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Ergonomic and Usability Studies on PLEMODS Dressing Kit Intended as Rescue Equipment for Uniformed Services

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Abstract. The article was written as part of the development project entitled "Dressing kit for protecting injuries suffered by uniformed services while performing official duties" No. DOB-BIO6/19/98/2014, co-financed by the funds from the Polish National Centre for Research and Development under competition No. 6/2014 for the implementation of projects in the field of scientific research or development work, within the area of state defence and security. The project's result will be the PLEMODS dressing kit, intended for saving the life and health of uniformed service officers who have suffered injuries while performing their duties. The kit was developed in response to the needs of both the police and the Polish army.

This work has been compiled from the paper presented during the 12th International Armament Conference on Scientific Aspects of Armament & Safety Technology, Jachranka, Poland, September 17-20, 2018.

The project owner is the police, however, in line with the project assumptions, the kit is dedicated to be used as service equipment of other uniformed services as well. The article presents the premises and conditions that the project team followed when developing the concept of the dressing kit and the functionality of its individual elements. The answers obtained from the research conducted to verify the functional properties of the PLEMODS dressing kit, indicated the need to introduce design changes in the developed model. At the same time, the high comfort of using the PLEMODS dressing kit while performing official duties was confirmed, as well as the effectiveness of the applied innovative solutions in the scope of treating bleeding wounds.

Keywords: personal safety, equipment for uniformed services, first aid in special operations, haemostatic dressings, dressing kit

1. INTRODUCTION

Safety of officers on duty, who perform a number of difficult and dangerous assignments every day, is one of the basic tasks of the state administration. Protection of health and life by providing the services with appropriate training and equipment, including first aid kits containing dressings to treat most injuries that may occur on duty, is crucial for ensuring their safety. This also includes the safety of other people who might need help. This is important, because it is a policeman's responsibility to provide immediate first aid, and this necessity may result from, among other things, measures of direct coercion, as well as firearms, used by the police officers themselves or by another person. This obligation has been regulated in Polish law.

For example, in accordance with the Act on measures of direct coercion and firearms [22], when a person is injured or there are other visible symptoms of a threat to their life or health as a result of the use of direct coercion measures, the entitled person immediately provides them with first aid. If necessary they also call for specialists qualified to provide first aid or medical emergency services[1].

[1] The necessity of providing medical assistance to people in need by the officers of uniformed services results from the actual circumstances, for example, of injuries that occur while they perform their official and legal activities. An example illustrating the legal obligation is the immediate provision of medical assessment or first aid in the event of a justified need, which is regulated by law in Art. 15 sec. 5 of the Police Act of April 6, 1990, Journal of Laws of 2016, item 1782, uniform text. This obligation has been specified in the Regulation of the Minister of the Interior of September 13, 2012 on medical assessment of persons detained by the Police, Journal of Laws of 2012, item 1102. Pursuant to § 1 sec. 1 of the aforementioned regulation, a person detained by the Police shall be provided with immediate first aid or qualified first aid in the event that the person is in a state of sudden health emergency, as defined in the provisions on Emergency Medical Services, with the 'emergency health emergency' defined in Art. 3 point 8 of the Act of September 8, 2006 on the Emergency Medical Services, Journal of Laws of 2016, item 1868, uniform text, as a condition consisting in the sudden or anticipated onset of health deterioration symptoms, which may lead to serious damage to the bodily functions, injury or loss of life and which require immediate medical assistance and treatment.

The results of surveys conducted in 2016 and 2017 among police officers, indicate that the majority of Polish police officers are well prepared to provide assistance to people who find themselves in a state of sudden health emergency and to cooperate with the staff of the Emergency Medical Service System [12]. However, in most of the cases the policemen encounter in their daily service, their knowledge and skills are not enough to help people in a state of emergency - proper emergency equipment is needed.

The dressing kits currently used by the police do not meet the expectations of the policemen and their superiors. The police and the military use either the domestically produced old-generation personal dressing (so called W-type), or foreign-made Olaes Modular or Emergency bandages [11]. It was one of the reasons why efforts were undertaken to create a domestic dressing kit of the highest global standards. This need was addressed by the scientific and industrial consortium led by the Police Academy in Szczytno (Poland), which has undertaken the implementation of the project entitled "Dressing kit for protecting injuries suffered by uniformed services while performing official duties" No. DOB-BIO6/19/98/2014. It was co-financed by the funds from the Polish National Centre for Research and Development under competition No. 6/2014 for the implementation of projects in the field of scientific research or development work within the area of state defence and security.

The main purpose of the project is to design, manufacture and implement a dressing kit intended to protect injuries sustained while performing official duties by officers subordinate to the Minister of the Interior and Administration, as well as soldiers subordinate to the Minister of National Defence. Currently, internal regulations for the police and other uniform services do not require officers to be equipped with a personal dressing, while most regulations, such as the Criminal Code or the Act on Emergency Medical Services, require them to provide first aid. Often, traumatised persons may suffer permanent health impairment, health dysfunctions or even die if first aid is not provided on time. An extremely important aspect is the social perception of the phenomenon of death and health detriment. This applies to the work of the police, the army and the emergency services. The project objectives result from the scale of the problem of so-called 'preventable deaths' and serious damage to health in the course of the performance of official duties. According to the results of research conducted in this area, the main cause of avoidable death in combat is haemorrhage. The research conducted by Ron Bellamy demonstrated that massive limb haemorrhage accounted for over 9% of all deaths in Vietnam. However, it constituted approximately 60% of the three main causes of preventable deaths [3]. Similarly, Eastridge et al. reported that 91% of patients with a chance of survival died due to haemorrhage [9]. Since such injuries constitute one of the main causes of preventable deaths, it is worth equipping officers with a dressing kit intended for their treatment [7]. An example of using the kit components to treat limb haemorrhages is the tactical tourniquet and the haemostatic compression dressing.

In the case of treating injuries, e.g. of the abdomen, the kit includes gauze dressing and thermal foil survival blanket (to protect the viscera visible in the abdominal wound). Using the gauze dressing (e.g. moistened with water) and the survival blanket, it is possible to professionally protect this type of injury and protect the viscera from drying. In the medical literature, this procedure is described as desirable because it protects the intestines against irreversible damage related to drying [3]. The design of the haemostatic compression dressing included in the kit also enables its use as an element immobilising a foreign body stuck in the abdominal wound in its current position. Penetration wounds to the chest are common injuries suffered during service. This is where the valved chest seal included in the kit becomes useful.

The dressing kit is intended as individual equipment for police officers and soldiers. It consists of a carrier, which is a packaging system in a specially designed form, and accessories, including innovative dressings. In broadly understood rescue, it is important that all devices, equipment and auxiliary materials are arranged in such a way as to facilitate procedures and gain valuable time, thus reducing the risks for the injured [10]. Therefore, the entire kit is properly packed and prepared for immediate and intuitive use. It consists of the following dressings and auxiliary materials:

- Dressing for penetrating wounds of the chest (valved chest seal).
- Haemostatic compression dressing.
- Haemostatic sponge dressing.
- Gauze dressing.
- Scissors.
- Gloves.
- Waterproof marker.
- Tactical tourniquet.
- Artificial respiration mask.
- Thermal foil survival blanket.

This dressing kit design is one of the most modern first aid kits planned for implementation. A prototype medical device - haemostatic polymer dressing with various use patterns, is characterised by a high degree of safety during application, mainly due to the active substance with haemostatic effect. Among the haemostatic dressings available on the market, the most popular are those made of natural biopolymers, i.e. chitosan and alginate [2, 5, 6, 8, 16, 17]. Both use patterns of the haemostatic dressing designed within the framework of the project and are based on chitosan [18]. Based on the assumed functionalities, the dressing kit, thanks to its multi-functionality and clinical versatility, has a wide range of clinical applications for treating various types of traumatic wounds.

So far, a dressing kit with haemostatic properties and a high degree of application safety, intended for such a wide range of use, including special areas, as a basic element of equipment for services subordinate to the Minister of Interior and Administration and the Polish Armed Forces has not been produced in Poland.

This article presents the design issues, which have already been implemented and influenced the development of the dressing kit concept and functionality of its individual elements. This article presents, among other things, the assumptions for a risk analysis conducted for the purposes of project works, organization of preclinical tests on animals, methodology of clinical trials on humans, as well as results of ergonomic and operational tests of selected elements of the dressing kit.

2. RISK ANALYSIS AND COMPLIANCE PROCEDURE FOR THE NEWLY DESIGNED DRESSING KIT

Due to the fact that, in accordance with the requirements of the European Directive 93/42 EEC and the PN-EN ISO 13485 standard, each of the medical devices must have analysed, the risk related to the use of the device by a patient-user. The risk analysis is carried out as part of the project. For the purposes of the project in question, the analysis complies with the Polish Standard PN-EN ISO 14971 [19]. It also takes into account the requirements of the PN-EN ISO 22442-1 standard (in terms of materials and raw materials of animal origin) [20]. The risk analysis is verified at every stage of the project. The risk management process within the scope of the project is to identify risks as early as possible in the design phase, assess the levels of acceptability and identify risk management measures, supporting the process of the identified risk reduction to a level acceptable for project stakeholders. The input data for the risk management process are the results of research from individual tasks carried out by the project partners. The risk management process is carried out continuously, and its results become the basis for implementing preventive or, in critical cases, corrective actions. The risk analysis is carried out by persons with appropriate competences and qualifications in the field of certification of personal protective equipment and medical devices working for the notified body, ITB MORATEX (Poland), and project partners.

In the risk management process, we have assessed the levels of all risks resulting from, amongst other things, the selection of materials (raw materials); model and prototype design; applied processing and manufacturing processes; data from the verification of functional properties (mechanical, chemical cleanliness, fatigue tests); potential toxicity and biocompatibility studies; the impact of storage conditions on functional properties and security, as well as data from previously implemented projects. The output data obtained after completing all project tasks will become the input data for the final risk analysis.

As part of the risk management procedures, a reporting system for identified risks has been adopted based on the PRINCE™ 2 project management procedures (risk strategy). It is assumed that risk analysis reviews should take place not more frequently than every six months (except for the stages selected in the project, at which key products - effects - related to the risk analysis being carried out are supplied). The review of the risk analysis is carried out by the Team established as part of the project, including people with appropriate qualifications to assess the risk (and also identify new risks). The description of the risk analyses being conducted is very general, as it is the subject of a separate publication [18].

3. PRE-CLINICAL AND CLINICAL RESEARCH

Animal testing is a necessary stage of work aimed at introducing a new medical device to the market. The tests of haemostatic dressings developed under the project were carried out at the Department of Forensic Veterinary Medicine, Faculty of Veterinary Medicine, University of Warmia and Mazury (UWM) in Olsztyn (Poland). An anaesthetic procedure was used to prepare the animals for the next stages of the experiment in order to make them painless. The animals (large domestic pigs) were immobilized with care to reduce stress, then they received an intramuscular injection of premedication agents, the task of which was to induce an anti-anxiety, analgesic and muscle relaxant effect before applying general anaesthesia. Next, general anaesthesia was induced by the intravenous route, the animal was intubated and received inhalation anaesthesia. The duration of the procedure was approximately 30 minutes.

In the course of the project execution, haematological tests of blood and coagulation factors in the blood collected from pigs wearing the dressing kits were carried out. Haemostasis is a set of processes aimed at preventing blood from clotting in the vascular bed, and in the case of vessel damage, preventing extravasation by creating first a platelet clot, and then a fibrin clot [15]. In the pathophysiology of haemostasis disorders, the important thing is the interaction and balance between the activating and inhibiting factors of the three systems: coagulation, anticoagulation and fibrinolysis. Imbalance leads to bleeding disorders or thrombotic complications. Damage to the blood vessel causes activation of coagulation processes, which, under the influence of thrombin, leads to the conversion of fibrinogen into chemically stable fibrin and clot formation. In the result of post-traumatic haemorrhages and heavy bleeding, coagulopathy may occur due to the exhaustion of coagulation factors. The use of appropriate haemostatic agents should aid the coagulation system. Laboratory tests were carried out during the experiment, which allowed the correct assessment of the effect of the haemostatic agent used during the dressing design and to control the functioning of the coagulation, anticoagulation and fibrinolysis systems. During the research, tissues were collected after animal euthanasia.

Next, histopathological examinations of soft tissue samples collected from the body and dressing contact point were performed. The dressings designed as part of the project were used on animals under general anaesthesia. The application of the selected dressing was preceded by surgical dissection of the femoral artery. The dressing was used on the cut artery. After the procedure, a standard antibiotic and analgesic treatment was applied. Blood was collected for coagulation tests prior to the application of a haemostatic agent, one hour after application, 24 hours, 48 hours and one week after surgery. One week later, the animals were euthanized[2] and subjected to histopathological examination. The obtained results of the tests on animals confirmed the effectiveness of the developed active substance with a haemostatic effect. Previously conducted studies on animals with the use of a modified set on also confirmed that it could be effectively used to design a new, effective and safe haemostatic dressing to stop heavy bleeding from large arteries [1].

After successful completion of animal studies and obtaining the necessary approvals, clinical trials began. They constitute the next stage of design studies and are carried out in accordance with the harmonized standard EN ISO 14155-1/2 "Clinical investigation of medical devices for human subjects" [21]. Tests are being performed in a specialized unit - Clinical Department of Plastic Surgery, Reconstructive Surgery and Burn Treatment of the Military Medical Institute in Warsaw (Poland). Clinical trials compare the effectiveness of the surface effect of the new haemostatic dressing in the proposed forms compared to a selected dressing available on the market. The research is conducted in hospital setting. The tests consist of performing two procedures in a group of 60 patients after excision of skin lesions or deep burns (debridement) with temporary dressing of the defect with a haemostatic dressing. Such a clinical model enables the evaluation of the effectiveness of the dressing in the case of bleeding that cannot be controlled on solely conservative basis. The assessment will include the time and durability of the effect of immediate bleeding control after 3 min., 5 min., 15 min., 1 day and 2 days after applying the wound dressing, as well as the ability to prevent infection and control the level of moisture in the wound (bacteriological tests).

The issue of clinical trials is very important and significant for the results of the entire project. Due to the ongoing work in this area, the article only mentions the currently used procedure and the basic assumptions regarding its course. After the completion of all clinical trials, the results will be the subject of a separate publication.

[2] Euthanasia: Introducing general anaesthesia in animals according to the described scheme. Euthanasia was performed using intravenous injection of Euthasol vet (140 mg/kg bw).

4. ERGONOMIC AND FUNCTIONAL TESTS OF THE DRESSING KIT ELEMENTS

Regarding the comfort of use, one of the most important elements of the PLEMODS dressing kit is the carrier. As part of the dressing kit, a concept of the structure and functionality of the carrier (e.g. bag, cover, backpack) was developed for the PLEMODS dressing kit being designed in the course of the project.

The tests verifying the functional properties of the developed model of the PLEMODS dressing kit were carried out with the participation of 101 officers from five services subordinate to the Ministry of the Interior and Administration: Police, Government Protection Bureau (currently the State Protection Office), Border Guard, State Fire Service, Internal Security Agency. The respondents performed a set of exercises specified in the scenario while wearing their official uniform and full-service gear, and then completed questionnaires consisting of 37 detailed questions. Before starting the research, the officers investigated were informed about the purpose of the research, confidentiality regarding the information provided, and the course of individual stages of the research. The subject of research and its elements in the form of a carrier and model elements of the PLEMODS dressing kit were also discussed. The aim of this research was to collect the opinions of potential users on the proposed design and functionality of the carrier containing the PLEMODS dressing kit. Based on the results of these studies, optimal detailed solutions were selected as the basis for the design and production of the *dressing kit* model.

During the study, the officers first assessed the possibility of attaching the carrier to and removing it from the main belt and vest. They also assessed the functionality of the carrier in terms of opening, closing, taking out elements of the dressing kit and the operation of the so-called quick release system. They then carried out four sets of exercises simulating basic activities performed at work (Table 1).

The obtained results were compiled in the form of tabular summaries, separate for each investigated service. The collected opinions were grouped according to separate categories and presented in the form of comments, while maintaining their affiliation to a specific service. Charts were prepared for selected questions to illustrate the distribution of the answers provided. The summary of the obtained responses indicated the need to make structural changes in several elements of the designed model of the PLEMODS dressing kit (Tables 2, 2a and 2b).

Table 1. A list of exercises carried out as part of the trials verifying the usability of the designed PLEMODS dressing kit - regarding the carrier

No.	Type of exercise	Repetitions
1	Attaching to and removing from the main belt - with right/left hand (quick release, opening, closing, taking out elements of the dressing kit from its 'packaging/cover')	3 tries
2	Attaching to and removing from the vest - with right/left hand (quick release, opening, closing, taking out elements of the dressing kit from its 'packaging/cover')	3 tries
SET I		
1	Kneeling on the right knee	3 tries
2	Kneeling on the left knee	3 tries
3	Kneeling on both knees	3 tries
4	Sitting on a chair	3 tries
5	Sitting on a chair for an extended period of time	3 minutes
6	Lifting both arms in sitting position	3 tries
7	Lifting both arms in standing position	3 tries
SET II		
1	Sitting on the floor	3 tries
2	Crawling, standard	20 m distance
3	Crawling, on the back	20 m distance
4	Rolling sideways in lying position	3 turns to the right and 3 to the left
SET III		
1	Climbing stairs/ladder up and down	3 times up and 3 times down
2	Lifting small objects (50 tennis balls)	1 try
3	Getting in and out of a passenger car (driver's seat)	3 tries
4	Getting in and out of a passenger car (back seat)	3 tries
SET IV		
1	Assuming shooting position with a short weapon (standing, kneeling and lying positions)*	3 tries each
2	Assuming shooting position with a long weapon (standing, kneeling and lying positions)*	3 tries each
3	Transporting a wounded person on stretchers	30 m distance

***** Does not apply to State Fire Service

As regards the placing of the packaging/cover during the exercises, it was determined that State Fire Service officers had a problem with placing the proposed dressing kit on their uniforms. Officers of other services had a different opinion in this respect. They chose the place for the kit 'packaging/cover' individually, either on the belt or the vest, and sometimes on the thigh.

Table 2. The numerical specification of replies provided by officers subordinated to the Minister of the Interior (n = 101) to the questions 1-14 included in the usability study survey regarding the designed model of the PLEMODS dressing kit

Symbol of chosen answers	Survey question number													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14..
	Number of replies													
a	10	49	70	65	63	57	91	98	85	77	67	72	92	92
b	25	14	8	14	12	13	7	1	12	16	14	22	3	4
c	19	16	9	6	4	8	1	0	2	4	9	1	1	0
d	21	17	14	10	16	18	1	1	0	1	6	3	2	0
e	9	0	0	0	0	0	0	0	0	0	0	0	0	0
f	1	0	0	0	0	0	0	0	0	0	0	0	0	0
g	8	0	0	0	0	0	0	0	0	0	0	0	0	0
h	3	0	0	0	0	0	0	0	0	0	0	0	0	0
i	18	0	0	0	0	0	0	0	0	0	0	0	0	0
no reply	4	5	2	6	6	5	1	1	2	3	5	3	3	5

Source: own research

Table 2a. The numerical specification of replies provided by officers subordinated to the Minister of the Interior (n = 101) to the questions 15-28 included in the usability study survey regarding the designed model of the PLEMODS dressing kit

Symbol of chosen answers	Survey question number													
	..15	16	17	18	19	20	21	22	23	24	25	26	27	28..
	Number of replies													
a	70	90	66	72	52	90	83	74	93	91	82	76	55	77
b	11	7	19	14	45	5	9	18	4	4	5	8	27	23
c	3	0	10	10	0	4	5	2	2	0	2	2	0	0
d	8	0	3	1	0	0	1	7	0	4	8	23	0	0
e	0	0	0	0	0	0	0	0	0	0	0	0	0	0
f	0	0	0	0	0	0	0	0	0	0	0	0	0	0
g	0	0	0	0	0	0	0	0	0	0	0	0	0	0
h	0	0	0	0	0	0	0	0	0	0	0	0	0	0
i	0	0	0	0	0	0	0	0	0	0	0	0	0	0
no reply	9	4	4	5	4	2	3	1	2	2	4	3	25	1

Source: own research

Table 2b. The numerical specification of replies provided by officers subordinated to the Minister of the Interior (n = 101) to the questions 29-37 included in the usability study survey regarding the designed model of the PLEMODS dressing kit

Symbol of chosen answers	Survey question number								
	..29	30	31	32	33	34	35	36	37
	Number of replies								
a	81	56	84	54	82	84	47	37	26
b	6	27	2	25	18	1	38	45	41
c	2	0	2	0	0	15	0	0	7
d	22	0	21	0	0	0	0	0	12
e	0	0	0	0	0	0	0	0	16
f	0	0	0	0	0	0	0	0	0
g	0	0	0	0	0	0	0	0	0
h	0	0	0	0	0	0	0	0	0
i	0	0	0	0	0	0	0	0	0
no reply	2	22	3	26	1	2	16	19	7

Source: own research

To question No. 2: *Does the applied 'packaging/cover' fastening system ensure its permanent attachment to tactical equipment?* less than half of the officers surveyed replied in the affirmative (Fig. 1).

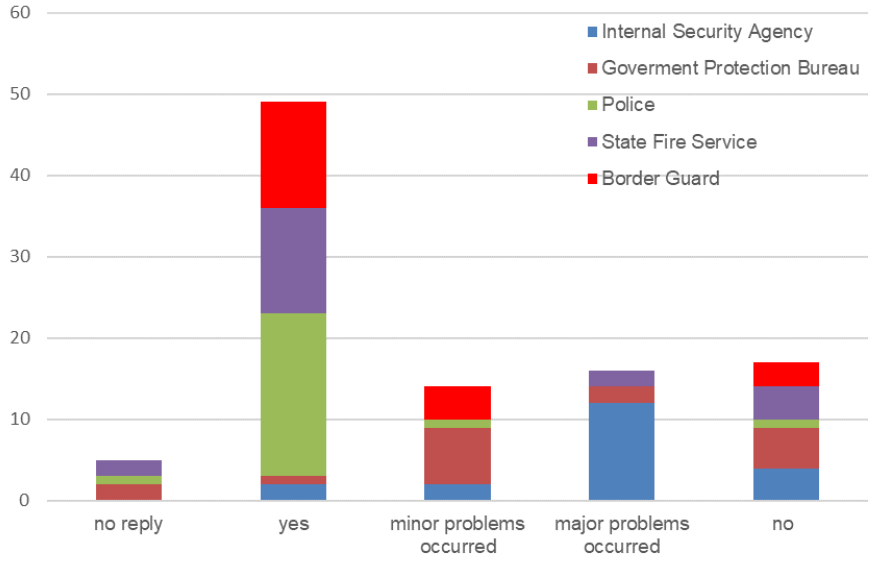

Fig.1. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No.2 (Source: own research)

There were many comments about the Velcro, the space between the belt and the carrier (loose MOLLE system, very poor quality MOLLE straps, too low belt loop), the lack of a grip to tear off, too soft base from which the Velcro detaches and the possibility of attaching the cover using a clip hook or steel lines.

Regarding question No. 3: *Is the 'packaging/cover' of the dressing kit easy to put on and take off without the help of third persons?* it was determined that nearly 70% of the surveyed officers answered this question in the affirmative (Fig. 2). However, there were comments about Velcro, that the cover is very difficult to remove, and that in combat operations the Velcro may get dirty; straps - a problem with interlacing straps was identified - they are too soft and there is no handle at the top of the cover.

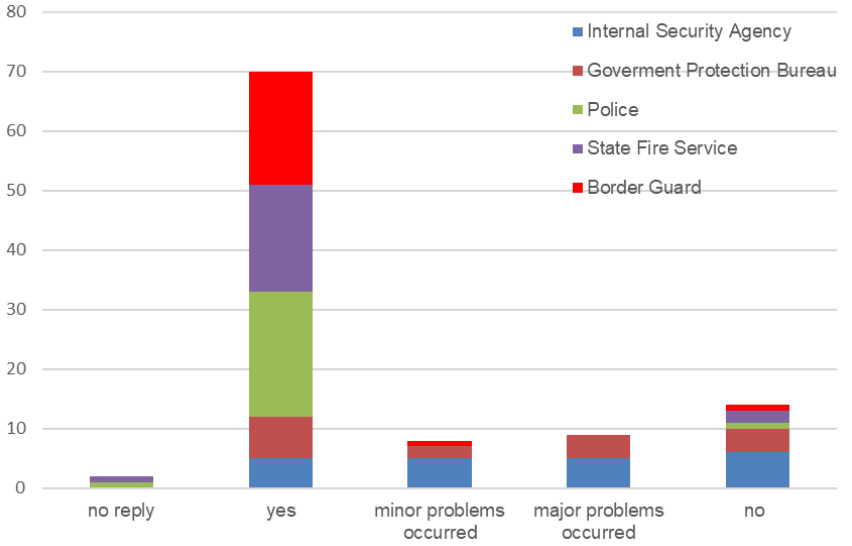

Fig. 2. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 3. (Source: own research)

To questions No. 4 and 5: *Can the 'packaging/cover' of the dressing kit be put on and taken off with the right/left hand?* most of the officers surveyed replied in the affirmative. However, there were comments about Velcro - that it sticks tightly and it is difficult to remove the cover with one hand, the lack of a handle (system) to detach the carrier from the Velcro, too soft cover material.

Most surveyed officers also replied in the affirmative to question No. 6: *Do the fasteners function properly - during putting on, taking off and drills?* (Fig.3). The indicated comments concerned too soft material, weak MOLLE system, weak Velcro, no strap stiffening or no additional protection in the form of a belt with a buckle.

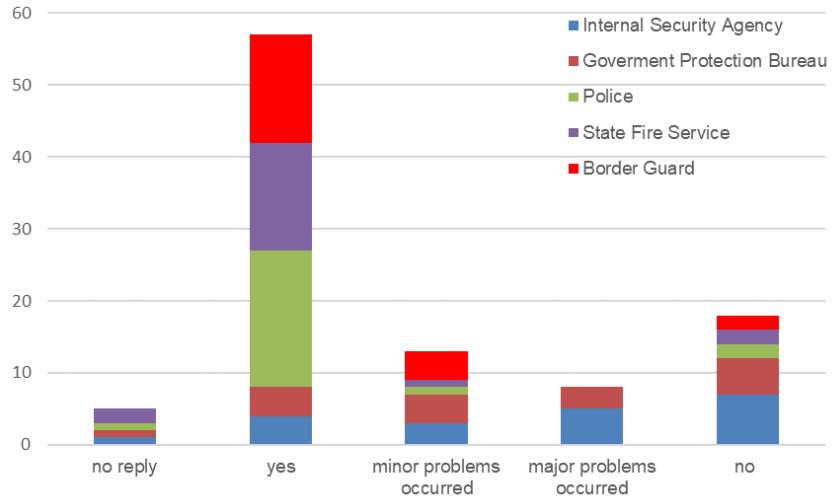

Fig.3. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 6. (Source: own research)

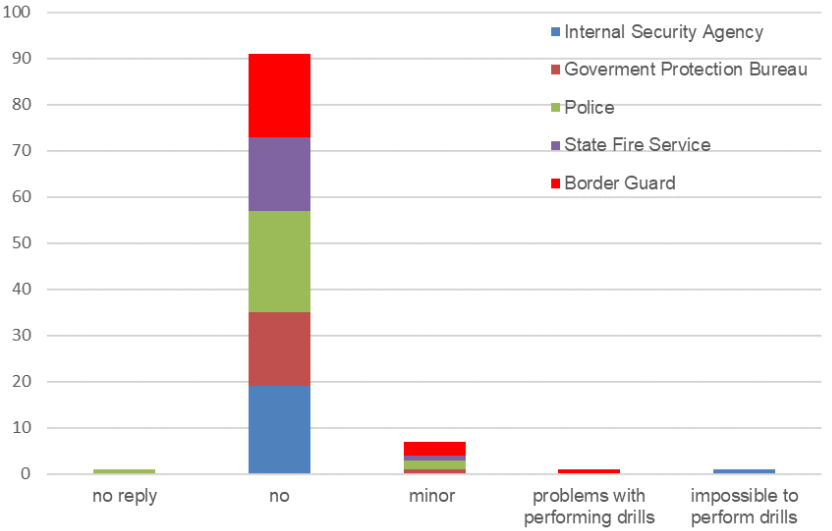

Fig. 4. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 7. (Source: own research)

Regarding question No. 7: *Does the 'packaging/cover' of the dressing restrain kneeling, including kneeling on one knee?* it was established that the vast majority of the officers surveyed did not find any problems in this regard (Fig. 4). There were individual comments about a too large carrier size.

Regarding question No. 8.: *Does the 'packaging/cover' of the dressing kit restrain the lifting of arms in sitting and standing positions?* almost all respondents replied that they did not experience such a limitation.

Based on the answers to question No. 9: *Does the 'packaging/cover' of the dressing kit restrain sitting, including sitting on the floor?* it was established that the vast majority of respondents had no problem with performing this exercise. The comments in this respect mainly related to the too large size of the packaging causing discomfort in the form of pressure.

To question no. 10. *During prolonged stay in a forced position (e.g. sitting), does the 'packaging/cover' of the dressing kit cause user discomfort, e.g. pressure on the legs, arms, hip joints?* nearly 80% of the respondents answered in the negative (Fig. 5). Among the formulated comments, there was information about pressure being exerted on the arms, hips, abdomen and waist. About 70% of the respondents answered that the 'packaging/cover' of the dressing kit did not limit standard crawling and crawling on the back, as well as rolling sideways in the supine position.

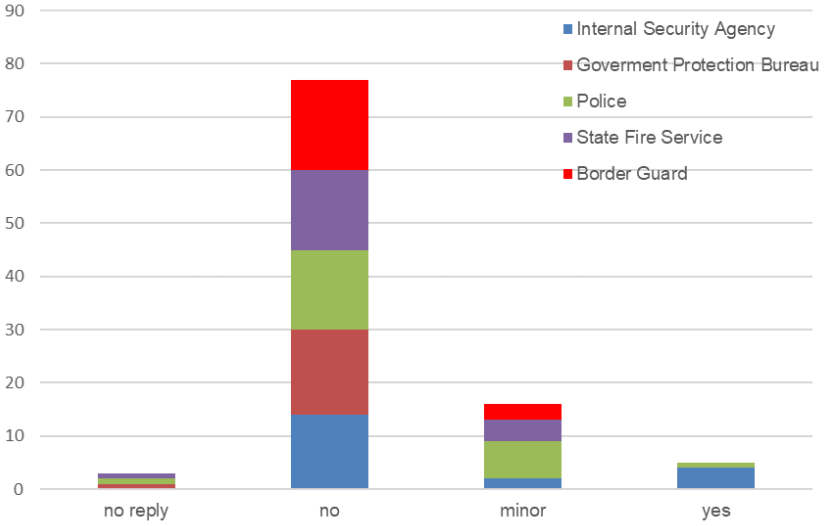

Fig. 5. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 10. (Source: own research)

Among the formulated comments, there was information about causing pressure on the hips, ribs, back and abdomen, as well as Velcro detachment when crawling on the back. The next two questions, No. 13 and 14, concerned the effect of the 'packaging/cover' of the dressing kit on restraining, climbing and descending a ladder, or lifting small objects. Over 90% of respondents answered that they experienced no such difficulties.

Among the formulated comments, there was information about the carrier getting hooked or detaching during this exercise.

Additionally, the majority – 70% of the respondents – replied that the 'packaging/cover' of the dressing kit did not restrain the use of weapons (short and long) in various shooting positions (standing, kneeling, lying) (Fig. 6). Among the formulated comments, there was information about difficulties in adopting a lying posture and switching from one weapon to another.

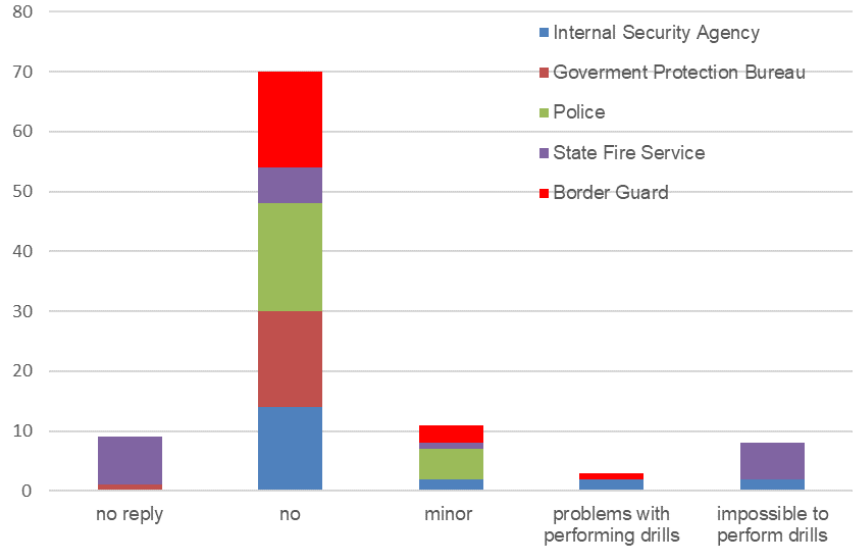

Fig. 6. The numerical specification of the answers provided by respondents – officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 15. (Source: own research)

Regarding question No. 16. *Does the 'packaging/cover' of the dressing kit allow the transport of an injured person?* 90% of respondents answered that it did not. Among the formulated comments, there was information about the carrier hooking to the stretcher and the possibility of Velcro detachment when squeezing through narrow spaces. On the other hand, over 70% of the respondents answered that the 'packaging/cover' of the dressing kit did not restrain getting in and out of a vehicle (passenger car, driver's seat, rear seat).

Among the formulated comments, there was information about hooking or even detachment of the carrier when getting in and out (hooking on the door, post) and pressure on the hip and loin area.

Regarding question No. 19. *Is the dressing kit's 'packaging/cover' quick release system working properly?* the respondents' opinions were divided: 52% of the respondents answered yes, while 45% concluded that the quick release system did not work properly (Fig. 7).

Among the formulated comments, there was information about Velcro - that it holds the carrier too tightly, but will not hold well after repeated use, too soft MOLLE straps, no handle for detaching, too soft material, no protection against unwanted removal.

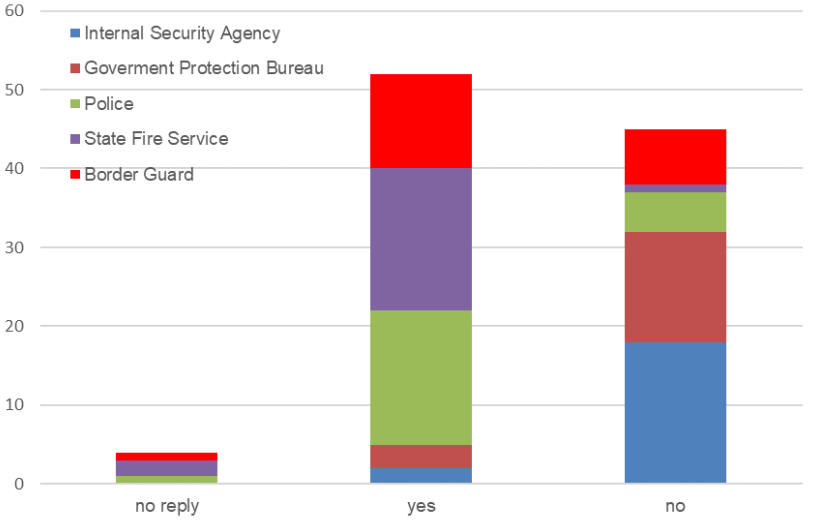

Fig. 7. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 19. (Source: own research)

90% of the respondents stated that the 'packaging/cover' of the dressing kit did not have any sharp edges, rough surfaces, fasteners, sutures and connections that could cause scratches or injuries during professional activities. Among the formulated comments, 10% of respondents reported pointed out to the slider - that it is metal and can sometimes press down on the body, and Velcro - that it is hard and has sharp edges. On the other hand, over 80% of the respondents answered that the dressing kit 'packaging/cover' design does not exert pressure. Among the formulated comments, there was information about pressure on the hip, abdomen and thigh as well as discomfort while sitting and crawling.

Regarding question No. 22. *Is the dressing kit 'package/cover' easy to open?* over 70% of respondents answered in the affirmative (Fig. 8). Among the formulated comments, there was information mainly about the zipper - that it is "hard to operate" and that it could be more robust, it would be advisable to install an additional opening option in the event of a jammed zipper, problem with closing and opening in the upper part of the cover, too large cover and too soft material.

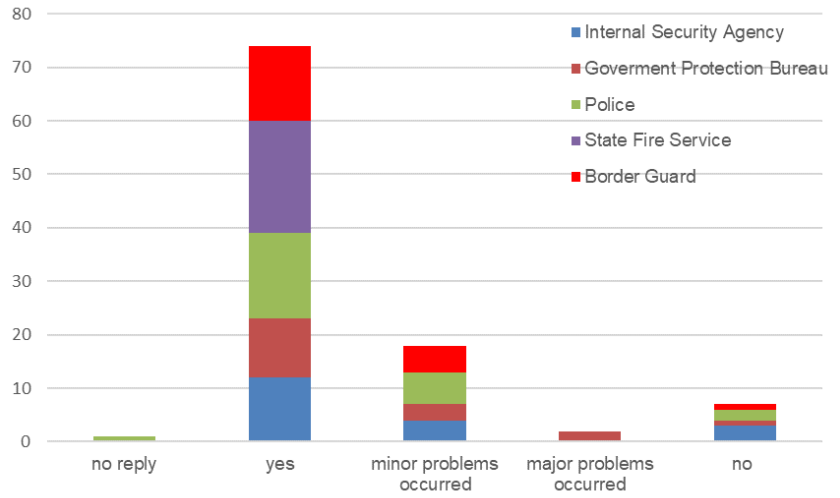

Fig. 8. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 22. (Source: own research)

Regarding questions No. 23, 24 and 25 relating to the ease of removing individual elements of the dressing kit from the 'packaging/cover', a vast majority of respondents (82-91%) replied that they had no problems with it. Among the formulated comments, there was information about the bandage, instructions and a compression dressing - that there are slight difficulties with their removal, especially when the cover is closed.

Regarding question No. 26, nearly 80% of respondents answered that the data on the dressing label were legible in both natural and artificial lighting, and nearly 2% found it legible even in the absence of lighting. There were comments about overly medical names of individual components of the kit, which might be incomprehensible to some users. Over 50% of the respondents stated that in order to improve the legibility of the data on the dressing label, the font should be increased, and almost 30% that the size of the pictograms should be increased. Nearly 80% of respondents answered that the symbols and descriptions placed on the dressing label clearly identify the contents of the package and that the information in the instructions for use is legible in natural and artificial lighting. In addition to this, the data included in the dressing kit content list is legible under both natural and artificial lighting. Nearly 60% of the respondents answered that in order to improve the legibility of the data included in the instructions for use and in the list of dressing kit content, the font size should be increased, while nearly 30% responded that pictograms should also be used and that they should be enlarged. The respondents also noted that sometimes pictograms came off from the packaging.

Regarding question No. 34, over 80% of respondents answered that the specification of the dressing kit contents facilitates the use of the kit.

In the case of question No. 35, the respondents' opinions were divided: nearly 50% of the respondents answered that the mesh pockets inside the packaging/cover should be placed on the internal surface of the module covered with Velcro on the outside, while nearly 40% that they should be located on the opposite side (Fig. 9). Among the formulated comments, there was information about Velcro - that it should also be present on the other external side of the kit and the Velcro strip should have rounded edges. There is also a suggestion for additional pocket protection with an elastic band.

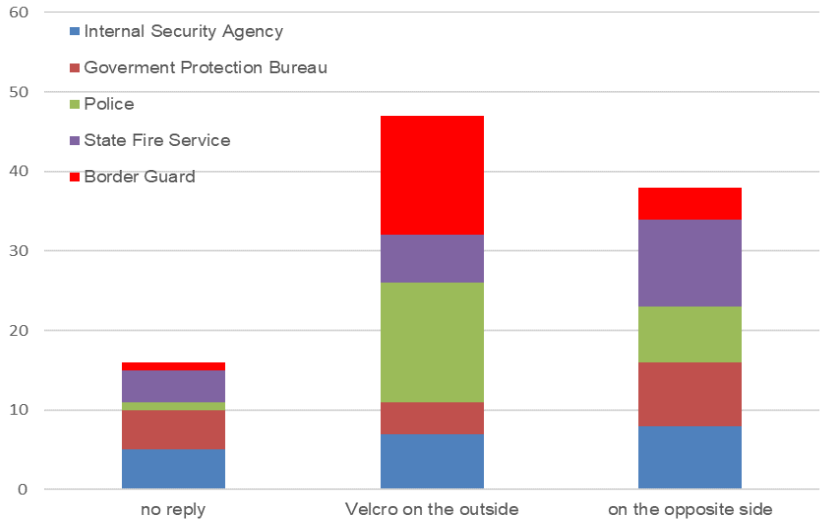

Fig. 9. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101) to question No. 35. (Source: own research)

In the case of question No. 36, the respondents' opinions were divided: almost 40% of the respondents answered that the elastic locking bands inside the packaging/cover should be placed on the internal surface of the module covered with Velcro on the outside, while nearly 45% that they should be located on the opposite side.

Regarding question No. 37. *Please specify the preferred location of the 'packaging/cover'*, the respondents most often indicated the belt, on the left - over 40%, while nearly 30% of the respondents preferred the right hand size. (Fig. 10). Among the formulated comments, there was information from firemen who stated that there is no space on their specialised uniforms to attach the kit and suggested placing the kit on the thigh, on the outer side of their right trouser leg. The surveyed officers were also allowed to post additional comments, apart from the questions included in the survey. The respondents once again drew attention to the size of the carrier - that it is too large.

They also pointed out the need for additional equipment such as a dressing for burns, insect stings, thermal foil, nasopharyngeal tube, marker pen to mark victims of a mass event, increasing the number of masks for artificial respiration and disposable gloves, attaching a clip hook to prevent the loss of the packaging.

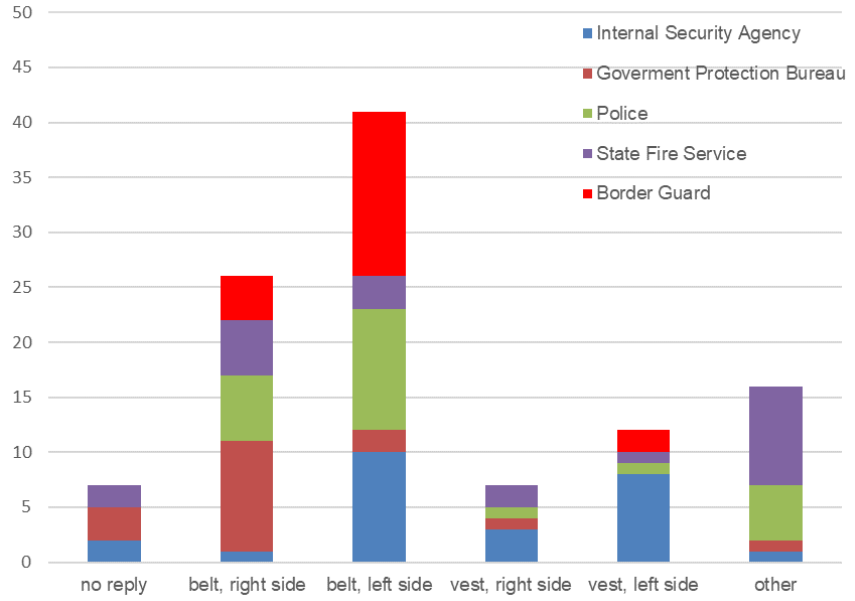

Fig. 10. The numerical specification of the answers provided by respondents - officers subordinate to the Ministry of the Interior and Administration (n = 101 but 109 answers) to question No. 37. (Source: own research)

Moreover, they referred to the markings - the dressings should be placed in fully or partly coloured packaging, because the small markings in the form of coloured dots are illegible, and the first aid kit itself should be clearly marked.

5. CONCLUSIONS

Summing up the above described considerations, it can be stated that the analysis presented, confirms the necessity to use the innovative PLEMODS dressing kit as equipment for uniformed services. The obtained results of tests on animals allowed the correct assessment of the effect of the applied haemostatic agent (the developed active substance with a haemostatic effect) produced as part of the project and its ability to control the functioning of the coagulation, anticoagulation and fibrinolysis systems. The answers obtained from the research conducted to verify the functional properties of the PLEMODS dressing kit, indicated the need to introduce design changes in the developed model regrading several elements, i.e.:

- changing the metal zipper to a plastic one due to the fact that the zipper used in the cover is hard, has sharp edges and can sometimes press down on the body,
- installing an additional option of opening the slider in case of jamming,
- placing the mesh pockets included in the package/cover on the internal surface the module, the outside of which is covered with Velcro,
- changing the Velcro – also placing it on the external kit surface and rounding the edges of the Velcro strip,
- additional protection of the internal kit pockets with an elastic band.
- colour marking of individual dressings,
- improving the readability of instructions by increasing the font and increasing the size of pictograms,
- clear marking of the first aid kit.

To sum up the results of our research, it can be concluded that the high comfort of using the PLEMODS dressing kit while performing official duties has been confirmed, alongside the effectiveness of the applied innovative solutions in the scope of treating bleeding wounds.

FUNDING

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REFERENCES

[1] Adamiak Zbigniew, Wioletta Krystkiewicz, Andrzej Pomianowski, Danuta Bukowiecka, Waldemar Zubrzycki, Marek Jałyński, Piotr Holak, Joanna Głodek, Paweł Jastrzębski. 2017. ”The effect of hemostatic dressing prototypes for the uniformed services on selected blood coagulation parameters in pigs”. *Acta Veterinaria Scandinavica* 59, 29; DOI: 10.1186/s13028-017-0297-9.

[2] Anitha A., S. Sowmya, P.S. Kumar, S. Deepthi, K.P. Chennazhi, H. Ehrlich, M. Tsurkan, R. Jayakumar. 2014. “Chitin and chitosan in selected biomedical applications”. *Prog. Polym. Sci.* 39 (9) : 1644–1667.

[3] Bellamy Ronald. 1984. “The causes of death in conventional land warfare: implications for combat casualty care research”. *Mil Med.* 149 (2) : 55–62. Based on the Wound Data Munitions Effectiveness Team (WDMET) during the Vietnam War between 1967 and 1969.

[4] Bennett Brad, Littlejohn Lanny. 2014. "Review of New Topical Hemostatic Dressings for Combat Casualty Care". *Military Medicine* 179 (5) : 497-514.
[5] Boonkong Wasinee, Amorn Petsom, Nuttha Thongchul. 2013. "Rapidly stopping hemorrhage by enhancing blood clotting at an opened wound using chitosan/polylactic acid/ polycaprolactone wound dressing device". *J Mater Sci: Mater Med* 24 : 1581–1593.
[6] Budynek Małgorzata, Cyprian Nowacki. 1999. *Wiedza o Opatrunkach [Dressings Knowledge]*. ADI: Lodz, Poland, ISBN 83-85815-38-4.
[7] Campbel John Emory (ed.). 2017. *International Trauma Life Support. Ratownictwo przedszpitalne w urazach*. Kraków: Medycyna Praktyczna.
[8] Cheung Randy Chi Fai, Ng Tzi Bun, Wong Jack Ho, Chan Wai Yee. 2015. "Chitosan: An Update on Potential Biomedical and Pharmaceutical Applications". *Marine Drugs* 13 (8) : 5156–5186.
[9] Eastridge Brian, Robert Mabry, Peter Seguin et al. 2012. "Death on the battlefield (2001–2011): Implications for the future of combat casualty care". *Journal of Trauma* 73 (6) : S431–S437.
[10] Flanke Frank, Klaus Runggaldier (ed.). 2012. *Ratownictwo medyczne. Procedura od A do Z*. Wrocław: Wydawnictwo Medyczne Górnicki.
[11] Jastrzębski Paweł. 2018. *Działania ratownicze polskiej Policji*. Olsztyn.
[12] Płaczek Adam. 2017. „Działania ratownicze policjantów w ocenie personelu systemu Państwowe Ratownictwo Medyczne". *Studia i Materiały Wydziału Zarządzania i Administracji Wyższej Szkoły Pedagogicznej im. Jana Kochanowskiego w Kielcach* 1 (4) : 513-522.
[13] Płaczek Adam. 2015. Police Officers' Qualifications to Provide Aid to a Persons in Life-threatening Conditions as an Important Element of Internal Security. In: Wiśniewski B., Kobes P., Sander G., (ed.) *Security and Law in the Cognitive and Utilitarian Context*. Verlag Dr. Kovac GmbH, Hamburg.
[14] Płaczek Adam. 2017. „Ocena współpracy funkcjonariuszy Policji z personelem Systemu Państwowe Ratownictwo Medyczne". *Policja. Kwartalnik kadry kierowniczej Policji*, 3. Szczytno: WSP.
[15] Sokołowska Bożena. 2010. "The physiological function of hemostasis". *Acta Haematologica Polonica* 41 (2) :245-252.
[16] Stephen-Haynes Jackie, Elaine Gibson, Michelle Greenwood. 2014. "Chitosan: A natural solution for wound healing". *J. Commun. Nurs.* 28 (1) : 48–53.
[17] Sun X., Z. Tang, M. Pan, Z. Wang, H. Yang, H. Liu. 2017. "Chitosan/kaolin composite porous microspheres with high hemostatic efficacy". *Carbohydrate Polymers* 177 : 135-143.

[18] Zielińska Dorota, Marcin Henryk Struszczyk, Longina Madej-Kiełbik, Edyta Chmal-Fudali, Magdalena Kucharska, Maria Wiśniewska-Wrona, Kinga Brzoza-Malczewska. 2017. „Design of New-Generation Usable Forms of Topical Haemostatic Agents Containing Chitosan". *Molecules* 22 (12) : 1-17.
[19] PN-EN ISO 14971:2012 „Wyroby medyczne – Zastosowanie zarządzania ryzykiem do wyrobów medycznych".
[20] PN-EN ISO 22442-1:2008 „Wyroby medyczne wykorzystujące tkanki zwierzęce i ich pochodne - Część 1: Zastosowanie zarządzania ryzykiem".
[21] EN ISO 14155-1/2:2011 „Clinical investigation of medical devices for human subjects".
[22] Ustawa z dnia 24 maja 2013 r. o środkach przymusu bezpośredniego i broni palnej, Dz.U. z 2017 r. poz. 1120.

Badania ergonomiczno-użytkowe zestawu opatrunkowego PLEMODS przewidzianego do ratowniczego wyposażenia służb mundurowych

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Streszczenie. Artykuł powstał w ramach realizacji projektu rozwojowego pn. „Zestaw opatrunkowy zabezpieczający urazy powstałe w trakcie pełnienia obowiązków służbowych przez służby mundurowe". Efektem projektu będzie zestaw opatrunkowy PLEMODS, przeznaczony do ratowania życia i zdrowia funkcjonariuszy formacji mundurowych, którzy podczas służby doznali urazów. Zestaw ten został opracowany w odpowiedzi na zapotrzebowanie zarówno policji jak i wojska polskiego. Gestorem projektu jest Policja, jednak zgodnie z założeniami zestaw jest dedykowany do wyposażenia służbowego także innych służb mundurowych. Artykuł przedstawia przesłanki oraz uwarunkowania, którymi zespół projektowy kierował się przy opracowywaniu koncepcji zestawu opatrunkowego oraz funkcjonalności poszczególnych jego elementów. Uzyskane odpowiedzi z badań weryfikujących właściwości użytkowe modelu zestawu opatrunkowego PLEMODS wskazały potrzebę dokonania zmian konstrukcyjnych w opracowanym modelu. Jednocześnie potwierdzono wysoki komfort użytkowania zestawu opatrunkowego PLEMODS podczas realizacji obowiązków służbowych.
Słowa kluczowe: bezpieczeństwo osobiste, wyposażenie służb mundurowych, pierwsza pomoc w warunkach działań specjalnych, opatrunki hemostatyczne, zestaw opatrunkowy