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The Influence of Driver's Working Environment on Thermical Changes of Their Organism

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The work presents the research on the influence of driver's working environment on thermical changes in their organism. The experiment was conducted between 24 and 31 March 2008 in the tram depot of Public Transport Agency in Tychy. Thermo-visual photos were conducted twice a day — before starting work and after finishing it during six following days. The group consisted of 14 drivers aged 24–49 driving city buses (the make: Solaris Urbino 18). The results were analyzed concerning statistics using Statistica. For the sake of the analysis the significance level was $p = 0.05$, the non-parametric Wilcoxon test or parametric T-test were used for two groups of dependent variables. The research and analysis show that driver's working environment has valid influence on thermical changes in their organism.

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1. Introduction

The drivers and passengers of public transport are exposed to two dominant factors from the work environment: low-frequency vibration and noise. Their source is, among others, driving gear, suspension and driving conditions (rolling resistance, type of surface, temperature, humidity and wind). The following work focuses on one dominant factor, namely vibration.

As early as 1877 Erisman made an observation concerning changes in the organisms of transport workers [1, 2]. The vibration complaint affects road transport drivers, although the effect is smaller due to modern methods of vibration reduction. In the majority of vehicles the vibration level is lower than maximum figure permitted by ISO 263 1-1:1997 [3] or 2002/44WE directive [4]. In spite of the attempts to eliminate vibration from the work environment there are still some complaints among drivers such as back pains called LBP (low back pain). The first symptoms of LBP can be observed very early among drivers, while among other under 35-year-old machinery operators after about 5 years of work [2]. The reason of this pain may be the uncomfortable driving position, badly shaped seat, lack of or old support to protect the spine [5]. Numerous research has been carried out to establish the cause of LBP. It has shown that vibration of the vehicle results, in many cases, in low back swelling (bigger than among average man) in dyscopathy and backache [6]. It has been observed that diversion of the support results in the increase or decrease of the driver's height [6–9]. Some of the research verifying this observation were different from earlier conclusions. They tried to prove that the increase or decrease of the driver's height depends mainly on frequency and acceleration of the generated stimulus [10]. As we can see in the literature, it is has not been proved which is better: to lengthen the spine or to shorten it, although some authors claim that vibration might be the best method to prevent the spine from shortening, which naturally occurs during the day and withdraws during sleep [5].

The research was started because there was no holistic exploration concerning the influence of work environment on the driver's organism. Nor was the research concerning thermal changes, stability of posture, basic physiological organism parameters, like: systolic and diastolic pressure, body temperature measured in the ear canal, amount of fatty tissue, body mass, physical fitness (squeezing and pressing) and biochemical parameters of blood.

The main aim of the work was to show the influence, or its lack, of the work environment on the driver's organism. The experiment was carried out at the bus depot of Public Transport Agency in Tychy. The study was conducted for six following days in a group of 14 drivers using Solaris Urbino 18 buses. Each study was performed twice a day, before and after work. The biochemical study of the blood was performed twice, after 3-day rest before starting the weekly work and after its finishing.

The work includes only the analysis of changes in thermo–visual parameters; the remaining analysis will be presented in due course.

2. Methodology of research

Radiation measurements were taken in accordance with the regulations currently Thermography is a fully painless, non–invasive and simple method of monitoring

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the changes of temperature with time. The obtained results will be objective and correct only when the standards concerning the registration of thermographs are followed.

A man is a homogeneous creature: they can keep the body temperature at a certain level in spite of changes in the surrounding temperature. Blood going through heart has the temperature of 37 ℃ and thanks to the special inner mechanism undergoes almost no changes at all. The temperature measured in different part of a body is different: in oral cavity it varies from 36.3 to 37.3 ℃, in rectum it is higher from 0.3 to 0.5 ℃, while in armpit it is lower from 0.3 to 0.5 ℃. The average temperature on the skin surface varies from 33.5 ℃ to 34.0 ℃ [11–13].

The living organism looses heat to the surrounding of lower temperature through skin (radiation, conduction and sweating), through respiratory system (with air expiration), through digestive tract and urinary system. The increase in blood temperature going to hypothalamus, thermoregulation centre, stimulates thermodetectors and makes the loss of heat quicker, which is the result of dilatation of skin vessels, sweat glands work, acceleration of heart activity and deeper breath. Most blood goes through lungs, so more heat is released with out-breathing. The amount of heat in the organism depends on basic metabolism connected with rest activity of all cells and organs, which is necessary to keep organism alive. It also depends on the work of skeletal muscles during movement and depents on the activity of digestive system connected with digestion and absorption of food.

Too much heat produced in the organism is expelled outside, while its lack makes the physiological mechanisms produce it [11]. In many situations the work of balanced heat system may be distracted, thus every general or local increase or decrease o temperature has a diagnosis information. Local increase or decrease of temperature is connected with the rise or fall of metabolism.

The room in which the experiment is carried out must be spacious, with min. 2×3 m. The distance between the man and the camera must be long enough to make the picture of the whole body — it depends on man's height and camera's lenses. The average distance is 2 m. The room should have a separate place for the person to take their clothes off, to uncover the place to be examined and to adapt to the conditions of exploration for 10–15 min.

The surrounding temperature during thermo-visual experiment should be constant with out exceeding 1 ℃ per hour. The examined person should feel comfortably in temperatures 18–25 ℃. Recommended humidity of the air is 45–55% [13–15]. The person should not have big meal before the examination, nor hot or cold drinks. Intensive exercise is not allowed. Psychological factors such as stress or worry can also influence the results.

A basic condition of good quality of thermal pictures is camera sharpness; the examined surface should be put vertically to the direction of observation.

It is necessary to establish standard projections of patient's body regarding the camera in order to enable repeatability of measurements [11, 15, 16]. The most important factors in evaluation of thermograms are the abilities and experience of the person who interprets them. Current software makes it possible to cover the picture with different pallet of colours: grey scale, rainbow scale or iron scale. The research is being carried out to establish quantity methods to help classify thermograms in order to minimalize the errors of subjective estimate. The simplest quantity method is to compare the temperatures in symmetric domains on the left and right sides, taking the anatomic lines as symmetric: a spine, sternum, nose [2–4, 8, 10]. Another research is being conducted using more advanced features of pictures to evaluate thermograms and neuron networks for their classification [17–19].

Fig. 1. Fluke Ti25 thermovisional camera.

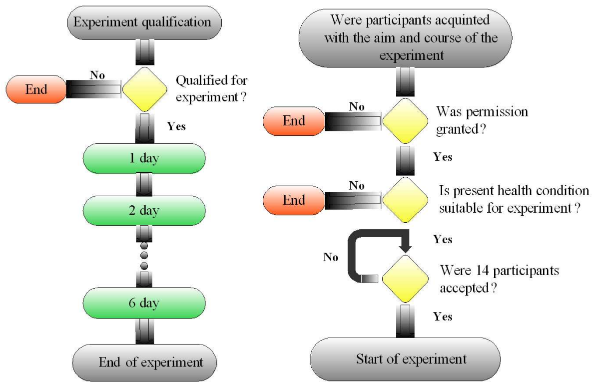

Fig. 2. Algorithm of the experiment in practice and algorithm of the experiment qualification.

Infrared cameras used nowadays have an option of minimum distinguishable change of temperature of 0.1 ℃, whereas there are systems which guarantee even better resolution [Fig. 1, Table I]. One can meet three types of cameras depending on a type of detector. The first two use photon detectors — so-called short-wave cameras which usually operate in 2–5.6 μm or long-wave ones 7–13 μm which are most often cooled by Stirling engine or thermoelectric cooler. A short–wave camera is more sensitive to the radiation of sunlight and artificial light. The third group consists of cameras with thermic detectors which are non-selective and their spectral range depends on the type of applied optics. Modern cameras have detector matrix so called FPA (Focal Pianę Array) which consist of e.g. 320 × 240 detectors (pixels) where the resolution is 1024 × 1024. These cameras are often not cooled so easy to use with excellent technical parameters; not much bigger than a typical video camera. One can obtain 30 pictures per second, but there are a faster systems. In modern cameras resolution of a signal is 14–16 bites and a digital picture can be easily processed and stored. At present software in cameras uses advanced correction techniques which enable to correct the emission of the object, to focus the lens and to visualize thermogram in a chosen palette [15, 20, 21].

Participants of the experiment were chosen from a group of drivers in Public Transport Agency in Tychy. The experiment was from 24 to 31 March 2008 for six following days. The main criterion was their health and medical examination; only healthy person could take part which was voluntary. 14 drivers were qualified; men aged 24–49. The algorithm showing the experiment and the qualification to the experiment is shown on Fig. 2.

TABLE I

Technical (A) and environmental (B) parameters of thermovisional camera.

A	
Measurement range	−20 °C to +350 °C (2 sub-ranges)
Precision	±2 °C or 2% (greater of the two)
NETD	< 0.1 °C at 30 °C
Resolution of matrix (infrared)	160 × 120 pixels
Resolution of matrix (visible light)	640 × 480 pixels
Vision area(FOV)	23° horizontally × 17° vertically
Min measure distance	Infrared: 15 cm; Visible light: 46 cm
Measure modes	Central point and the coldest and the hottest points
Ways of projecting pictures	Picture–in–picture and thermographic picture
Minimum range width	5 °C/2.5 °C
B	
Work temperature	−10 °C to +50 °C
Relative humidity	10% to 90%
Level of protection	IP54
Resistance to a fall from 2 m	yes
Mass with a battery	1.2 kg
Measurements	267 mm × 127 mm × 152 mm

3. Results

The experiment was conducted every day (according to the drivers' timetable). The temperature was measured in a standing position in ten experimental situations. The picture of the face was scanned (head and front), legs-front, legs-back, trunk-front and trunk-back. The procedure was repeated at the beginning (P) and the end (K) of a working day. For each zone a temperature was indicated: maximum, minimum and average. Numeric analysis was prepared in Statistica 8.1. A zero hypothesis H 0 was assumed: driver's work environment does not cause changes of temperature with the level of relevance < 0.05.

Having conducted the experiment they received a matrix of 'initial" results with 30 analyzed dependent variables for 14 cases. The results underwent numeric analysis according to the algorithm of statistic conclusion. The dispersion of initial results was examined as to avoid measurement mistakes. All the variables had descriptive statistics calculated (e.g. average, standard deviation, 95% confidence interval) and differences relevance tests (Tables II and III, Figs. 3 and 4).

TABLE II

Descriptive statistics and difference relevance tests (* SD — standard deviation; ** 95%CI — 95% confidence interval).

Dependent variable [℃]	Average	SD*	−95% CI**	+95% CI**
$T_{\max}$ head P	37.043	0.435	36.792	37.294
$T_{\max}$ head K	36.877	0.604	36.529	37.226
$T_{\min}$ head P	26.227	1.043	25.625	26.829
$T_{\min}$ head K	25.658	0.885	25.148	26.169
T_{av} head P	33.869	0.771	33.424	34.314
T_{av} head K	33.768	0.876	33.262	34.274
$T_{\max}$ legs front P	33.611	0.577	33.277	33.944
$T_{\max}$ legs front K	33.795	0.576	33.463	34.128
$T_{\min}$ legs front P	23.325	0.714	22.913	23.737
$T_{\min}$ legs front K	22.863	0.831	22.383	23.343
T_{av} legs front P	30.707	0.792	30.250	31.164
T_{av} legs front K	30.313	0.730	29.892	30.735
$T_{\max}$ legs back P	34.035	0.605	33.685	34.384
$T_{\max}$ legs back K	34.039	0.686	33.643	34.435
$T_{\min}$ legs back P	23.796	0.696	23.395	24.198
$T_{\min}$ legs back K	23.252	0.644	22.880	23.624
T_{av} legs back P	30.763	1.070	30.146	31.381
T_{av} legs back K	31.286	0.645	30.913	31.658
$T_{\max}$ trunk front P	33.848	0.482	33.570	34.126
$T_{\max}$ trunk front K	35.677	0.397	35.448	35.907
$T_{\min}$ trunk front P	25.135	0.636	24.767	25.502
$T_{\min}$ trunk front K	23.739	0.787	23.285	24.194
T_{av} trunk front P	33.081	0.608	32.730	33.432
T_{av} trunk front K	33.027	0.500	32.739	33.316
$T_{\max}$ trunk back P	35.271	0.719	34.856	35.687
$T_{\max}$ trunk back K	35.739	0.368	35.527	35.952
$T_{\min}$ trunk back P	24.126	0.745	23.696	24.556
$T_{\min}$ trunk back K	23.804	0.601	23.457	24.151
T_{av} trunk back P	32.540	0.798	32.080	33.001
T_{av} trunk back K	33.113	0.349	32.912	33.314

TABLE III

Descriptive statistics and difference relevance tests (p^{***} — test probability (p — value, a — test t for independent variables, b — Wilcoxon test).

Dependent variable [℃]	Average	Difference	p***	Changes fraction	
				%	increase, decrease
$T_{\min}$ legs back P	23.796	−0.544	0.040^{a}		↓
$T_{\min}$ legs back K	23.252			71	
$T_{\max}$ trunk front P	33.848	1.830	$< 10^{-8\,a}$		↑
$T_{\max}$ trunk front K	35.677			100	
$T_{\min}$ trunk front P	25.135				↓
$T_{\min}$ trunk front K	23.739	−1.395	0.001^{b}	100	
$T_{\max}$ trunk back P	35.271	0.468	0.031^{a}		↑
$T_{\max}$ trunk back K	35.739			79	
T_{av} trunk back P	32.540	0.573	0.014^{a}		↑
T_{av} trunk back K	33.113			71	

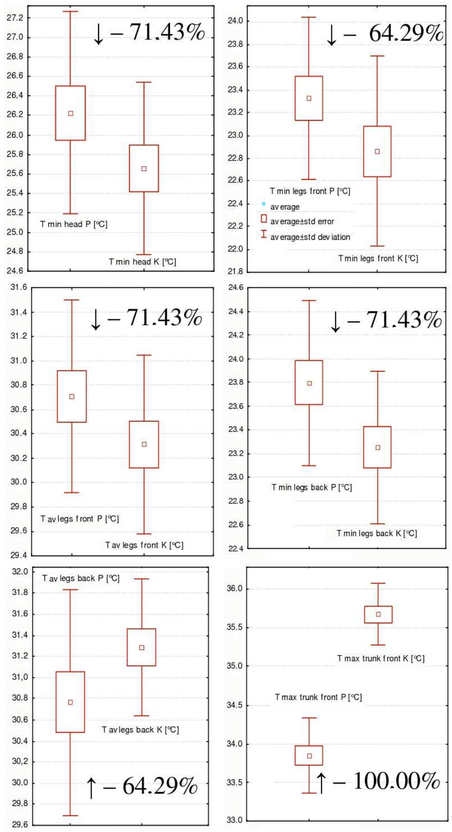

Fig. 3. Graphic analysis of thermal changes (changes fraction > 60%).

4. Conclusions

Following the experiment results and analysis we can state that drivers working conditions cause statistically valid:

increase of values:

- maximum temperature, trunk front [°C] from 33.848 ± 0.482 to 35.677 ± 0.397 among 100% of the participants with $p < 10^{-8}$,
- maximum temperature, trunk back [°C] from 35.271 ± 0.719 to 35.739 ± 0.368 among 79% with $p < 0.031$,
- average temperature, trunk back [°C] from 32.540 ± 0.719 to 33.113 ± 0.368 among 71% with $p < 0.014$,

decrease of values:

- minimum temperature, legs back [°C] from 23.796 ± 0.696 to 23.252 ± 0.644 among 71% participants $p < 0.04$,
- minimum temperature, trunk front [°C] from 25.135 ± 0.636 to 23.739 ± 0.787 among 100% with $p < 0.001$,

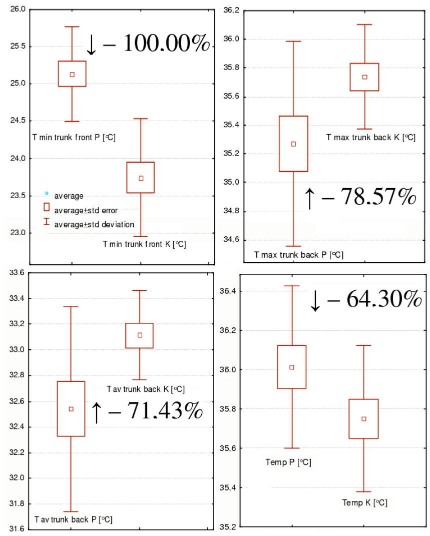

Fig. 4. Graphic analysis of thermal changes (changes fraction > 60%).

statistically irrelevant decrease of values:

- minimum temperature of a head among 71% participants,
- minimum temperature legs front among 64%,
- average temperature legs, front among 71%,

statistically irrelevant increase of average temperature of legs, back among 64%.

The increase in changes range ($T_{\min}$, $T_{\max}$) for the trunk and legs in each experimental situation which was observed, together with the increase of maximum temperature of the trunk and average temperature trunk-back, may indicate greater work of postural muscles responsible for vertical sitting position and smaller work of muscles in the front part of a trunk and legs.

The research was conducted within own experimental work no. 10.10.130.631 and statutory no. 11.11.130.119.

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