The main objective of this study was to determine the effect of stress of a practical, thirty-hour driving course on changes in salivary cortisol concentration and on changes in systolic and diastolic blood pressure. The second objective was to determine the relation between the style of coping with stress (psychological indicator) and changes in the assessed biological parameters.

All volunteers aged 18-30 years completed the Coping Inventory for Stressful Situations (CISS) before the start of the course. They were divided into control (n=15) and experimental (n=18) groups. In the experimental group saliva samples to measure cortisol were collected from each participant: before the start of the course, before the 1st, 13th and 28th driving hour, and blood pressure was measured before the course, during the 15th and 30th hour of the course. Participants in the control group had one saliva sample taken and their blood pressure was measured once at the same time.

The results suggest that cortisol concentration in saliva correlates with the hour of the course. Systolic and diastolic pressure also correlates with the hour of the course. CISS test related differences among the individuals in copying with stress (psychological indicator) but they did not correlate with the cortisol and blood pressure responses.

A driving course is a stress factor that causes changes in salivary cortisol concentration and systolic and diastolic blood pressure. The style of coping with stress does not correlate with changes in the salivary cortisol concentration during the course. Changes in systolic and diastolic blood pressure during the driving course do not depend on the way of coping with stress.

**Key words:** stress, coping, cortisol, driving license, students
BACKGROUND

A driving license course and the concluding state exam (test) are stressful events for the participants. As a result of a neurohormonal response to the stressor, adrenal hormones are secreted, in humans these being mainly cortisol, to the peripheral circulation. Increasing the concentration of steroid hormones launches a series of adaptive responses facilitating functioning of the brain and muscles in an emergency.

Making decision about signing up for a driving course is often accompanied by anxiety, which can sometimes be further aggravated by circumstances. This is due to the fact that having a driving license can help to fulfil life dreams, such as having a stable, well-paid job. The stress experienced by students is sometimes augmented by the demands of the driving instructor, family and friends, as well as by those taking the course themselves. The environmental requirements can constitute support or a barrier en route to the goal [Borecka–Biernat 2006].

The harmful effects of a stressor interpreted as a threat to the individual can affect different intellectual functions. Mild stress preferred in cognitive tasks affected results by increasing efficiency, while stress with a higher intensity resulted in mental health disorders, such as depression or anxiety [Skybo, Buck 2007]. Usually, the greater the stress, the greater its negative effects on the cognitive abilities manifested as a decrease in intellectual performance and a distortion in thinking flexibility.

Dealing with stress is a process by which a human seeks to neutralize excessively aggravating factors [Miller O’Callaghan 2002]. It is defined by a „relatively stable individual predisposition to the use of certain forms of coping with stressful situations” [Terelak 2001; Wrześniewski et al. 2006].

Strelau et al (2007) have identified three main ways of coping with stress. Emotional way is characterized by a person focusing in a stressful situation on their own emotional experiences. Persons seeking to solve the problems by trying to change the situation display a task style of coping with stress. While an escape style of coping with stressful situations describes the units bewaring the thinking, experiencing a stressful situation.

In the context of an examination, anxiety is understood as „a state, or a feeling of fear and tension that are perceived consciously and subjectively.” Anxiety is dependent on factors in a particular situation interpreted as a threat [Guzik 2001]. Both the theoretical test and the practical part of the driving course should be considered in the category of examination stress. Despite the fact that course participants are familiar with the requirements and rules for both types of test, this is a situation associated with a high degree of uncertainty. The examined person is subjected to evaluation and is exposed to criticism by the examiner, which results in a decrease of self-esteem. The exam score is considered to be „a test of their abilities” [Borecka–Biernat 2006].

The main objective of this study was to determine the effect of stress of the practical, thirty-hour driving course on changes in salivary cortisol concentration and on changes in systolic and diastolic blood pressure. The second objective
was to determine the relation between the style of coping with stress (psychological indicator) and changes in the assessed biological parameters.

**MATERIAL AND METHODS**

The study involved volunteers aged 18 to 30 years participating in a category B driving course (a vehicle up to 3.5 t in weight). They were divided into control (n=15) and experimental (n=18) groups. Before starting the course, all participants were asked to fill in the CISS questionnaire (Fig. 1). Based on the completed CISS questionnaire they were divided into 3 groups, according to sex, age and style of coping with stress. Examinations of saliva cortisol have been widely used to assess secretion of the hormone since the early eighties.

Saliva samples for measuring the concentration of cortisol were collected from each participant four times: before the start of the practical course, before the first, thirteenth and twenty-eighth hour of driving instruction (Fig. 1). The samples were frozen pending the radioimmunoassay (RIA) determination of the concentration of cortisol in saliva.

Systolic and diastolic blood pressure were measured before the course and during the fifteenth and thirtieth hour of course (Fig. 1).

In addition, a control group was included (15 people) to investigate any possible differences of the tested parameters within the population.

The results are presented as means ±SD. A two-way analysis of variance (ANOVA) followed by a post-hoc Tukey test was used for the statistical analysis.

**RESULTS**

The results suggest that the stress associated with the start of a practical, thirty-hour driving course caused an increase in cortisol concentration in saliva that was dependant only on the time the samples were taken (Fig. 2).

There were no statistically significant differences in the cortisol concentration between the sexes, different age groups and participants exhibiting different

![Fig. 1. The experimental procedure: 0, 1, 13, 15, 25, 28, 30 – hour of the driving course; splotches – blood pressure test; question mark – paper tests and questionnaires; tubes – saliva samples collecting; racing flags – internal practical examination](image-url)
ways of coping with stress. After the start of the practical course, there was also a significant increase in systolic and diastolic blood pressure (Fig. 3).

In both cases, the time when the sample was taken was important, while the sex of the course participants, their age and ways of coping with stress were not significant factors. During the twenty fifth hour of the course a practical driving test was conducted. There were no statistically significant differences in the positive or negative assessment, among men and women, different age groups, and different styles of coping with stress. Interestingly, all the women representing the younger (18-23 years) age group passed the exam (test). The behavioral assessment of stress intensity during the course as performed by a driving instructor correlated with the time of evaluating (Fig. 4).

![Fig. 2. Concentration of cortisol in saliva during the driving course; * p <0.05](image1)

![Fig. 3. Systolic (SYS) and diastolic (DIA) pressure during the driving course; * p <0.05](image2)
DISCUSSION

In this study the effect of stress during a driving course was determined based on those psychological and biological indicators considered to be signs of a stress response. The secretion of cortisol, in humans commonly called the „stress hormone” [Kenwright & Liddell, 2011], is associated with the activation of the HPA. This is a natural reaction of the body in response to stimulation [Lazarus & Folkman 1984], though it has been recognized that increased concentration of this hormone has not been clearly associated with a high level of stress. Differences in the susceptibility to stress in individuals of both sexes (men and women) are dependent on a number of factors, including the type of stressor, endogenous hormonal status [Pekrun et al. 2004] or age-related changes [Chaplain 2000].

Although the students were informed about the purpose and method of carrying out the study, they did not know the exact schedule thereby excluding the possibility of memorizing the sequence of events and the element of excitation associated with the expected collection of samples of saliva or blood pressure measurement. In humans, the process of waiting for a specific, exciting event (for example, an exam) can induce a significant increase in the concentration of cortisol in saliva, something which was observed by Smyth in 1998 [Swales 1997].

The last saliva sample was collected before the final driving lesson (the 28th -30th hour of the course). There was no statistically significant increase in cortisol concentration as a result of the upcoming state driving test. However, the results could have been different if the samples had been taken immediately before the test itself.

The results showed that an increase in systolic and diastolic blood pressure depended only on the time of sampling, but according to Swales (1997) there is a connection between blood pressure, gender and age. According to Morys et al (2005), blood pressure does not differ during puberty in girls and boys. After this period an increase in blood pressure is observed, wherein in girls it is slower. In adults, both systolic and diastolic pressure increases. Due to the fact that women age faster than men, in elderly people (about 70 years old) the blood
pressure in both sexes is compensated for. Changes in blood pressure also occur as a result of the situation. In emergencies the peripheral blood vessels become narrow, and the heart rate and blood pressure increase [Kasuya et al 2002]. Concomitantly an increase in the amount of blood flowing through the heart and an increase in left ventricular work, resulting in an increased consumption of oxygen by the myocardium, is observed. This is a physiological defensive reaction of the body. Fainting or a very bad mood in healthy people under low stress, can be a manifestation of an excessive reaction of the cardiovascular system, which in people diagnosed with cardio-vascular diseases can cause life-threatening situation (myocardial infarction, strokes, a sudden cardiac arrest) [Singh et al 2012]. Therefore, the inclusion of a survey with questions about cardio-vascular problems or diseases seems to be justified.

The results of this study confirmed the hypothesis that stress on the practical driving course changes the concentration of cortisol in saliva, as well as the systolic and diastolic blood pressure. In addition, the results indicate no association between the studied biological parameters and the preferred way of coping with stress. This is consistent with previous studies [Terelak 2001], although it can be observed that despite the absence of a significant statistical dependence a mixed ways of coping with stress obtained weaker results, while those representing the emotional ways. This may be due to the difference in the level of hope for success. Pekrun et al. (2004) while other researchers (including Andrews and Wilding, 2004) have focused on the relationship with the accompanying anxiety achievements. And they have observed a significant correlation between an emotional ways of coping with stress and high levels of anxiety [Singh et al 2012]. The researchers suggest that the interdependence of a high level of hope for success and the task ways of coping with stress (a style concentrated on the tasks), and the emotional ways of coping with stress are associated with a low level of hope for success [Guzik 2001]. No statistically significant differences between the studied biological indicators of stress and the ways of coping with stress were found. This confirms the general increase in the level of stress in people representing a different ways of coping with stress associated with the new situation which is the start of practical driving. The results relating to increased stress levels as a response to the threat confirm the theoretical assumptions and the results of previous studies [Goluch 2011]. Women tended to be better than men during the twenty-fifth hour of the course during the internal exam (test), but the result was not statistically significant. The same situation occurs in the case of the results obtained by the younger and older age group as viewed – despite there being no statistically significant difference in people under twenty-four years old, they did gain a better result.

Based on the obtained results it can be concluded that for people enrolling on a driving course, driving (as a completely new experience in life) is treated as a threatening situation. This was confirmed in Goluch’s studies (2011), which indicated „a general increase in the level of anxiety” before the first hour of practical driving. However, these data are contrary to the results presented by Weber
and Bizera (2006). They showed an intensification of anxiety levels in preparation for the exam (test). Yet, our data confirmed the views of Skybo and Buck (2007), who examined the perception of exams in school-age children and showed that „exams are perceived as more stressful at the beginning of the school year, but a few days before exams are perceived as less stressful“ [Guzik 2001]. This can be explained by a significant increase in the concentration of cortisol in students’ saliva at the beginning of the practical course and the gradual decline as the course progresses.

In the experimental group the cortisol levels before a stressful event, such as a driving license test grew as expected. That increase might be connected with the fact that it is a completely new experience in the participants’ life. Despite contact with various everyday stressors and the need to deal with them, the beginning of a driving course though providing a strong incentive. Over the duration of the course, the concentration of cortisol in students’ saliva decreased, which could be expected because repeated exposure to the same stressor can lead to a lack of response; something we call adaptation or habit [Moryś et al. 2005]. Another explanation may be that student mastered the skills to effectively „manage“ stress in the specific condition which was driving a car. This would explain the lack of an increase in cortisol levels in the saliva of students before the upcoming state exam (test).

This preliminary study indicates problems which should be addresses before a more advanced study can be carried out. The main issue is the sampling of saliva - appropriate instructions given to participants, checking whether the product is well marked, placing the samples on ice for transport to a laboratory where they will remain frozen until the determination of the hormone concentration.

The experiment includes broadly defined issues of stress examination. The results suggest that some biological indicators of stress may be independent of the style of coping with stress. Further studies with additional variables that may affect the biological indicators of stress and ones conducted with a larger participant group are needed to explore more thoroughly the relation between the ways of coping with stress and biological stress parameters.

Our results on the effect of stress determined by psychological and biological indicators during the driving course, ones considered as signs of a stress response, might be interpreted according to the microgenetic theory of brain function (Pachalska, Góral-Pólrola, Mueller & Kropotov 2017).

**CONCLUSIONS**

A driving course is a stress factor that causes changes in the salivary cortisol concentration and systolic and diastolic blood pressure. The ways of coping with stress does not correlate with changes in salivary cortisol concentration during the course. Changes in systolic and diastolic blood pressure during the driving course do not depend on the style of coping with stress.
ACKNOWLEDGEMENTS

The authors would like to thank Karolina Brejt, MA at the University of Gdansk and the Pomeranian Centre of Road Traffic in Gdansk for her contributions and ideas as well as Wojciech Glac- supervisor of the ‘Homunculus’ Student Scientific Society, University of Gdansk for financial support.

REFERENCES


Address for correspondence:
Martyna Siudak
Department of Animal and Human Physiology,
Faculty of Biology,
University of Gdansk, 59
Wita Stwosza Street, PL 80-308
Gdańsk, Poland
e-mail: martyna.siudak@phdstud.ug.edu.pl