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ORIGINAL ARTICLE

COGNITIVE IMPROVEMENTS FOLLOWING BODY MASS REDUCTION INDUCED BY INTRAGASTRIC BALLOON PLACEMENT IN MORBIDLY OBESE PATIENTS. A PRELIMINARY STUDY

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Introduction: Obesity and type 2 diabetes mellitus (T2DM) are associated with poorer cognitive performance. Reports suggest that bariatric surgery may lead to improvements in cognitive processes. However, the potential effects of mood improvements have not yet been evaluated. The aim of the study was to assess the effects of intragastric balloon (IGB) induced weight loss on cognitive performance in morbidly obese patients and relate them to changes in mood.

Methods: Twenty four morbidly obese patients (43.9±12.0 years of age, 145.6±22.3kg, body mass index (BMI): 49.8±6.9, 11 females, 14 with T2DM), underwent tests of visual short-term memory (Benton Visual Retention Test), sustained and divided attention (Color Trail Test), and verbal short-term memory: (Digit Span from WAIS-R) 1) a month before IGB insertion, 2) three months after, 3) one month after IGB removal. Depressive symptoms were evaluated with the Beck Depression Inventory (BDI).

Results: Significant cognitive improvement was observed over the first three months of IGB treatment in verbal short-term memory, visual short-term memory, and sustained and divided attention among all patients, regardless of their T2DM status. However, these changes correlated with weight loss only in patients without comorbid T2DM. The cognitive changes were not associated with changes in depressive symptoms. The improved cognitive performance was sustained over the last three months of the treatment.

Figures: 1 • **Tables** 1 • **References:** 37 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2018 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

Conclusions: Morbid obesity treatment with an intragastric balloon leads to cognitive improvements. These improvements are not associated with mood changes.

Keywords: cognition, obesity, type 2 diabetes mellitus, bariatric surgery, metabolic surgery, intragastric balloon

INTRODUCTION

A growing body of research demonstrates that obesity is associated with poorer cognitive processes in healthy adults [14], faster cognitive decline in the elderly [36], poorer executive functions at any age [4,11,12,28,30,31]. Compared to non-obese individuals, obese individuals demonstrate lowered performance in attention switching skills, inhibition, flexibility and attention [8,35]. Finally, it was demonstrated that a larger increase in BMI in adulthood was associated with lower executive function [31]. A series of studies focused on the speed of cognitive aging among overweight and obese in twin populations demonstrated that being overweight or obese in midlife and late midlife was associated with lower cognitive skills in later life [5,15]. Moreover, it appears that people suffering from obesity are often more prone to experience distress, depression and eating disorders, such as Binge Eating Disorder, among others [17,33].

A review article by Brandao et al. [3] revealed that 20%–56% of preoperative bariatric patients have a current psychiatric diagnosis. Moreover, the authors pointed out that major depressive disorder is the most frequent condition, followed by social phobia, anxiety disorders, somatization, hypochondria, and obsessive-compulsive disorder [3]. Higher BMI [21,34] and increased visceral fat [25] are frequently reported to be associated with depressive symptoms, e.g., in adults with current depression, or a history of diagnosed depression or anxiety [34]. Obese people are not only at a higher risk of depression but depression is also a predictor of weight gain and future obesity [2,23]. Consistently, an epidemiological study of almost 44,800 (United States) nationally representative respondents [16] demonstrated that obese women and overweight (but not obese) men were more prone to depressive mood than their non-overweight counterparts; the depressive mood was operationalized by whether or not the participant reported feeling sad, blue, or depressed for more than seven days during the month prior to answering the questionnaire.

T2DM not only exacerbates these cognitive deficits, but also detrimentally affects the following cognitive domains: abstract reasoning, memory with subdomains of working memory, immediate memory and learning rate, and incidental memory, information processing speed, attention and executive function, and visuospatial skills [37]. Furthermore, morbid conditions co-occurring with obesity, such as T2DM, may be related to declines in episodic memory [27], working, and verbal memory, as well as mental flexibility [19].

Bariatric surgery is the only effective method leading to sustained long-term weight loss and reversal of medical dysfunction associated with obesity. One explanation shows that obesity and depression can be related through inflammation [26,32]. Previous neuroimaging studies suggested that bariatric surgery leads to changes in patterns of brain activity elicited by appetitive stimuli [29], improvements in memory function over just three months following the surgery [13], and improvements in attention, executive function, and memory [1]. However, performance on tests of language functioning remained stable[1]. We have demonstrated that three-month-long treatment with an intragastric balloon (IGB) leads to remission of neuroinflammation in patients with T2DM participating in this study [10].

IGB placement is an endoscopic method of obesity treatment. It is a minimally invasive procedure inducing weight loss by reducing the gastric reservoir capacity, leading to premature satiation and prolonged satiety, and modulation of hormone levels regulating energy balance. The balloon is a smooth, spherical, saline or air-filled, silicone elastomer of the size between 500 and 800 ml. There is one type of balloon adjustable in size. Balloon treatment is temporary and the balloon should be removed after six months, except for adjustable balloon, which can remain in the stomach for 12 months. This method is used for patients who 1) need a surgery, but whose excessive weight would put them risk or reduces their likelihood of good outcome, 2) patients who refuse bariatric surgery or would benefit from a "bridge" to bariatric surgery (weight loss preceding the actual surgery), and 3) patients with a BMI of up to 35 with or without comorbidities, who have not achieved sustained weight loss with other methods.

Here, we evaluated if IGB treatment lasting for six month leads to improvements in short-term memory, processing speed, visual search and visual memory, and whether these changes are related to changes in depressive symptomatology and weight changes.

METHODS

This study was part of a larger project involving neuroimaging using magnetic resonance methods to evaluate neural changes accompanying weight loss [10]. Fourteen morbidly obese patients with comorbid T2DM (hence labeled **OD patients**, 47.9±7.8 years of age, five females, 144±28kg, BMI=47.2±6.6, %EW=89±27% — excess body weight) and 10 morbidly obese patients without T2DM (hence labeled **OB patients**, 48.6±14.9 years of age, six females, 148±13kg, BMI=53.4±5.9, percent excess body weight, EW=114±24%) underwent pen and paper versions of tests of visual short-term memory (Benton Visual Retention Test, 37), visual search and sustained and divided attention (Color Trail Test, CTT-1, CTT-2, Polish normalization, [6], auditory attention and verbal working memory (Digit Span from WAIS-R, Polish version revised and renormalized in 2004), and depressive symptoms (Polish translation of Beck Depression Inventory, BDI, [22]: a) one month before IGB insertion, b) three months after, c) one month after IBG removal (fig. 1). They were consecutive patients qualified for saline-filled IGB treatment lasting six months between April 2015 and December 2016, who did not have contraindications for magnetic resonance. Parallel versions of these tests were utilized in random order. Depressive symptoms were evaluated at all time-points. The standard cut-off scores are as follows: 0-9 — indicates no depression; 10–18 — indicates mild depression; 19-29 — indicates moderate depression; 30-63 — indicates severe depression. All tests were performed by an experienced (MJ) in a quiet room, same every time. All procedures were performed according to manuals, in the morning hours, one on one with the psychologist; no third party observers were present. Among OD, scores of four patients indicated mild depression and scores of four patients indicated moderate depression, whereas among OB two patients were qualified as having mild depression and one as having moderate depression. No patient obtained scores qualifying as having severe depression. None of the patients reported a diagnosis of major depressive disorder, nor was taking anti-depressive medications at the time of the study.

All enrolled patients were consecutive patients qualified for IGB treatment over two years, who did not have counterindications for magnetic resonance.

Among OD patients, 11 reported hypertension, ten were taking hypertension medications. However, when their blood pressure was measured, they all met the criteria for hypertension. Seven patients had dyslipidemia (five taking medications), 10 had a fatty liver diagnosis, four were cigarette smokers; smoking is a factor known to detrimentally affect cognitive function [7]. Nine of them had a history of gastritis, seven were H. Pylori positive, two patients had cholecystolithiasis, two were after cholecystectomy because of cholecystolithiasis, two had diabetic polyneuropathy, one had diabetic retinopathy, three had obstructive sleep apnea (OSA). Twelve OD were taking metformin and three of them were taking other oral anti-diabetic medications. Three OD were taking insulin. Due to IGB treatment, two of them ceased taking insulin, another two reduced the number of types of anti-diabetic medication. Five OD had normal blood pressure after IGB removal. One patient had gastric ulcer hemorrhage caused by taking aspirin against medical prescription. It led to premature IGB removal one month prior to the scheduled time [24]. However, his scores on

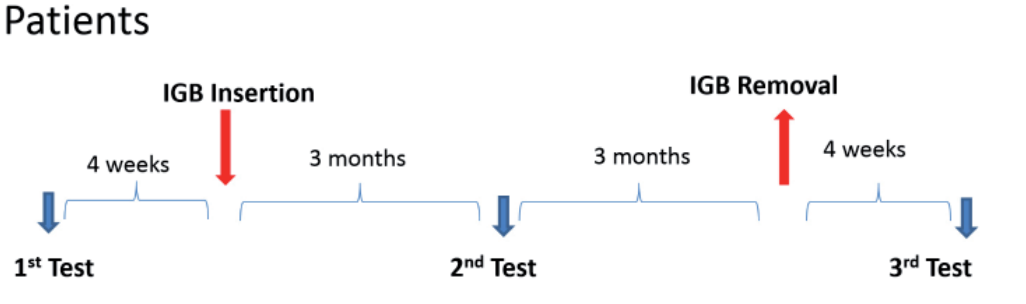

Fig. 1. Timeline of the study. Patients undergo the 1st cognitive testing four weeks before IGB insertion, 2nd testing three months after, and the last, 3rd testing four weeks after IGB removal.

the tests were within the range of results obtained by other patients taking part in the study; his exclusion did not affect the results.

Among OB patients, two reported hypertension and were taking hypertension medications. Two patients had dyslipidemia (all of them were taking medications), one had a fatty liver diagnosis, and one was cigarette smoker. Four of them had a history of gastritis, two were H. Pylori positive, one patient had cholecystolithiasis, two were after cholecystectomy because of cholecystolithiasis, and one had hypothyroidism. All the patients were Caucasian.

All participants gave written informed consent to all procedures approved by the Bioethical Commission at the Military Institute of Aviation Medicine, Warsaw, Poland (permission number 03/2013, in agreement with the Declaration of Helsinki. Written informed consent was obtained from all participants in this study.

Statistical analyses

The changes in body weight and BMI were evaluated using 2 (groups: OD vs. OB) x 3 (time-points) repeated measures ANOVA. The group effect (T2DM diagnosis) is referred to as the T2DM effect, whereas the time effect is referred to as the effect of treatment for excessive body weight.

Given the non-linearity changes in cognitive and BDI scores (tab. 1), they were evaluated using 2 (groups: OD vs. OB) x 2 (time-points) ANOVA repeated measures, separately for the first three months of the treatment (fig. 1), and for the following three months. In the analyses, time-point was used as the intra-group factor, whereas the T2DM status was used as the between-group factor. The interactions between the time-point and the T2DM status were the basis for evaluation of differences in cognitive recovery between both groups. Correlations between changes in cognitive and BDI scores were calculated using Pearson's product-moment correlation. A significance level of $p<0.05$ was considered statistically significant. Given the preliminary nature of the study, no corrections for multiple comparisons were performed. All statistical tests were conducted with R version 3.4.4 (with the "ez" package developed for that version of R).

RESULTS

Weight changes induced by IGB between insertion and three months thereafter

The 2 (group) x 3 (time-point) repeated measures analyses yielded significant main effects of treatment for body weight [$F(2,44)=57.45$, $p<0.001$], and BMI [$F(2,44)=60.90$, $p<0.001$]. The main group effect was significant only for BMI [$F(1,22)=6.43$, $p=0.02$]. None of the interactions reached statistical significance. These effects in OD correspond to 10.6% and 5.1% decrease in BMI over the first three months of therapy and the following three months of therapy, whereas the corresponding BMI decreases in OB are 8.6% and 5.1%. In terms of body weight, it decreased by 10.6% and 5.4% respectively in OD, and 8.3% and 4.6%, respectively in OB.

Cognitive changes between IGB insertion and three months thereafter

The 2 (group) x 2 (time-point) repeated measures analyses yielded significant main effects of treatment for digit span [$F(1,22)=4.66$, $p=0.042$], completion time for CTT-1 [$F(1,22)=4.41$, $p=0.048$], completion time for CTT-2 [$F(1,22)=4.68$, $p=0.042$], and number of errors regarding colors in CTT-2 [$F(1,22)=)=8.08$, $p=0.009$]. These effects corresponded to a 9% increase in repeated digits in

Tab. 1. Mean scores obtained at respective time points. CTT-1 time and CTT-2 time – the time needed to finish the respective tests. CTT-2 #colors - properly selected digit but wrong color. OD: BMI, OD: Body mass – mean BMI and mean body mass in patients with type 2 diabetes mellitus; OB: BMI, OB: Body mass – mean BMI and mean body mass in patients without T2DM.

	TP1	TP2	TP3
Digit span	12.4 ± 4.1	13.6 ± 4.7	14.2 ± 4.5
CTT-1 time	43.5 ± 10.5	38.8 ± 10.5	40.5 ± 12.3
CTT-2 time	87.3 ± 22.6	80.8 ± 22.6	78.4 ± 20.3
CTT-2 #colors	0.4 ± 0.5	0.0 ± 0.2	0.2 ± 0.4
BENTON #errors	4.2 ± 2.2	3.0 ± 2.8	3.5 ± 2.7
BDI	10.3 ± 6.8	10.2 ± 9.0	6.0 ± 6.3
OD: BMI [kg/m^2]	47.2 ± 6.6	42.2 ± 7.3	39.8 ±7.6
OD: Body mass [kg]	144.0 ± 27.6	128.7 ± 25.7	120.9 ±25.6
OB: BMI [kg/m^2]	53.4 ± 5.9	48.8 ± 4.6	46.1 ± 4.4
OB: Body mass [kg]	147.9 ± 12.8	135.6 ± 12.7	128.2 ± 14.8

the Digit Span test, an 8% decrease in CTT-2, as well as a 89% decrease in the number of errors regarding colors, as well as a 40% decrease in the total number of errors in the Benton test (tab. 1). Furthermore, there was an impact of treatment on the total number of errors in the Benton test [$F(1,22)= 6.30$, $p=0.020$]. Neither the main effect of T2DM status nor the interaction between the T2DM status and the treatment were significant for any measure. No significant main effects or interactions were found for the BDI scores. The mean results for each measure at each time point are provided in table 1.

Cognitive changes between three months after insertion and one month after IGB removal

No change in cognitive measures was significant between three months after IGB insertion and one month after its removal. Neither T2DB nor the interaction between T2DM status and time was significant for any measure. Similarly, for the BDI scores, none of the effects was significant.

Correlates of cognitive changes

In OD, none of the absolute changes in cognitive measures between one month before insertion and three months thereafter correlated with changes in BDI, body mass, and BMI.

However, in OB, larger weight loss and larger BMI loss correlated with a larger reduction in number of errors regarding color on CTT-2 ($r < -0.641$, $p < 0.046$), as well as larger weight loss and larger BMI loss had a correlation to improvement in digit span ($r < -0.604$, $p=0.06$).

DISCUSSION

We have observed improvements in short-term memory, visual search and memory and sustained and divided attention in morbidly obese patients during intragastric balloon treatment over the first three months of the treatment, regardless of depressive state changes (measured using the Beck Depression Inventory) and type 2 diabetes mellitus diagnosis. Interestingly, cognitive improvements correlated with decreases in body weight and BMI only in the group of patients without T2DM. However, no statistically significant changes were observed over the following three months of treatment.

These findings in general support the existing body of evidence that bariatric surgery leads to improvement in cognitive functioning [1,13]. Surprisingly, we did not find any interaction effect between T2DM diagnosis and cognitive improvement due to treatment. This is unexpected given that our magnetic resonance spectroscopy study in the same population demonstrated normalization of brain myo-inositol, a marker of neuroinflammation, only in the OD group during the treatment [10]. Similarly, T2DM was associated with more brain atrophy in the OD than in OB [9] and IGB treatment lead to some morphological brain recovery in the OD cohort (to be described separately). However, the cognitive improvements correlated with decreases in body weight and BMI only in the group of patients without T2DM; it suggests that the mechanisms of cognitive improvement in patients with and without comorbid T2DM might be different. Cognitive improvements after IGB insertion were not related to changes in depressive symptomatology. Similar findings, i.e. a lack of relationship between history of major depressive disorder preceding bariatric surgery with post-surgery cognitive improvements, were reported [1].

The lack of statistically significant changes over the last three months of treatment may be due to smaller weight loss over this period than over the first three months of treatment (tab. 1). It may also be interpreted that the observed cognitive improvements are transient, possibly associated with the effects of IGB on the host [20]. Therefore, the changes in cognition due to IGB treatment should be also evaluated long-term after IGB removal.

The major limitations of this study are the small sample size and the small/limited battery used in the assessment. Future studies should utilize comprehensive cognitive batteries and larger cohorts.

To sum up, similarly to more invasive bariatric techniques, morbid obesity treatment with the intragastric balloon leads to cognitive improvements that are related to weight loss in patients without comorbid type 2 diabetes mellitus. These improvements do not seem to be related or accompanied by significant mood changes.

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AUTHORS' DECLARATION:

Study Design: Michał Janewicz, Marek Binder, Olaf Truszczyński, Stefan P. Gaździński**. Data Collection:** Michał Janewicz, Agata Gaździńska, Aleksandra Mojkowska. **Manuscript preparation:** Michał Janewicz, Stefan Gaździński. **Funds Collection:** Stefan P. Gaździński. The Authors declare that there is no conflict of interest.

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EVALUATION OF NUTRITIONAL STATUS AND THE LEVEL OF PHYSICAL FITNESS OF MILITARY FLYING PERSONNEL STAYING AT THE TRAINING CAMP

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Introduction: The aim of the conducted research was to assess the nutritional status and level of physical fitness of the military flying personnel staying at the three-week training camp in Zakopane-Gronik.

Material and methods: The research involved 90 members of the military flying personnel staying on a three--week camp in the Military Training and Fitness Centre (WOSzK) in Zakopane. The mean age of the respondents was 34.57±7.14 years. At the beginning and at the end of the camp period the body composition was measured and anthropometric tests were performed. In order to assess physical fitness, the scores from a physical fitness test carried out on the last day of the camp were used.

Results: During the training and fitness camp period, significant improvements ($p < 0.05$) were observed in the nutritional status of military flying personnel, including the content of body fat (20.14±4.02 vs. 19.50±3.89%), visceral fat (6.48±2.79 vs. 6.16±2.65), muscle mass (61.23±5.61 vs. 61.77±5.61 kg), total body water (44.59±3.70 vs. 44.75±4.42 kg) and waist circumference (88.51±6.78 vs. 87.18±6.72 cm), and basal metabolism (1891.5±78.5 vs. 1903.9±177.3 kcal). 62.2% of the examined participants of the camp obtained a very good final score in the fitness test in all of the disciplines assessed, which indicates their high physical fitness. The soldiers who obtained a very good final score from the exam were younger (33.39±7.08 vs 36.50±6.92; $p < 0.05$) and had lower content of body fat (18.73±3.89 vs 20.77±3.53; $p < 0.05$) compared to those who obtained a good final score.

Figures: 3 • **Tables** 3 • **References:** 14 • **Full-text PDF:** http://www.pjambp.com • • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

Conclusions: In connection with the improvement of nutritional parameters of the military flying personnel, as well as their high physical fitness shown in the study, it should be concluded that training and fitness camps play an important role in maintaining high psychophysical fitness of the participants.

Keywords: nutritional status, physical fitness, training camp, military flying personnel

INTRODUCTION

Proper nutritional status is one of the basic factors for maintaining high psychophysical fitness and good health of members of military flying personnel.

The nutritional status of the organism is understood as the health condition resulting from the usual consumption of food, including the absorption and utilization of the nutrients contained therein, as well as from the influence of pathological factors on these processes [4]. Although the nutritional status of the body is influenced by various factors, i.e. genetic, environmental and psychological factors [13], it is essential to maintain a proper energy balance, i.e. to ensure a balance between the energy and nutritional value of the food consumed and the amount of energy expenditure required for everyday life activity.

In order to assess the nutritional status, it is common to conduct anthropometric tests and to use the non-invasive bioelectrical impedance analysis (BIA), determining, among others, body fat mass (FM), fat-free body mass (FFM) and total body water (TBW) [5].

In military aviation, much attention is paid to issues related to the proper preparation of military flying personnel for performing tasks in the air. Maintaining proper nutritional status of the body, and consequently high efficiency and psychophysical fitness increases the body's tolerance to adverse environmental factors and, consequently, allows to extend the period of service. One of the very unfavorable phenomena that should be counteracted in members of military flying personnel is the so-called hypokinetic syndrome, which consists in limiting their mobility. Counteracting this type of phenomena is one of many tasks of the Military Training and Fitness Centres (WOSZK), to which military pilots and other flying personnel must come once a year. The centres, where three-week training camps are organized, have a rich sports base, including swimming pools, gyms, various sports grounds, climbing walls, as well as highly qualified staff. The assessment of the level of physical fitness of the participants is carried out at the end of the camp in the form of a physical test. The aim of the examination is to assess the muscle endurance, speed, dynamic strength and agility of the participant.

The stay of members of the military flying personnel in the Military Training and Fitness Centres is primarily aimed at regenerating their physical strength and improving their psychophysical resistance. The role of the centres should also be to improve the nutritional parameters of the trained soldiers with a properly designed training plan and correctly composed and balanced meals during the camp.

The aim of the conducted research was to assess the nutritional status and level of physical fitness of the military flying personnel staying at the three-week training camp in Zakopane-Gronik.

MATERIAL AND METHODS

Characteristics of the test group

The research was carried out among military flying personnel staying at the Military Training and Fitness Centre in Zakopane-Gronik for three weeks. The research was conducted in 2014. The study group consisted of 90 men. The average age of the participants was 34.57 ± 7.14 years, average body mass 80.97 ± 8.33 kg, average height 177.44 ± 6.39 cm and average BMI 25.74 ± 2.52 kg/m^2.

The research was voluntary, the soldiers gave their informed consent for participation in it. The research was approved by the Ethics Committee which issues opinions on biomedical research at the Military Institute of Aviation Medicine in Warsaw (Decision No. 03/2015).

Measurement methods

At the beginning and at the end of the camp, the military flying personnel were subjected to the following tests:

1. Measurement of body composition (including body fat, fat-free body mass, total body water and basal metabolism) using the bioelectrical impedance method, with the use of Tanita SC-330 analyzer (produced in Japan). The subjects were fasted, in underwear only.

2. Assessment of the degree of overweight and obesity based on the BMI (Body Mass Index) and body fat content, according to the criteria of the World Health Organization (WHO) [14].
3. Anthropometric measurements, including height, body mass, waist and hip circumference.

In order to assess physical fitness, the scores from the military fitness test for the flying personnel, carried out on the last day of their stay in the WOSZK, were used. The following sports disciplines were included in the fitness test: zigzag run (sec.), pull-ups (number), long jump (cm), sit-ups (within 2 min.), running 10x10 m (sec.), push-ups with legs on bench (number) and swimming over 50 m (sec.). In order to compare the scores obtained during the fitness test with the applicable standards, the participants were divided into age groups, in accordance with the regulations applied in the Polish Army in carrying out the physical fitness test [9], namely:

a) < 30 y.o. – group I,
b) 31-35 y.o. – group II,
c) 36-40 y.o. – group III,
d) 41-45 y.o. – group IV,
e) > 46 y.o. – group V.

All soldiers during their stay at the training camp were provided with full board, planned according to the basic board standard 040 [10].

Statistical tools used

The statistical analysis of the data was performed in PS IMAGO PRO (IBM SPSS Statistics 25). The level of statistical significance was assumed to be $p < 0.05$. The normality of data distribution was verified using the Shapiro-Wilk test. Descriptive statistics were calculated for the examined variables, i.e. mean, standard deviation, median, minimum value and maximum value. The chi-square test and U Mann-Whitney test were used for intergroup comparisons (final evaluation). The Wilcoxon test and McNemar-Bowker test were used to verify the significance of differences before and after the camp. Descriptive statistics are presented in tables, the calculated percentages are shown in diagrams.

RESULTS

The results of the analyses showed that during a three-week stay at a training camp most of the

Tab. 1. Assessment of the nutritional status of the flying personnel before and after the camp at the WOSzK in Zakopane-Gronik.

Parameters	Beginning of the camp						End of the camp					
	N	X	SD	ME	MIN	MAX	X	SD	ME	MIN	MAX	p
WEIGHT [kg]	90	80.97	8.33	81.90	59.10	101.40	80.90	8.02	81.10	59.60	102.70	0.9250
BMI [kg/m²]	90	25.74	2.52	26.00	19.10	32.50	25.72	2.42	25.90	19.50	32.10	0.9520
FATP [%]	90	20.14	4.02	20.15	10.20	33.00	19.50	3.86	19.50	9.70	28.40	**0.0002**
FATM [kg]	90	16.46	4.27	16.60	6.30	27.40	15.91	3.99	16.00	6.40	26.70	**0.0014**
MM [kg]	90	61.23	5.61	61.55	44.50	76.80	61.77	5.61	61.75	43.20	77.70	**0.0003**
VFATL	90	6.48	2.79	6.50	1.00	15.00	6.16	2.65	6.00	1.00	13.00	**0.0001**
FFM [kg]	90	64.48	5.86	64.75	46.90	80.80	64.99	5.84	64.95	45.50	80.60	**0.0004**
TBW [kg]	90	44.59	3.70	44.55	32.80	55.70	44.75	4.42	44.55	21.80	55.50	**0.0016**
TBW [%]	90	55.23	2.56	54.96	48.62	62.33	55.32	4.86	55.59	16.80	63.61	**0.0001**
BMR [kcal]	90	1891.5	178.5	1891.7	1394.5	2423.0	1903.9	177.3	1899.4	1361.4	2422.0	**0.0018**
METAAGE [years]	90	34.09	11.64	34.00	12.00	67.00	32.63	11.11	32.00	12.00	67.00	**0.0010**
Waist circumference [cm]	89	88.51	6.78	88.00	71.00	111.00	87.18	6.72	86.50	69.70	106.00	**0.0005**
Hip circumference [cm]	89	96.38	4.09	96.00	84.00	105.50	96.72	4.57	96.75	84.00	106.70	0.9078

N – number of participants, X – mean value, SD – standard deviation, Me – median, Min. – minimum value, Max – maximum value, p – Wilcoxon test score.

Weight [kg] – body mass; BMI [kg/m²] – body mass index; FATP [%] – body fat percentage; FATM [kg] – fat mass; MM [kg] – muscle mass; VFATL – visceral fat level; FFM [kg] – fat-free body mass; TBW [kg] – total body water mass; TBW [%] – body water percentage; BMR [kcal] – basal metabolism.

Tab. 2. The results obtained from the fitness test by members of the military flying personnel staying at the WOSZK in Zakopane-Gronik.

Exercises	Total					
	N	X	SD	Me	Min.	Max.
Zigzag run [sec.]	90	24.17	1.40	24.20	21.30	27.40
Pull-ups [number]	89	12.40	6.29	11.00	2.00	35.00
Standing long jump [cm]	90	231.17	17.96	235.00	185.00	280.00
Sit-ups (in 2 minutes) [number]	90	64.93	17.61	65.00	33.00	120.00
Running 10x10 [sec.]	90	29.12	1.76	29.10	23.30	33.40
Swimming [sec.]	90	50.05	10.52	49.00	33.00	79.04
Push-ups [number]	89	46.73	16.32	45.00	15.00	110.00
Overall score	90	4.57	0.70	5.00	3.00	5.00

N – number of participants, X – mean value, SD – standard deviation, Me – median, Min. – minimum value, Max. – maximum value

measured parameters of the nutritional status of military flying personnel improved significantly (tab. 1).

The data presented in table 1 indicate that the mean total body fat content, visceral fat content, as well as the waist circumference of the examined participants ($p < 0.05$) have significantly decreased. However, the average body water content, muscle mass and basal metabolism increased significantly ($p < 0.05$).

There were no significant changes in the value of BMI of the participants over the course of the camp (fig. 1).

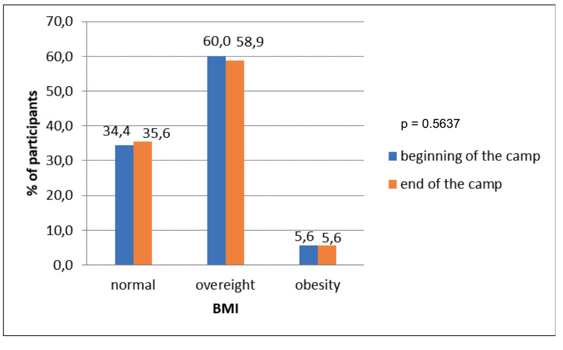

Fig. 1. Percentage distribution of the BMI of the flying personnel flying before and after the camp at the WOSzK in Zakopane-Gronik.

p – chi-square test result

The percentage of people with overweight and obesity according to the BMI was similar at the beginning and at the end of the camp, as shown in figure 1. However, the percentage of people with normal body fat content increased significantly from 43% to 51%, while the percentage of people with body fat content indicating overweight and obesity decreased (fig. 2).

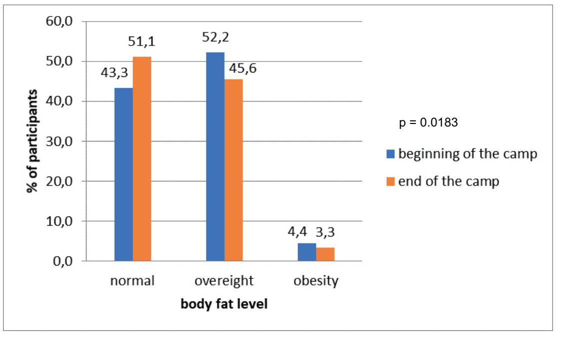

Fig. 2. Percentage distribution of the interpretation of the body fat content of the flying personnel before and after the camp at the WOSzK in Zakopane-Gronik.

p – chi-square test result

The scores obtained by the participants of the training camp are presented in table 2.

62.2% of the examined participants of the camp obtained a very good final grade in the fitness test in all of the disciplines assessed. This grade decreased with the age of the examined soldiers, as shown in figure 3.

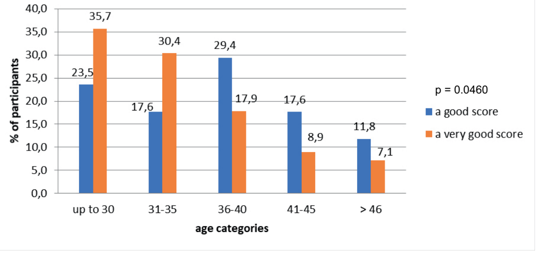

Fig. 3. The final grade for the exam by age group.

p – chi-square test result

The analysis of the test results also revealed significant differences in the overall scores from the fitness test obtained by the participants of the camp, differentiated in terms of the body fat percentage. Those who obtained a very good score

Tab. 3. The results of anthropometric measurements of the flying personnel staying at the WOSZK in Zakopane-Gronik depending on the final score from the fitness test.

	Good score						Very good score						
	N	**X**	**SD**	**Me**	**Min.**	**Max.**	**N**	**X**	**SD**	**Me**	**Min.**	**Max.**	**p**
Age [years]	34	36.50	6.92	37.00	24.00	52.00	56	33.39	7.08	33.00	24.00	53.00	**0.0407**
Body weight [kg]	34	80.27	8.56	79.60	59.60	98.40	56	81.28	7.72	81.70	62.00	102.70	0.6712
BMI [kg/m^2]	34	25.93	2.35	26.15	19.50	30.70	56	25.59	2.48	25.70	20.20	32.10	0.3364
FATP [%]	34	20.77	3.53	20.65	10.60	28.40	56	18.73	3.89	19.20	9.70	28.40	**0.0086**
FATM [kg]	34	16.77	3.66	16.50	6.40	25.90	56	15.39	4.13	16.00	7.20	26.70	0.0903
MM [kg]	34	60.41	6.20	60.50	43.20	75.40	56	62.59	5.10	62.05	48.10	77.70	0.0703

from the fitness test at the end of the camp had a lower body fat content compared to those who obtained a good score (p = 0.009), as shown in table 3.

DISCUSSION

Physical fitness, as well as nutritional status, are linked to health, which is why the Polish Army devotes much attention to them. The requirements for military pilots concerning general physical fitness and performance are very high. The way to improve and achieve the optimum level of fitness and performance parameters of military flying personnel is a regular training oriented to general and specialist preparation. These functions are carried out, among others, in the WOSZK in Zakopane-Gronik.

The assessment of nutritional status indicates whether the physiological needs of the examined person are met in relation to their nutritional requirements. The research on the nutritional status of the Polish Army soldiers carried out for years shows the occurrence of overweight and obesity both in soldiers beginning their military service, and in those serving in the army for many years. According to the research carried out by scientists from the Military Institute of Aviation Medicine in Warsaw, overweight and obesity assessed on the basis of body fat content were found in respectively 21.6% and 16.2% of 4th and 5th year students of the Air Force Academy [3]. In other studies, conducted on a group of 172 military pilots, obesity was found in 5.2% of soldiers [2].

Research on the nutritional status of military flying personnel published in 2008 by the team from the Military Institute of Hygiene and Epidemiology on the basis of BMI analysis showed the occurrence of overweight in a smaller number of participants (50%) compared to the authors' research presented in this paper. Obesity, on the other hand, was found in a higher percentage of respondents, i.e. 10.5% in the age group up to 30 years and 18.9% of older respondents [6].

Bertrandt and Kłos, when examining a group of military flight engineers and navigators based on the BMI index, found overweight in 45% and 54% of them respectively, while obesity was observed in 24% of engineers and 22% of navigators [1]. Taking into account the assessment of the BMI, overweight was also observed in 80% of the GROM soldiers. No obesity was found in this group. However, the authors of the study indicate the occurrence of overweight resulting from muscles, as the body fat percentage was within acceptable standards [11].

In the study of the nutritional status of the soldiers of the Representative Honor Guard Regiment of the Polish Armed Forces, the highest number of soldiers with overweight (BMI > 25 kg/m^2) was found in the group aged 26-30 - 60.8%, and the lowest in the group of the oldest soldiers over 40 - 42.8%. The oldest age group recorded the highest number of obese soldiers (BMI > 30 kg/m^2) - 28.6%, while in the younger age group (31-40) almost every 10th soldier was obese (9.1%). The lowest percentage of obesity was observed in younger soldiers (5.0%) [8].

In the study on the nutritional status of 123 soldiers serving in one of the units of chemical troops, half of the examined soldiers in the group of up to 30 years old were found to have normal body mass, while in the group of older soldiers the percentage of people with normal body mass (BMI in the range 18.5-24.9 kg/m^2) was lower and amounted to 46.4% [7].

In the above-mentioned works, researchers evaluated body mass disorders based primarily on the BMI. However, it should be remembered that despite its simplicity and frequent use in studies on nutritional status, this index is burdened by an error because it does not take into account the body composition of the examined person and therefore may lead to misinterpretation of the results, especially in people with extensive muscle mass.

Based on the conducted research, it should be concluded that the nutritional status of the examined military flying personnel is not fully satisfactory, as excessive body weight according to the BMI was found in over 60% of the examined persons, while excessive body fat content was observed in over 50% of the participants (fig. 1 and fig. 2).

As far as the level of physical fitness of the military flying personnel is concerned, the conducted research has shown that the soldiers received good and very good scores for particular physical fitness tests, according to the system of scores adopted in the Polish Army. Similar results were obtained by Tomczak et al. [12], assessing the level of physical fitness of air cavalry soldiers. In addition, the study revealed that those who received a very good final score from the fitness test were younger and had a lower body fat content compared to soldiers who received a good score. On this basis, it can be concluded that training plans should be properly designed, especially for older groups of soldiers, in order to help them maintain high physical fitness in subsequent years of service.

Comparing the results of the physical fitness assessment of the military flying personnel during the training camp with the results of the GROM soldiers, it has been demonstrated that the level of physical fitness of the soldiers of the special unit is much higher. They received a very good score in all fitness tests [11]. For example, in the sit-ups they had 91.5 repetitions (i.e. 26.6 more repetitions) and 18.27 repetitions in pull-ups (i.e. 5.9 more repetitions). In a 10 x 10 m run, however, the GROM soldiers recorded a time that was 2.9 seconds worse than that of the military flying personnel examined.

To sum up, the research conducted revealed that members of military flying personnel are characterized by high physical fitness and that their body composition parameters are improved during the training camp. On this basis, it can be concluded that the Military Training and Fitness Centres perform their functions and allow to improve the overall psychophysical fitness of the military flying personnel.

CONCLUSIONS

Participation in the three-week training camp has a positive impact on the nutritional status of the military flying personnel.

The results obtained from the fitness test indicate high physical fitness of the participants of the training camp.

Due to the improvement in the nutritional status parameters observed in the respondents, as well as taking into account their high physical fitness, it can be concluded that training camps play an important role in maintaining high psychophysical fitness of the military flying personnel.

AUTHORS' DECLARATION:

Study Design: Agata Gaździńska, Paulina Baran; **Data Collection:** Agata Gaździńska, Paulina Baran; **Manuscript Preparation:** Agata Gaździńska, Paulina Baran, Paweł Jagielski. The Authors declare that there is no conflict of interest.

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INITIAL DEPRESSION AND NORMALIZATION OF HIGHER EXTREMITY OXYGENATION IN AN AUTISTIC GIRL DUE TO KINESITHERAPY USING AN ADAPTED HIGH ALTITUDE PROTECTION SUIT: A CASE STUDY

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Introduction: Autism spectrum disorder is often accompanied by motor impairments that can be treated with kinesitherapy. At Neures Poland, we use high-altitude compensation suits (R-WUK) to help stabilize patients. Here, we report on a case of very low oxygenation of peripheral tissue (hands) in a fifteen-year-old girl (52 kg, 165 cm) with a diagnosis of autism. That oxygenation normalized during kinesiotherapy utilizing the R-WUK over the period of two months.

Methods: Before the commencement of therapeutic sessions, the patient's vital signs and tissue oxygen saturation (SpO_2) in upper extremities were measured. These measurements were repeated before and following the rest of the therapeutic sessions.

Results: Before the sessions, SpO_2 was 74%, while the other measures were in the normal range. Over the first month of therapy, SpO_2 was low, but after sessions, it was higher, except for the first session in the normal range. SpO_2 remained normal before and after the sessions following a seven-week break in the therapy.

Conclusions: R-WUK caused an equalization of saturation levels at the distal level in the upper limbs. Understanding the mechanisms requires further research.

Keywords: high altitude protection suit, psychiatric disorder, autism spectrum disorder, physiology

Tables 3 • **References:** 6 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2018 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

INTRODUCTION

Our search for new solutions in the field of physiotherapy equipment has focused on height compensatory clothing. Its mechanism consists in the administration of increased pressure in the tubing that causes shrinkage of the fabric on muscle structures. The principle of operation points to the concept of increasing prioperceptive sensation, which would allow accelerating the rehabilitation process, especially in patients with neurological deficits or neurological diseases.

Altered motor behavior is commonly reported in Autism Spectrum Disorder [1]. At Neures Polska (www.neures.pl), we started using high-altitude compensation suits (R-WUK) to help stabilize patients during kinesiotherapy, similar to an earlier Russian experience [3]. The mechanisms of R-WUK in some regards resemble the mechanism of hyperbaric therapy, which is used to treat patients with Autism Spectrum Disorder [2,5,6], although its use is not recommended as a treatment method [4].

In the presented study we used an adapted version of high-altitude compensations protection suits (R-WUK (WUK-90, Air-Pol, Legionowo, Poland). It is a capstan-type suit. In this system, compression over the body is achieved through inflating rubber tubes, which increase the pressure on the body with non-distending tapes sewn into the suit's fabric. In addition, the suit is equipped with an abdominal bladder exerting pressure on the lower abdomen and the frontal pelvic region. Precise adjustment of the suit is done with the use of polypropylene laces. Closing of the suit is achieved by means of metal zippers. Here, we report a case of improvements of finger-tissue oxygenation that accompanied the therapy.

MATERIAL AND METHODS

A fifteen year old girl (52 kg, 165 cm) with a diagnosis of autism and attending a special school for mentally challenged children underwent 16 kinesiotherapy sessions divided into two blocks (see table 1 and table 3) with an R-WUK, similarly to [3]. The sessions were seven weeks apart. The disease was preceded by a strong incident at the age of 2.5 years, the direct cause of which was the appearance of siblings in the family. The girl reacted with strong crying and screaming, which lasted many hours. As a result of this event, the mental development of the patient was completely inhibited. The patient is in full verbal contact with the parents. The study protocol was approved in advance by Bioethical Committee of the Military Institute of Aviation Medicine in Warsaw (decision no. 3/2017). The parents of the patient provided a written informed consent before the study.

Before and after each kinesiotherapy block, the patient's systolic and diastolic blood pressure was measured (with OMRON™ M2 BASIC blood pressure monitor, OMRON Healthcare, Wegalaan 67-69, 2132 JD Hoofddorp, The Netherlands). Arterial blood saturation SpO_2 was measured twice each time with the use of a finger pulse oximeter Nonin Medical Model 8500 M (Nonin Medical, Inc., Tilburg, The Netherlands). Mean blood oxygenation (both oxygenated and de-oxygenated blood) of the frontal lobe of the brain was measured using near infrared spectroscopy (NIRS; INVOX 5200 (INVOX Medical, Vocali, Spain)). An optode was attached to the forehead of the patient. These parameters were measured before and after each training session.

RESULTS

An improvement has been observed in the form of greater cooperation between the patient and therapists, as well as less aggressive reactions. This behavior was present even if the patient was dissatisfied that she had to follow orders.

Systolic blood pressure before the training (SBP1) and after the training (SBP2), diastolic blood pressure before (DBP1) and after (DBP2) each session, heart rate before (HR1) and after (HR2), as well as peripheral oxygen saturation before (SpO_2-1) and after (SpO_2-2) each session are presented in table 1. Please note that the SpO_2 before the first session was 74%. Normal blood oxygen levels in humans is considered to amount to 95–100 percent. If the level is below 90 percent, it is considered low, resulting in hypoxemia. Blood oxygen levels below 80 percent may compromise organ function, such as the brain and heart, and should be promptly addressed. (https://en.m.wikipedia.org/wiki/Oxygen_saturation_(medicine)). However, the patient had no typical symptoms of hypoxia of tissue structures such as pallor, bruising or seizures.

It is worth noting that the low saturation result was last recorded by the investigators at the ninth therapeutic unit, but in the eighth one full oxygen saturation was recorded.

The first result (SpO_2 =74%) was at first treated as a measurement device error or a measurement error, but in the case of subsequent sessions, when the result was significantly abnormal, daily home monitoring was commissioned to observe SpO_2. The results obtained during home observation are presented in table 2. Brain saturation was measured only during the 9th session of the first therapeutic block, after normalization of peripheral saturation, and was normal.

Tab. 1. Vital signs and oxygenation changes with consecutive therapeutic sessions: Systolic blood pressure before (SBP1) and after trainings (SBP2), diastolic blood pressure before (DBP1) and after (DBP2) sessions, heart rate before (HR1) and after (HR2), as well as peripheral oxygen saturation before (SpO_2-1) and after (SpO_2-2) sessions.

Session No:	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
SPO_2-1	74	–	79	99	80	–	96	100	83
SPO_2-2	84	–	97	99	92	–	98	99	96
SBP1	115	116	120	119	118	119	126	119	120
DBP1	71	64	65	62	68	64	71	63	66
SBP2	124	95	116	122	116	105	135	124	119
DBP2	63	52	61	63	57	69	75	63	64
HR1	49	69	72	80	66	99	79	79	95
HR2	87	70	71	75	64	75	82	69	66

Tab. 2. Blood saturation at home. Missing values due to lack of collaboration of the patient. *- reading before therapy unit.

	1st day	2nd day	3rd day	4th day
Morning 6.00- 7.30	–	97	97	98
Afternoon 14.00-16.00	–	90	99	97
Evening 21.00-22.30	98	89	–	80

Tab. 3. Vital signs and oxygenation changes during the second block of therapy seven weeks after the first block: Systolic blood pressure before (SBP2-1) and after trainings (SBP2-2), diastolic blood pressure before (DBP1) and after (DBP2) sessions, heart rate before (HR1) and after (HR2), as well as peripheral oxygen saturation before (SpO_2-1) and after (SpO_2-2) sessions.

Session No:	1st	2nd	3rd	4th	5th	6th	7th
SPO_2-1	97	99	98	99	97	99	97
SPO_2-2	99	99	–	98	99	99	99
SBP1	116	124	104	105	127	116	116
DBP1	63	61	57	60	70	65	60
SBP2	124	124	–	120	129	129	121
DBP2	66	61	–	61	71	72	62
HR1	81	82	88	86	90	89	90
HR2	85	84	–	90	90	88	85

DISCUSSION

We have observed severely depressed SpO_2 in a 15 year old girl diagnosed with autism, that was reversed after a few sessions of kinesitherapy with an adapted high-altitude protection suit (R-WUK). These changes were persistent.

O_2 saturation disturbances are observed in chronic lung diseases, asthma or mountain diseases. In chronic diseases, the adaptive mechanism of the body allows one to reduce the oxygen saturation of HBO_2 to the level of 80%, but at the expense of the efficiency of the human body — movements are sluggish and slowed down. In addition, not always is the state of consciousness of the patient full and the level of perception and logical thinking in these conditions is significantly reduced. The above-mentioned symptoms of hypoxia are similar to autistic symptoms such as motor slowdown, disorders resulting from the function of receptors and the desire to restore them, lack of reaction, etc. Therefore, low tissue oxygenation may partially account for the symptoms of autism.

The results of research on the use of R-WUK suits adapted for therapeutic purposes suggest that the suit does not only affect the mechanism associated with prioperception, but also includes a much larger spectrum of physical interactions, which translate into the physiology of the body and define their area not only to patients with neurological diseases but also mental diseases.

Furthermore, the reading of the pulse oximeter are mostly affected by blood oxygenation in the capillary vessels, in which the device directly carries out measurements. These results may indicate that the original, low blood saturation in the finger of the patient is related to small blood vessels, such as arterioles and capillaries, and the action of the R-WUK suit modifies the blood arterioles restoring normal blood flow.

AUTHORS' DECLARATION:

Study Design: Maciej Abakumow, Krzysztof Kowalczuk. **Data Collection:** Maciej Abakumow, Krzysztof Kowalczuk. **Manuscript preparation:** Maciej Abakumow, Stefan Gaździński, Krzysztof Kowalczuk. The Authors declare that there is no conflict of interest.

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TECHNICAL NOTE

CONSTRUCTION OF A DETECTOR OF FATIGUE SYMPTOMS IN CAR DRIVERS

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Abstract: This paper is aimed at presenting the main technical aspects of the video recorder developed to detect fatigue symptoms that appear while driving a car. The principle of operation is based on filming the driver's face illuminated with light in the near-infrared band and detecting changes in the location of the characteristic points on the face, which may indicate fatigue. An off-the-shelf camera was used as an element of the detector, whereas another part were the illuminator and software created in-house. The detector's supporting frame was designed to be made using 3D printing technology. The application areas of the detector include monitoring car drivers and other vehicle operators, e.g. rail vehicles, in the context of drowsiness and fatigue during driving.

Keywords: video cameras, car drivers, drowsiness, fatigue symptoms, infrared illuminators, optical sensors, traffic safety

Figures 6 • **References:** 35 • **Full-text PDF:** http://www.pjambp.com • **Copyright** © 2018 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

INTRODUCTION

Fatigue in drivers is a significant issue and real threat to traffic safety. Based on the literature [14,16,23,27,32], driving a car in the state of fatigue is one of the factors significantly increasing the risk of an accident on the road. It is estimated that the probability of participating in an accident of a tired driver may be up to eight times higher than a rested driver [3].

In order to increase the level of driver's safety on the road, it is important to detect psychophysiological symptoms indicating increasing weariness, drowsiness and fatigue while driving a car early enough. The literature lists occulographic parameters and facial mimic-associated indicators, which may reflect an elevated level of fatigue, as follows: the average time of eye fixation [2,6,9,12,33], eye saccadic velocity [1,4-8], percentage of eye closure (PERCLOS) [15,17,31], eye closure duration (ECD), frequency of eye closure (FEC) [11], as well as droopy corners of the mouth [26]. However, other physiological indices of human arousal state in real-world driving, including drowsiness and fatique, are also described in the literature, e.g. heart and brain electrical activity, blood pressure, electrodermal activity and electrical activity generated by muscle fibers [18]. All of them are measured by various systems and devices, which differ, among others, in the way of acquiring physiological signals, the type of construction, the cost of manufacturing, as well as the ergonomics and the degree of comfort of the person being monitored [20-21,29-30,34]. In this paper we present the construction and general technical description of the video sensor designed to capture moving images of the driver's face and identify fatigue signs using software data analysis. The detector itself is a non-invasive measuring device of small

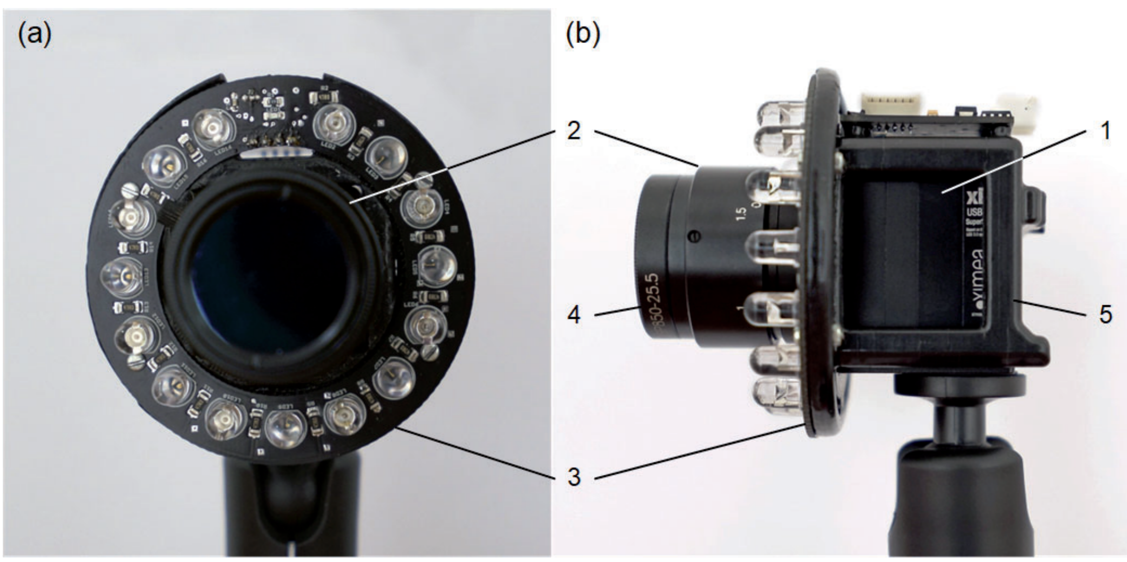

Fig. 1. Main hardware components of the detector: (a) front view and (b) side view.

Fig. 2. Detector (a) ready to use and (b) located in the car cabin.

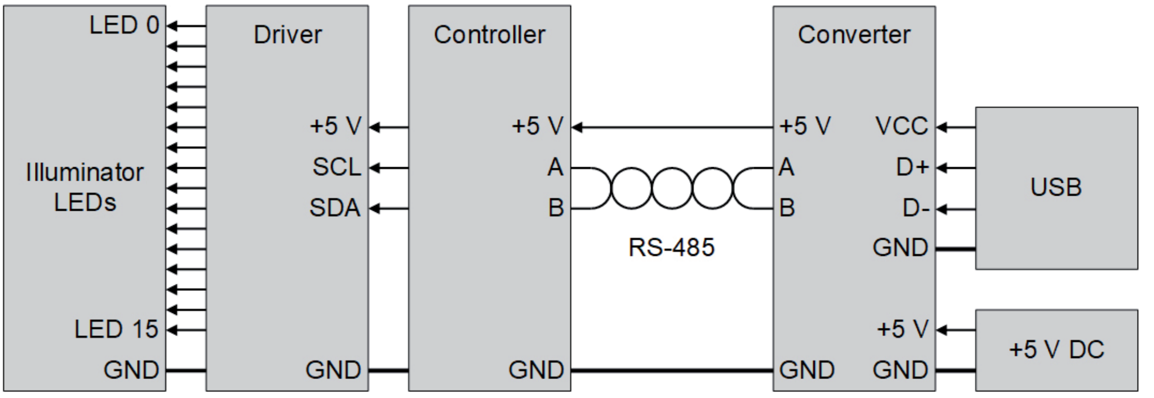

Fig. 3. Schematic diagram of the illuminator structure.

size and relatively inexpensive to build, hence it can be widely used to record fatigue symptoms in vehicle drivers. Nevertheless, the results of the research carried out with this sensor on a group of car drivers will be presented in a separate paper.

GENERAL DESIGN

The detector consists of hardware and software modules. The hardware module utilizes a commercially available MQ013RG-E2 camera by *Ximea* (marked '1' in fig. 1) equipped with 25HB lens by *Tamron* ('2' in fig. 1). The camera records images with a resolution of 1280 × 1024 pixels at 60 frames per second (fps) using a complementary metal-oxide semiconductor (CMOS) near-infrared (NIR) sensor. To enable image recording in places with limited lighting conditions, e.g. in the car cabin, a face illuminator using light in the NIR band was designed ('3' in fig. 1). Additionally, a band-pass filter for the illuminator infrared (IR) light-emitting diodes (LEDs) is applied to the lens ('4' in fig. 1). Both the camera and illuminator were mounted on a supporting frame that was designed as the Standard Template Library (STL) model and made using 3D printing technology ('5' in fig. 1). The supporting frame was mounted on a ball-joint holder with a suction cup to attach the detector to the car window, as shown in fig. 2.

FACE ILLUMINATOR

The illuminator was implemented as a client-server architecture shown schematically in fig. 3. The server was designed using AT89s8253 microcontroller by *Microchip Technology*, clocked at 11.0592 MHz. The microcontroller communicates with the client and controls the operation of the illuminator LEDs. Since the microcontroller is not equipped with the I2C hardware, the transmitter/receiver of the I2C bus is achieved in a software way. In order to increase the range of the USB cable between the server and client to tens of meters, the microcontroller is equipped with an UART-to-RS-485 data converter. The A and B lines of the RS-485 interface are connected to the inputs of MAX1487ECSA+ transceiver by *Maxim Integrated*. By default, the transceiver is configured as the receiver. At the client's request, the microcontroller switches the transceiver to data transfer state. In this case, these are confirmations of the received and executed commands. The received commands affect the states of the I2C bus lines, which together with the +5 V and ground lines are fed to the illuminator controller. The current status of the microcontroller is shown by three indicating LEDs. The controller is also equipped with reset and user buttons. The user button in the adopted software implementation is used to incrementally increase the brightness of the illuminator LEDs. The control of the illuminator LEDs is based on PCA9622DRT driver by *NXP Semiconductors*, which contains 16 pulse-width modulation (PWM) channels. Each of them can control the LED current up to 100 mA.

The server cooperates with the client via a converter from the RS-485 to UART standard using another MAX1487ECSA+ transceiver, and then from the UART to USB standard using *FTDI* FT232RL chip. The converter in the host system is recognized as the virtual COM port (VCP). The TxD, RxD, RTS, CTS, CBUS0 – CBUS2, CBUS4 and GND lines of the FT232RL chip are used. The TXD line is connected to the DI input of MAX1487ECSA+ transceiver, whereas the RXD signal is connected to its RO output. By connecting the RTS and CTS pins of the FT232RL chip together, the interface is always ready to send and receive data. The CBUS2 and CBUS4 lines are used to control the direction of data transmission on the RS-485 bus. When the CBUS2 line is in the high state, the data fed to the DI input are delivered to A and B lines. The zero state on the CBUS2 line, which is the default state, means blocking the transmitter and entering the data receiving mode. The receiver of the RS 485 bus is controlled by the CBUS4 line. This line is configured as PWREN#, for which the default state is '1'. The enumeration procedure, after connecting the converter USB connector to the computer socket, changes the state of the CBUS4 line to '0' and the receiver of the RS 485 bus is ready to receive data. The CBUS0 and CBUS1 lines are connected to two indicating LEDs that show the current status, i.e. transmission or receiving mode. Another LED indicates a +5 V power connected to the converter. A photograph of the converter in the form of an USB dongle is shown in fig. 4.

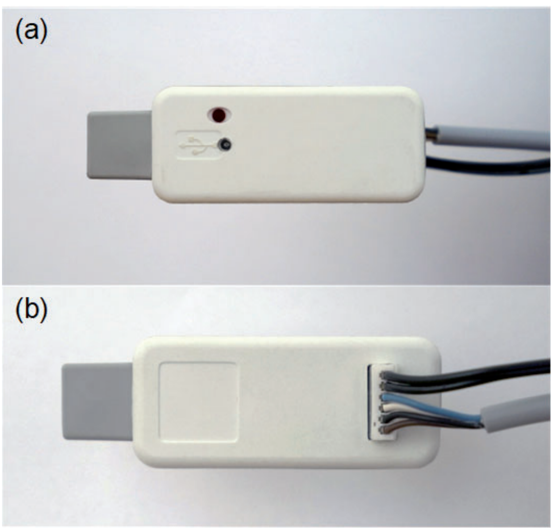

Fig. 4. RS-485-to-USB converter: (a) top view and (b) bottom view.

SOFTWARE

The computer application allows for detecting the characteristic points on the driver's face in video data captured from the connected camera or archived on the disk. fig. 5 shows the main panel of the application while detecting the characteristic points on the face of a subject. The location of the characteristic points can be visualised in the form of time charts and analysed in an automated way or manually step by step. fig.6 shows an example of the time charts with the coordinates of the characteristic points chosen by the user for analysis. The results can be printed as reports and saved as files in the comma separated value (CSV) format for further statistical analysis. The software runs on the *Microsoft* .Net Framework 4.0 platform and was prepared in the C# language using the Visual Studio environment. Algorithms from specialized OpenCV and Luxand libraries were used to create the software.

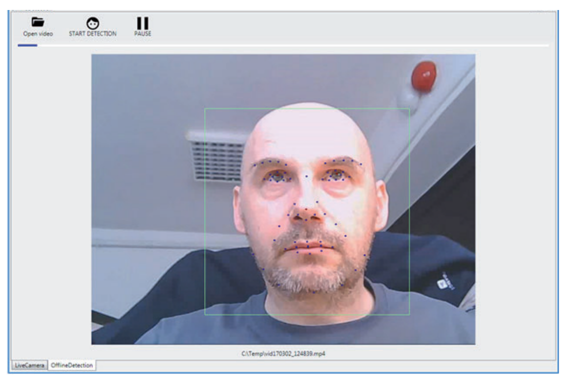

Fig. 5. Main panel of the software while detecting the characteristic points on the face.

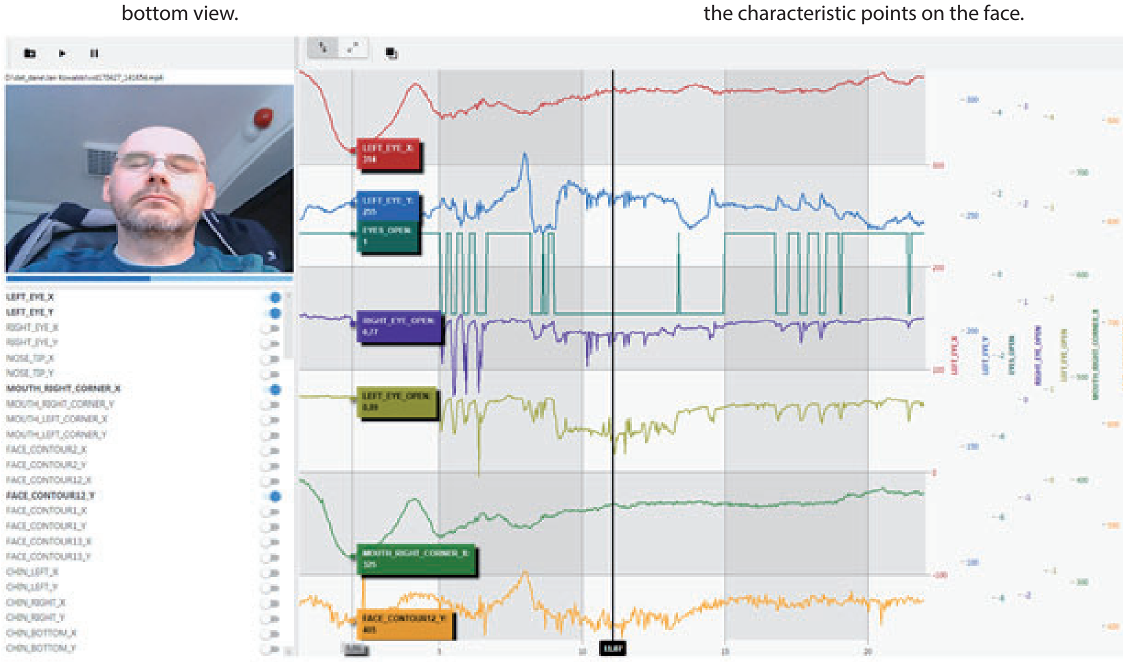

Fig. 6. Visualisation panel with the time charts chosen for analysis.

The location of the characteristic points is closely related to the arrangement of the eyes, eyebrows, nose, mouth and face oval. Their detection allows for calculating occulographic parameters and facial mimic-associated indicators, i.e.:

- eye opening/closing,
- PERCLOS calculated as the percentage of eyelid closure over the pupil in a pre-defined period of time; the simplified method of measuring the PERCLOS value is to calculate the ratio of the eyes being open and closed with the total number of frames for the given period [15,17,24,31],
- ECD calculated as the number of closed eye frames divided by the number of eye closures in a pre-defined period of time [11,24],
- FEC calculated as the number of eye closures in a pre-defined period of time [11,24],
- distance between the centres of the eyes and the corners of the mouth,
- eye surface area,
- yawning frequency.

SUMMARY

The detector is a mobile device of a compact size, i.e. 61 mm × 61 mm × 66 mm in dimensions, and as low as 112 g in weight. It can be attached to the windscreen of any car or simulator. It does not limit visibility and in no way affects the safety of the driver. The detector can be used in studies to assess the occulographic parameters [13,22,35] and facial-mimic reactions [10,19,25,28] of drivers in response to various road situations, including unexpected events threatening traffic safety, e.g. sudden pedestrian intrusion on the road. The detector can be useful for assessing the behaviour and reaction of drivers during long-term and monotonous driving, which can cause weariness and drowsiness, e.g. driving on a highway. Moreover, the detector was developed for scientific experiments as it can not only deepen our knowledge about the effects of fatigue on drivers' psychophysical state and operational efficiency, but also allow for recording symptoms of weariness, drowsiness and fatigue appearing in drivers at their early stages. Finally, it is worth noting that due to its design, mobility, small size and the way of recording signals, the detector can be used not only for car drivers, but also for operators of other vehicles, e.g. rail vehicles.

AUTHORS' DECLARATION:

Study Design: Łukasz Dziuda, Krzysztof Murawski, Mariusz Dziwosz, Paulina Baran. **Data Collection:** Mariusz Dziwosz, Mariusz Krej, Marcin Piotrowski. **Manuscript Preparation:** Łukasz Dziuda, Paulina Baran. The Authors declare that there is no conflict of interest.

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Preliminary evaluation. Received manuscripts are first examined by Editors according to 'technical' requirements and journal policy. Incomplete packages or manuscripts not prepared in the advised style will be sent back to author(s) with suggestions for correction. The authors are notified with the reference number upon manuscript registration at the Editorial Office. The Editor-in-Chief or Section Editor reads every manuscript received and assigns a general priority level:

1. Manuscripts sent to reviewers immediately;
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Text should be 1,5 spaced, in Times New Roman, 12-point typeface. Margins: 2.5 cm (1 inch) at top, bottom, right, and left. All pages of manuscripts should be consecutively numbered.

The manuscript should include:

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- **Abstract page:**
  - Structured abstract (up to 250 words), consisting of the following sections: Introduction, Methods, Results, Discussion and Conclusions.
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Body text (Introduction, Methods, Results, Discussion, Conclusions, Acknowledgements, Glossary and References);

Introduction should contain the hypothesis and specific aim of the study or (in case of a review) purpose of the article. Authors should briefly introduce the problem, particularly emphasizing the level of knowledge about the problem at the beginning of the investigation.

Methods should describe clearly the selection of observational or experimental subjects including controls, such as age, gender, inclusion and exclusion criteria, (the circumstances for rejection from the study should be clearly defined), randomization and masking (blinding) method. Use of subheadings is advised.

The protocol of data acquisition, procedures, investigated parameters, methods of measurements and apparatus should be described in sufficient detail to allow other scientists to reproduce the results. Name and references to the established methods should be given. References and brief description should be provided for methods that have been published but are not well known, whereas new or substantially modified methods should be described in detail. The reasons for using them should be provided along with the evaluation of their limitations. Names of chemicals and devices used should be followed by the information on the manufacturer (name, city, and country) set in parentheses. Please provide generic name, dose and route of administration.

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Conclusions should be linked with the goals of the study. State new hypotheses when warranted. Include recommendations when appropriate. Unqualified statements and conclusions not completely supported by the obtained data should be avoided.

Acknowledgements. List all contributors who do not meet the criteria for authorship, such as technical assistants, writing assistants or head of department who provided only general support. Describe their role. Financial and other material support should be disclosed and acknowledged.

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Standard journal article

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Article with published erratum

Koffler D, Reidenberg MM. Antibodies to nuclear antigens in patients treated with procainamide or acetylprocainamide [published erratum appears in N Engl J Med 1979;302:322-5]. N Engl J Med 1979; 301:1382-5.

Article in electronic form

Drayer DE, Koffler D. Factors in the emergence of infectious diseases. Emerg Infect Dis [serial online] 1995 Jan-Mar [cited 1996 Jun 5];1(1):[24 screens]. Retrieved 25 January 2013 from: http://www.cdc.gov/ncidod/EID/eid.htm.

Electronic resource

Health on the net foundattion code of conduct (HONcode) for medical and health websites. 1997; Retrieved 9 January 2013 from https://www.hon.ch/HONcode

Article, no author given

Cancer in South Africa [editorial]. S Afr Med J 1994;84:15.

Book, personal author(s)

Lazarus RS, Folkman S. Stress, appraisal and coping. New York: Springer Publishing Co.; 1984.

Book, editor(s) as author

Norman IJ, Redfern SJ, eds. Mental health care for elderly people. New York: Churchill Livingstone; 1996.

Book, Organization as author and publisher:

Institute of Medicine (US). Looking at the future of the Medicaid program. Washington: The Institute; 1992.

Chapter in a book

Charzewska J, Wajszczyk B, Chabrom E, Rogalska-Niedżwiedż M. Aktywność fizyczna w Polsce w rożnych grupach według wieku i płci. In: Jarosz M, ed. Otyłość, żywienie, aktywność fizyczna i zdrowie Polaków. Warszawa: Instytut Żywności i Żywienia; 2006:317-339.

Conference proceedings

Kimura J, Shibasaki H, eds. Recent advances in clinical neurophysiology. Proceedings of the 10th International Congress of EMG and Clinical Neurophysiology; 1995 Oct 15-19; Kyoto, Japan. Amsterdam: Elsevier; 1996.

Conference paper

Bengtsson S, Solheim BG. Enforcement of data protection, privacy and security in medical informatics. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O, eds. MEDINFO 92. Proceedings of the 7th World Congress on Medical Informatics; 1992 Sep 6-10; Geneva, Switzerland.

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- 5 to 10 key words, glossary figure and table lists, figure and table legends.
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The Low-Pressure Chamber „WAWELSKA"

In the Low-Pressure Chamber are performed surveys and trainings for aircrew of the Polish Armed Forces in conditions of low barometric pressure in complex combination of altitudes.

The chamber has been equipped in IT system allowing for recording of physiological parameters (heart rate, arterial blood oxygen saturation and carbon dioxide content in exhaled air) and technical parameters (barometric pressure, temperature and humidity) and full monitoring of these parameters on a computer screen during the survey that allows for accurate and objective way to evaluate test people and a possible quick help. These parameters are presented as digital and graphic, and archived on a computer hard disk.

This chamber is designed to conduct following research:

- periodic tests – to determine the degree of the human organism immunity to influence of the oxygen deficiency and to impact of altitude;
- occasional tests – to determine or update of the human organism immunity to the oxygen deficiency;
- specialist test – due to required profile.

The low-pressure chamber is characterised by following technical parameters:

- barometric pressure achieved in the chamber – 9 mmHg;
- pressure changes regulated continuously in the range from 0 to 15 mmHg/s;
- usable volume of the chamber – 50 m3;
- once inside the chamber can be tested ten people.

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