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RESPIRATION UNDER MONOTONOUS HYPOKINETIC CONDITIONS. FIRST RESULTS

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SUMMARY

The aim of our work is to assess the influence of tiredness on changes in respiratory parameters during monotonous hypokinetic loading. In the current phase of the work, we are looking for the answer to the question whether these changes can predict upcoming tiredness or indicate only.

On the pilot measurement, three males and two females aged 25–35 were participated. To capture the transition states of consciousness, a measurement was proposed in two modes: active vs. tired individual. For recording of breathing, two chest straps and a spiroergometer were used. Symptoms of tiredness were monitored by ECG and EEG. The course of the experiment was recorded by a video camera.

Currently, we process the obtained data and from actual results, we can confirm that the upcomming tiredness can be with certainty found in the respiratory curves. The upcoming tiredness assessed merely by subjective analysis of videos was apparently associated with changes in breathing pattern. Quite a clear answer, if changes of the breathing pattern has predictive or indicative character, we will obtain from further comparison the respiratory curves with results of analyses of EEG and ECG signals, which are currently under processing.

Key words: respiration, tiredness, hypokinetic load, monotony

INTRODUCTION

The restriction of movement (hypokinetic load) and repeatedly performed (monotone) activities cause an increase in number of errors in a performed task thereby lead to the lower operating performance. As those phenomena can be confounded by many other activities of any particular person, there is still a need for more reliable detection of upcoming tiredness, which would effectively warned of its arrival and helped prevent the potential negative effects and/or risks. Systems for monitoring drivers' attention, which are installed in vehicles of some manufacturers (Volvo, M-B, etc.) may serve as a typical

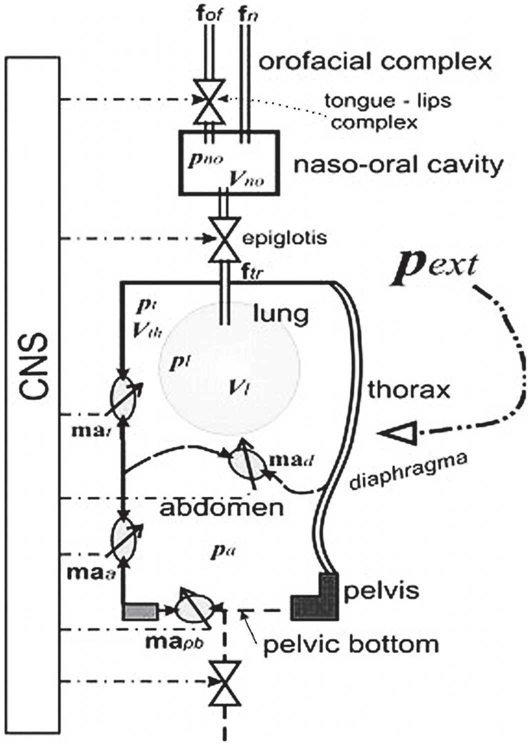

Figure 1. A model of the situation – relations between cooperating subsystems (adopted from Otáhal, 2010).

example of this approach. Most of those systems are based on monitoring of driver's behavior, monitoring of eye movements, etc., while monitoring of respiratory parameters have not been widely investigated (Novák, 2002).

The aim of our work is to assess the influence of tiredness on changes in respiratory parameters during monotonous hypokinetic loading. In the current phase of the work, we try to answer the question whether those changes can predict the upcoming tiredness or occur just concurrently.

The overall breathing pattern results from quite many phenomena and events. Air flow changes under normal conditions are governed by setting the active elements of the system (abdominal muscles, diaphragm, intercostal muscles, chest muscles and pelvic floor), influenced by external environment, modulated by the change in diameter of the upper and lower respiratory tract (trachea, glottis, oral cavity) and controlled by central nervous system (CNS) (Otáhal, 2010). The problem of respiration during monotonous hypokinetic load can be understood as a question of mutual relations of the mentioned subsystems (Fig. 1).

External conditions do not change significantly and their influence remains constant. Active components also remain in a mostly unchanged as well as properties of the upper and lower respiratory tract. That leaves the CNS, which thus has crutial influence on the character of breathing for the given conditions. For this reason, we believe that the

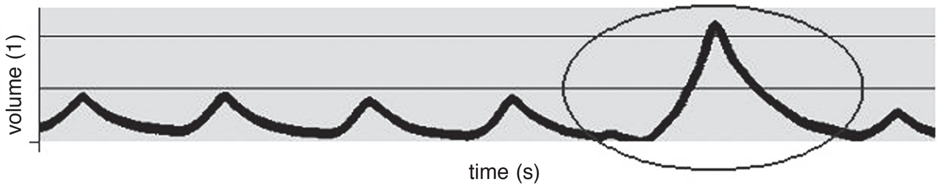

Figure 2. Steady respiration with a non-stationarity.

information about tiredness could be reliably detected from the breathing curves. Because tiredness results from many processes that are influenced by the CNS and vice versa, one can suppose that changes of breathing could predict the upcoming tiredness early.

Definition of used terms

Monotonous hypokinetic load is caused by the mobility restriction which leads to motoric deprivation and by restriction of number of inputs from sensors (proprio and exteroceptors) which causes ther sensoric deprivation. These phenomena give rise to the so called sensomotoric tiredness together (Jančík, 2007).

To assess the changes of respiratory curves, we introduce the concept of non-stationarity which are understood like time-limited periods radically different from the long-term steady breathing (Fig. 2).

Experiment setup

To capture the transition states of consciousness, we designed the measurement as two-phased, with an alert vs. a tired proband. Tiredness was induced by overnight sleep deprivation. The same person was measured in both phases. Each phase consited of two intervals differing in atention required from the proband. The overall measurement schedule was as follows:

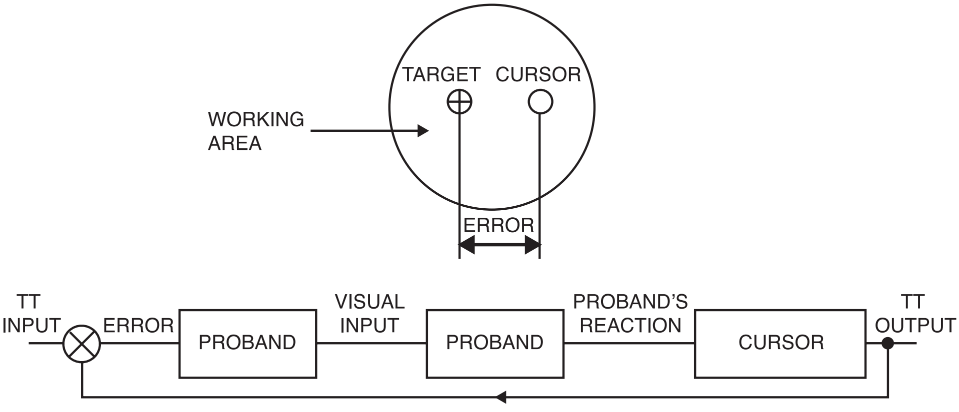

Figure 3. The tracking task – the principle (adopted from Otáhal, 2010).

Figure 4. The workplace

1. alert proband performing repetitive activity (tracking task; TT) requiring his attention,
2. alert proband watching TV without any need to keep the attention,
3. tired proband performing the TT,
4. tired proband watching TV.

Each proband was measure in two consequentil stages in two different days. In the first stage (after a 30-minute training), the proband performed the TT on a PC with highest possible precision for 1.5 hours. The task was to follow the goal on the monitor by cursor controlled by joystick (Fig. 3.).

After about 30 minutes break for toilet, snack or short physical exercise, the proband watched a movie for cca 1.5 hours fully relaxed.

The second phase were done under the same conditions after overnight sleep deprivation.

For recording of breathing, two chest straps and a spiroergometer were used. Tiredness was monitored by ECG and EEG (Smrčka, 2002). The course of the experiment was recorded by a video camera. For communication with the proband, a web camera with a microphone was installed (Fig. 4).

Three males and two females aged 25–35 participated in the pilot experiment. None of them took any medication and all were in good health condition corresponding to their age.

Data processing

Currently, we are completing the first stage of processing the data which is focused on evaluation of incidence of non-stationarities in comparison with the subjective assessment of the video in which the time of the upcoming tiredness start was determined by five different persons.

For the video analysis, a methodology developed and validated in the project of CTU "sleeping driver – waken car" was used. The method consists of assessing of the video by more people who mark the time of upcoming tiredness. The final value of the time of upcoming tiredness for each video was calculated as arithmetical average of times determined by the 5 evaluators. Despite the high degree of subjectivity, this method seems to be very reliable because of low variability of particular designated times.

The respiratory curves were segmented in two-minutes intervals in which the non-stationarities incidence was calculated. These particular results were arranged into a plot as a function of time.

The evaluation of the data is based on the comparison of times obtained from the analysis of the video-recordings with corresponding graphs of the incidence of non-stationarities.

RESULTS AND CONCLUSION

Currently with regards to the actual results, we can confirm that the upcoming tiredness can be with certainty found in the respiratory curves. The upcoming tiredness assessed merely by subjective analysis of videos was apparently associated with changes in breathing pattern (Fig. 5).

Quite a clear answer, if changes of the breathing pattern has predictive or indicative character, we will obtain from further comparison the respiratory curves with results of analyses of EEG and ECG signals, which are currently under processing.

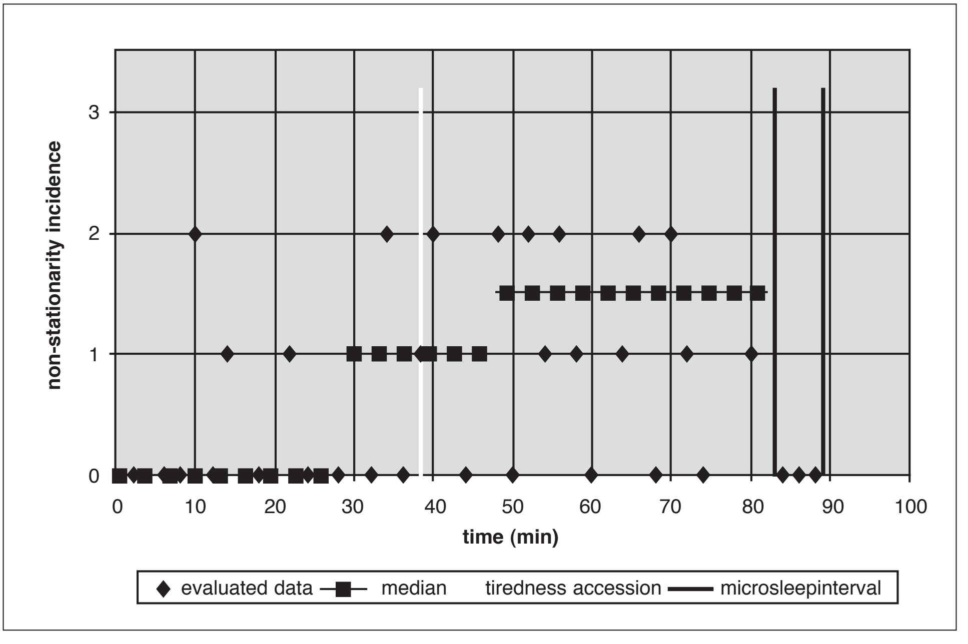

Figure 5. Incidence of breathing non-stationarities in time (an example).

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RESPIRACE ZA MONOTÓNNÍCH HYPOKINETICKÝCH PODMÍNEK. PRVNÍ VÝSLEDKY

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SOUHRN

Cílem naší práce je zhodnotit vliv únavy na změny dechových parametrů v pdmínkách hypokinetické monotónní zátěže. V současné fázi práce hledáme odpověď na otázku, zda tyto změny mohou nástup únavy predikovat, či zda jej pouze indikují.

Pilotního měření se zúčastnili dvě ženy a tři muži ve věku 25–35 let. Pro zachycení přechodových stavů mysli byl experiment proveden ve dvou variantách: čilý vs. unavený proband. Dech byl zaznamenáván prostřednictvím dvou hrudních pásů a spiroergometru. Projevy únavy byly monitorovány pomocí EKG a EEG. Vlastní průběh experimentu byl nahráván na video.

V současné době zpracováváme získaná data a z dosavadních výsledků můžeme potvrdit, že nástup únavy je v dechových křivkách viditelný. Nástup únavy byl posuzován prozatím pouze analýzou videozáznamů porovnávaných z časového hlediska s příslušnými záznamy dechových křivek. Zcela jasnou odpověď, zda změny dechových parametrů mají prediktivní nebo pouze indikativní charakter, získáme z následujících porovnání dechových křivek se záznamy EEG a EKG, která v současné době probíhají.

Klíčová slova: dýchání, respirace, únava, hypokinetická zátěž, monotonie

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