and forth between a vehicle and the street (e.g., delivery men).

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Context

- On a daily basis, working in those environment might leads to **higher levels of stress**, which is conducive to occupational injuries and chances of hazards.

- In Quebec, pedestrian workers are involved in about 6% of the occupational road accidents, but represent **23% of the number of serious injuries and fatalities** (Pignatelli et al., 2013).

Context

Solutions must be proposed to prevent any dangerous situation arising from carrying out pedestrian work.

- This could help enhance security for both workers and road users.

Measuring stress variations during work activities may allow to pinpoint situations that pose greater risks and to develop prevention tools

Work stress can be assessed by using

- Self-reported data (e.g., Damaske et al., 2016)
- Physiological responses (e.g., Sun et al., 2012)
- Situational measures (e.g., Holt, 1993)

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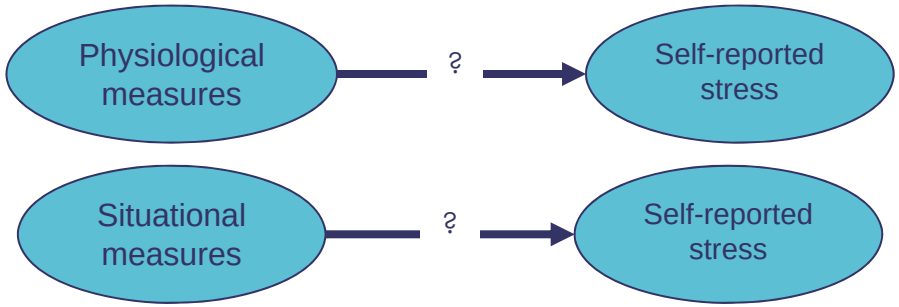
Study aims

To collect data from police officers performing real-time traffic duties to:

- Study the factors that are conducive to stress
- Calibrate a physiological stress model

Measures:

- Self-reported stress (each 15 min)
- Physiological data (wearable sensors)
- Situational measures (observed environmental characteristics and punctual events)



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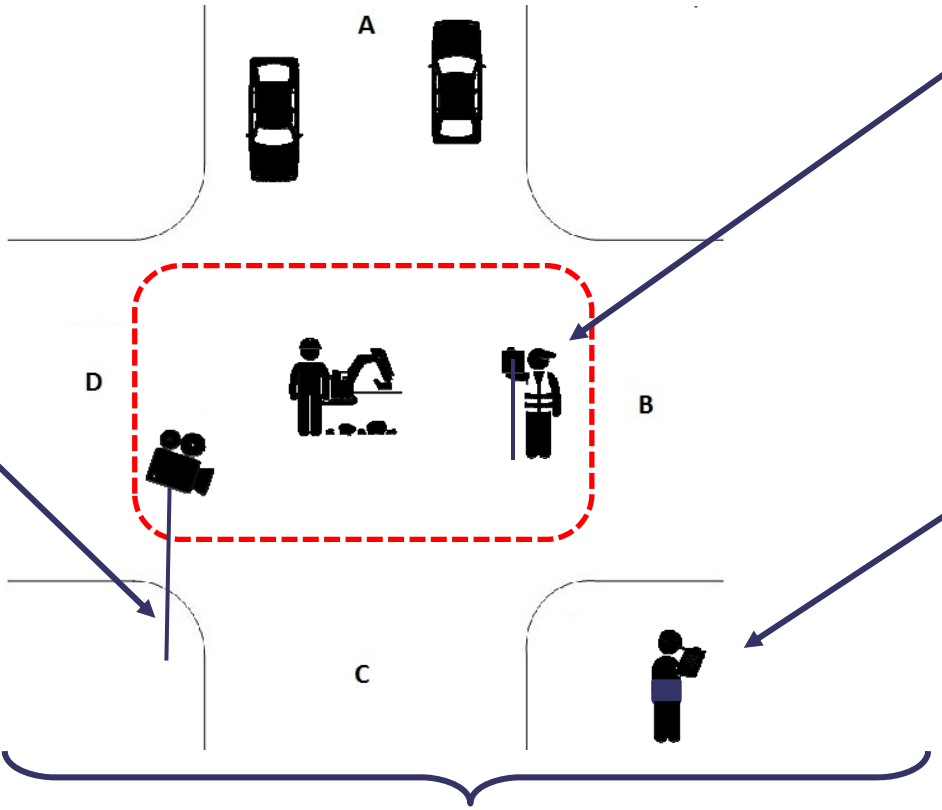
Data collection (Summer/Fall 2017)

Video recordings

+

+



During several work shifts

Physiological measures

+

Body sensors

Portable app

Observations

Observations collected on a tablet

+

Self-reported stress

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Measures of stress

Self-reported stress

- Initial measure on a 10-point Likert scale (1 = low, 10 = high)
- Stress variations every 15 min (decreased, increased or remained stable)

Physiological measures

- Heart rate (HR), heart rate variability (HRV), respiratory rate (RR), activity and core temperature
- Resampled at 1 Hz and averaged each 15 min (to correspond to situational measures)

Situational measures

- Dynamic: Work state (on- or off-task), stressful events, and traffic density (for cars, cyclists and pedestrians)
- Static: Number of lanes (at working site and under construction) and presence of road construction

Results

Participants (*N* = 19)

- 8 police officers from Montreal (3 men/5 women)
- 11 police officers from Quebec City (10 men/1 woman)

37 different sites

54 work shifts comprising 614 periods of 15 minutes

- 1 to 8 work shifts/participant (*M* = 3.3)
- Work shift duration: 60 min to 4h45 min (285 min) (*M* = 150 min)

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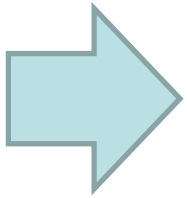
Results: Self-reported stress (dependent variable)

Initial value (1-to-10 scale)	
M	2.06
SD	2.01

Stress variation (each 15 min)	↓	=	↑
Frequency (%)	8.14%	78.83%	10.91%

Anchored-stress (from the initial measure)	
Min	-2
Max	17
M	2.31
SD	2.69



Dichotomous anchored-stress (DAS) frequency	
Low	331
High	188

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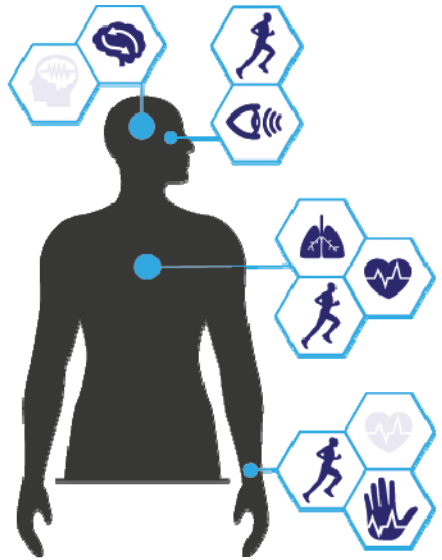
Results: Self-reported stress and physiological measures

Physiological measures		
Measure	*M*	*SD*
Heart rate (HR)	89.7 beats/min	13.16
Heart rate variability (HRV)	43.30 *SD*s/ms	17.74
Respiratory rate (RR)	23.23 breaths/min	5.94
Activity (A)	0.08 g	0.04
Core temperature (CT)	37.42 °C	0.37



- **Averaged each 15 min and aligned with self-reported stress**

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Results: self-reported stress and physiological measures: 2 models

	Multifactorial logistic regression model	Decision-tree model
Y variable	DAS	DAS
Significant predictors or Priority tree	oHR (+) oHRV (-) oRR (+)	oRR oHR oActivity oHRV oCore Temp
Predictive accuracy	63.49% (κappa = .11)	77.47% (κappa = .49)

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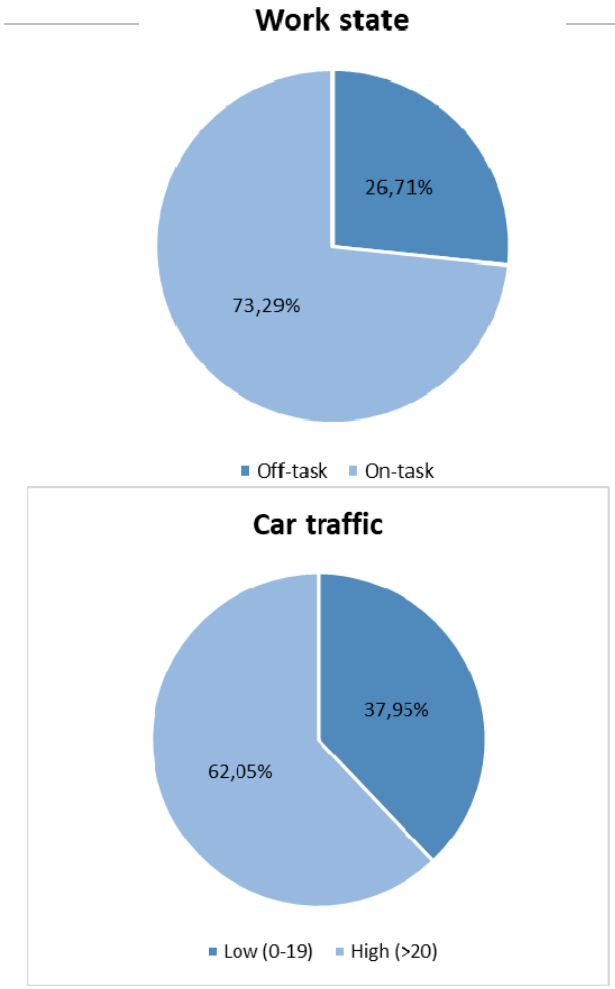
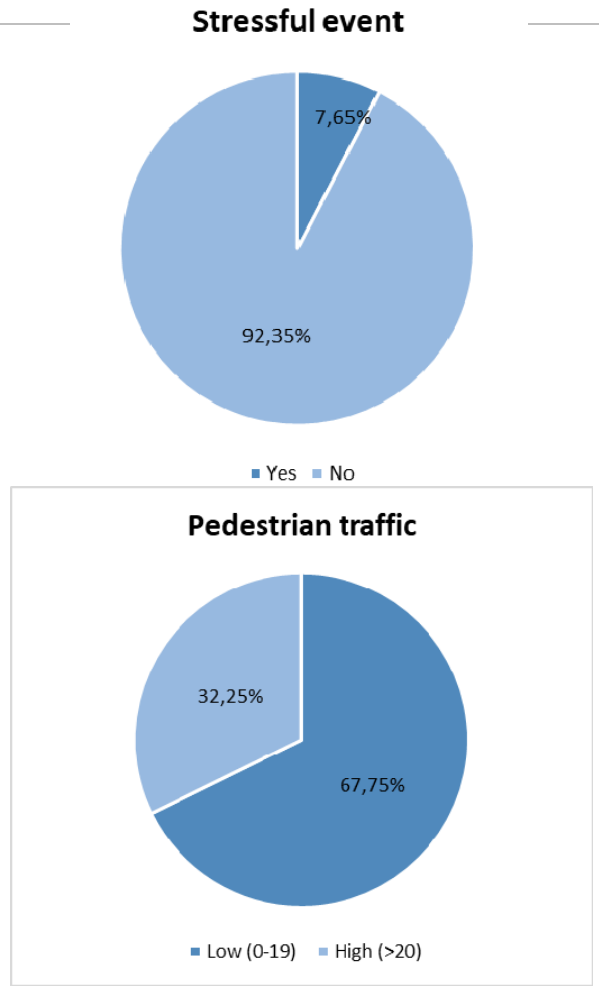
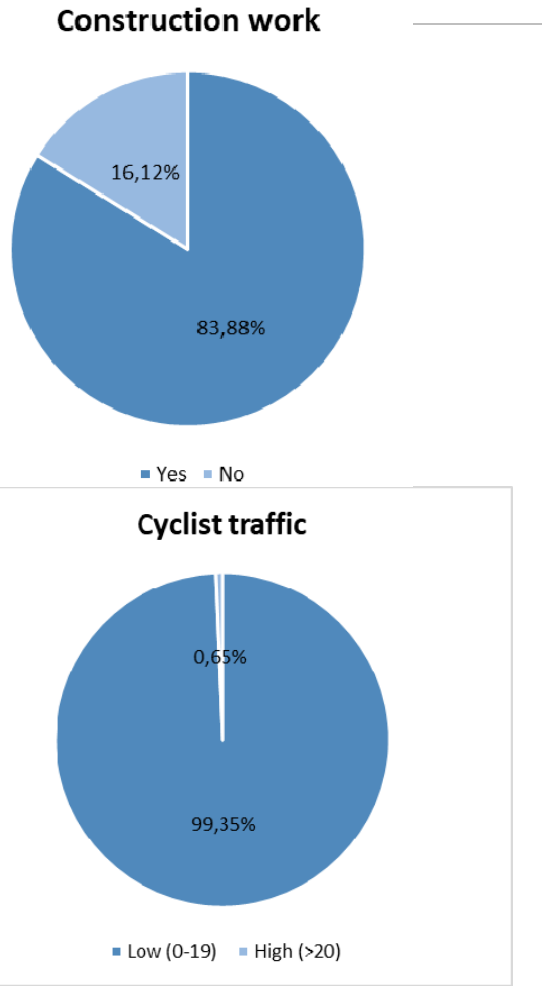
Results: Situational measures







Results: self-reported stress and situational measures: 2 models

	Multifactorial logistic regression model	Decision-tree model (top 5)
Y variable	DAS	DAS
Significant predictors	oNumber of lanes under construction (+) oWork state: on task (+) oTraffic density (car) (+) oTraffic density(ped)(+) oNumber of lanes (+)	oTraffic density(ped) oTraffic density (car) oNumber of lanes under construction (4 lanes+) oNumber of lanes (2+) oWork state: off task
Predictive accuracy	66.04% (κappa = .24)	79.13% (κappa = .53)

Discussion

- **Stress measurements were sensitive to situational risk factors and could be predicted using an ensemble of physiological responses**
  - Better predictive accuracy using decision-tree modeling
- **These stress models could be used as prevention and monitoring tools for:**
  - Detecting in real time high-stress situations among pedestrian workers
  - Predicting environments in which workers may be more stressed and at risk

- ***Such prevention strategies may help mitigate stress and, potentially, some high-consequence errors and occupational road injuries among pedestrian workers***

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Thank you! Questions?

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