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Daugavpils Universitātes 57. starptautiskās zinātniskās konferences rakstu krājums tiek publicēts 3 daļās: A. daļa. *Dabaszinātnes*; B. daļa. *Sociālās zinātnes*; C. daļa. *Humanitārās zinātnes*.

The annual scientific conferences at Daugavpils University have been organized since 1958. The themes of research presented at the conferences cover all spheres of life. Due to the facts that the conference was of interdisciplinary character and that its participants were students and outstanding scientists from different countries, the subjects of scientific investigations were very varied – in the domains of exact sciences, the humanities, education, art and social sciences.

The results of scientific investigations presented during the conference are collected in the collection of scientific articles ***Proceedings of the 57th International Scientific Conference of Daugavpils University.***

Proceedings of the 57th International Scientific Conference of Daugavpils University are published in three parts: part A. *Natural sciences*; part B. *Social Sciences*; part C. *Humanities*.

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GREAT CORMORANTS (PHALACROCORAX CARBO) IN THE RAZNA NATIONAL PARK – CURRENT SITUATION AND NEED FOR FUTURE MANAGEMENT

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Abstract

Key words: Great Cormorants, the Razna national park, opinion poll

Nesting Great Cormorants (*Phalacrocorax carbo)* in Latvia firstly were observed at the end of the 80th. Increase of population was rapid and in 2012 there were estimated 3106 breeding pairs in nine colonies. Colonies in the lake of Razna and the lake Ežezers in the Razna national park (RNP) are one of the smallest in Latvia.

One of the targets for establishing the RNP in 2007 has been protection of the Lake of Razna where nowadays one of islands is already destroyed by nesting Great Cormorants (GC). The lake Ežezers has been under protection since 1928 due to unique biotopes situated on the islands. Today a part of islands is intensively used by GC. Detailed research on birds' impact on soil and vegetation in the park was done in 2007, since that there are only visual observations. In 2010 a peak for number of GC (136 nests) was fixed in the RNP. Currently situation related to GC in the RNP is stable, and a number of nests do not exceed 100 for the last years.

Experience gives evidence that number of these birds can increase sharply and cause substantial damage to environment which will take long time to avert. It is important to work out the management plan of GC before irreversible damage will be done and this research is base for proposals.

Methodology of opinion poll of experts and population in the RNP was designed and implemented by author in 2014 to fixed observations; clarify knowledge and understanding of local residents on GC. Acquired information was compared with research results of domestic and foreign authors and can be used to work out proposals for the management of GC in the RNP.

Kopsavilkums

Atslēgas vārdi: jūras kraukļi, Rāznas nacionālais parks, aptaujas

Ligzdojošie jūras kraukļi (*Phalacrocorax carbo)* Latvijā pirmo reizi novēroti astoņdesmito gadu beigās. Populācija pieauga ļoti strauji un 2012.gadā Latvijā deviņās kolonijās bija ap 3106 ligzdojoši putnu pāri. Jūras kraukļu kolonijas Rāznas nacionālajā parkā ir vienas no mazākajām Latvijā.

Viens no Rāznas nacionālā parka izveidošanas mērķiem 2007.gadā bija saistīts ar Rāznas ezera, kur šobrīd viena no salām ir būtiski cietusi no jūras kraukļu ietekmes, aizsardzību. Ežezers ar tā salu unikālajiem biotopiem ir viena no vissenāk aizsargājamām dabas teritorijām Latvijā, kopš 1928.gada. Šodien vairākas tā salas apdzīvo jūras kraukļi. Jūras kraukļu ietekme uz augsni un veģetāciju Rāznas nacionālā parka ezera salā tika pētīta 2007.gadā, kopš tā laika notiek tikai putnu vizuālā novērošana, kurā autors iesaistījies kopš 2014.gada. Visvairāk ligzdojošo jūras kraukļu ligzdas uzskaitītas 2010.gadā, kad ligzdu kopskaits sasniedza 136. Šobrīd ligzdojošo jūras kraukļu skaits ir samazinājies un situācija pēdējos gados ir stabila, kopējais ligzdojošo putnu pāru skaits nepārsniedz 100. Pieredze un ārvalstu pētījumi liecina, ka ligzdojošo putnu skaits kolonijā ir neprognozējams un var strauji pieaugt un nodarīt būtisku kaitējumu apkārtējai videi. Pētījuma rezultāti ir pamats priekšlikumiem, lai izstrādātu jūras kraukļu populācijas apsaimniekošanas plānu Rāznas nacionālajā parkā, kamēr nav nodarīti nenovēršami kaitējumi.

Autors 2014.gadā izstrādāja metodoloģiju iedzīvotāju un ekspertu aptaujām un ieviesa to praksē. Aptaujas laikā tika apzināti respondentu novērojumi, zināšanas un izpratne par jūras kraukļiem un to ietekmi uz vidi. Pētījumu rezultāti salīdzināti ar vispārējo situāciju un citu pētījumi rezultātiem. Rāznas nacionālā parka un reģiona attīstības un apsaimniekošanas plānos jāietver jūras kraukļu apsaimniekošanas aspekti.

Introduction

RNP was established in 2007 and covers an area of 59615 ha. The park was created to protect the Lake of Razna (the second largest lake in Latvia) and the surrounding areas. The lake Ežezers is one of the oldest protected areas in Latvia since 1928. Valuable ecosystems - natural deciduous forests with many rare species of plants are found on several of the 26 islands in this lake.

Nowadays several islands of these lakes are colonised by Great Cormorants (GC), and one of the islands in the Lake of Razna is already destroyed due to the impact of the birds.

Management plan of the RNP was worked out in 2009 and during this process 16 biotops of the EU importance were recognised. Project on Protection of Habitats and Species in the RNP is ongoing and includes the control and protection of fish species habitat at five major lakes of the RNP. Main tasks of this project are to design and implement a set of measures for protection and management of five habitats and eight species of the EU and international importance, and raise public awareness regarding the need for protection of these habitats. Management of GC is not included in any plan or project of the RNP, even if the birds nesting in colonies in trees are an extreme natural disturbance in woodlands, which promotes formation of glades and destroy vegetation for long time.

According to the literature GC as invasive and very aggressive species have emerged in Latvia only about 30 years ago (Bregnballe et al. 2014). They are nesting in colonies in trees next to water bodies. In 2012, Latvia had an estimated 3106 breeding pairs of GC in nine colonies. A total of 2634 nests were counted, with the total coverage of all breeders estimated at 80%. This is an increase of approximately 600 pairs compared to 2011. The majority of GC (71%) was breeding in western Latvia, bordering with the Baltic Sea. Colonies of GC in the RNP are relatively small to compare with other ones, but because of the small size islands are sensitive ecosystems and the impact of GC is fairly strong.

Monitoring of GC in Latvia has started in 2005. Studies of the impact of the birds to environment in Latvia started in 2006, but are very limited (Atmata 2014; Bumbiere 2014; Laiviņš and Čekstere 2008). Management of GC is carried out in two areas in Latvia where conflicts with fisheries are intense. Annual permits to shoot approximately 50-70 GC yearly were allocated by the Nature Conservation Agency to the Nagli fish pond (about 70 km from the RNP) and regulation of GC were allowed also in the Dagda municipality (21 km).

Task of the research is to evaluate situation related to GC in the RNP based on the previous research projects, observations done by ornithologists with participation of author and results of the opinion poll organised by author. Generalisation of literature was done to obtain information on GC, their behaviour, distribution and impact on the environment. Requirements of the EU and local legislation and policies were studied to realize possible management strategies. Findings of observations and results of opinion poll are compared with current management plan of the RNP and it forms a base for future decisions related to the management of GC.

Methodology and methods

Author of the paper has participated in the observations of GC since 2014 and used the methodology designed in 2007 (Bregnballe et al. 2014). In the first step numbers were given to the

islands because most of them are without names (Fig 1). Observations started with the inspection of islands already colonized by the birds or potentially suitable for them in two lakes. GR are concentrated only in the west of the Lake Razna and in the east of the Lake Ežezers. Route of observation was worked out and binocular observation from a boat was done in June. In summer when weather conditions where appropriate the islands with nests were visited and trees with nests were marked with bright ribbons and geographical coordinates of each tree were taken with help of *GPS Trimble Juno series SB*. Obtained data were processed with *ESRI* program *ArcGIS* and *ArcMap10* and trees with nests were presented on the map (Fig 2; right side). Number of nests per tree and also fallen nests were counted. Islands were visited second time during the winter of 2014 to recount nests. It was more easy to count nests after fall, but it was not possible to define a nest was populated in the summer or not.

Figure 1. *Mapping of islands occupied or potential for GR in the lake Razna (left) and the Lake Ežezers (right)*

Author designed methodology for interviews of environmental specialists and experts, as well as population and implemented it in practice during autumn 2014 to winter 2015. Opinion poll of population was carried out on the phone or with the help of personal interviews. Target of the poll was to find out observations, knowledge, comprehension and attitude of population to GC. Information sources and viewpoints of respondents were also studied. Qualitative and quantitative analyses of the data were done for the different groups of respondents – fishermen, hunters, owners of guest houses. Answers of the environmental specialists were compared with answers given by population.

It was a plan to interview about 30 experts, but only 19 agreed to participate. Altogether 150 people were asked to participate in the opinion poll. More than a half of accosted refused to answer the questions mostly because they did not know anything about GC and had never seen them. There were about ten people who started to respond the questions, but in the course of time it was noticed that their viewpoints were based only on the prevalent viewpoint of society about the evil impact of

the birds. Answers of seven respondents who consider other birds as GC also were excluded from the analyses. Totally 58 questionnaires were analysed for the needs of this research. 42 respondents were from population and 16 respondents were the specialists and the employees of environmental organisations.

Results of GC observations in the RNP

Totally there are about 35 islands and 20 of them are with big trees appropriate for nesting of GC in the Lake Ežezers. In 2014 nests of the birds were located on two islands (Nr.12 (Siena sala) and 17; Fig 1) of the Lake Ežezers, but totally seven islands were used by the birds. GC very often used to sit on the trees with the slope to water bodies, also other big trees in the islands and on the coasts of lakes. Totally 30 trees with 53 nests were counted and mapped in the island Siena sala in the Lake Ežezers (Fig 2). It means that there were 106 nesting birds in the season of 2014.

Figure 2. *Trees with the nests of GC in the Lake Ežezers*
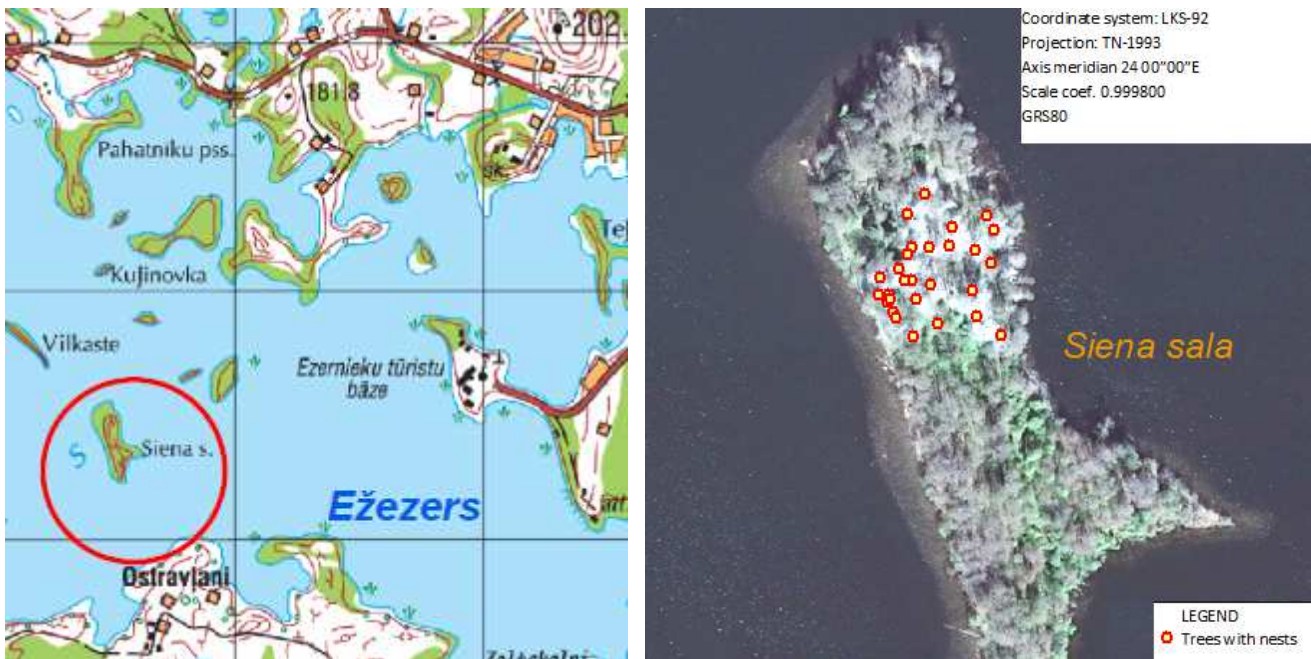
There are ten islands in the Lake of Razna. It is observed that GC used only six islands situated in the western part of the lake (Fig 1), no GC were observed in the eastern part of the lake. One of the islands (Nr.4; Fig 1) of the Lake of Razna has already been destroyed by GC - there are no more suitable trees for nesting. It was the reason why no nests of GC were observed during 2011 to 2013. Nowadays GC colonise other island (Nr.3; Fig 1) in the Lake of Razna.

Totally six islands in the Lake of Razna and eight islands in the Lake Ežezers were visited for direct observation in 2014. Monitoring data of GC in the RNP are available from 2007 (Table 1).

Table 1. *Number of nests of Great Cormorants in the lakes of the RNP*

Lake	2007	2008	2009	2010	2011	2012	2013	2014
Lake of Razna	30	48	57	60	0	0	0	8
Lake Ežezers	46	52	50	76	90	80	86	57

Results of opinion poll

Respondents were in age between 30 to 75 years, most part of them in the age group from 40 to 60. Largest part of respondents was male. Small difference between groups of population and experts were noticed – highest percentage of females and lower average age of respondents were fixed in the expert group in comparison to the group of population.

81% observed GC in the territory of the RNP. Time frame when the first observations of GC were fixed was wide – starting from 1995. Almost a half of respondents observed GC several times in a week in 2014 while about 18% only once a year (Figure 1).

Close to a half of respondents pointed out that they saw GC in their farms only flying over. 21% of respondents considered that there was no damage or disturbance to their household caused by GC. In the first moment a part of respondents considered that GC did harm to their properties, but during the conversation they explained the misinterpret of the question and related harm to nature in general. No private farm or other property was harmed or burdened in any ways by GC.

61% of respondents were fishermen, 15% were hunters and 13% considered themselves as owners of guest houses. Only 17% of respondents were outside above mentioned activities, and largest part of them was in the group of environmental specialists or experts. No significant differences were found among these groups.

Each third respondent had been fishing in the lakes of the RNP. Several lakes were mentioned as fishing places. About 22% of respondents mentioned the Lake of Razna and 12% - the Lake Ežezers where GC were nesting. Each second of fishermen pointed out that they foddered fish, but only a few observed that GC visited these places. Answers related to fishing and resources of fish were contradictious. 77% of fishermen mentioned significant harm to fish resources, but 9% of fishermen thought that there was no negative impact of GC. Totally 45% of respondents considered, that the number of fish had decreased in recent years, while 21% expressed opposite viewpoint. Despite everything one third of respondents were strongly assured that the main reason for decrease of fish population is GC. The same number of respondents mentioned also increasing number of fishermen and 17% - illegal fishing as a reason for it. In the expert group some other reasons were also mentioned – HPS, deterioration of ecological conditions, passive regeneration of fish resources.

83% of respondents considered they had knowledge about GC. About 60% mentioned that they had read about GC in the printed materials or in the Internet and nearly the same amount had seen or heard about GC on TV or over the radio. 40% mentioned friends, relatives or other persons as a source of information.

Large part of respondents considered negative impact to fish resources and nature in GC nesting places, as well as hold a view that GC jeopardized other species of birds (figure 2). No significant difference was found between the knowledge of respondents and sources of information; as well as between the answers of population and specialists.

About 78% of respondents had a viewpoint that the number of GC is increasing, while 7% had opposite one. The rest did not have any ideas. Similar distribution of answers was also on question about the need to regulate the number of GC - 81% held a view that it is necessary to regulate (diminish) number of the birds and based their viewpoints mostly on damage to fish resources done by GC. Despite of negative attitude to GC, some positive aspects were also mentioned by respondents in discussions – beautiful and interesting birds and attraction of tourists.

Discussion and conclusions

Analyses of legislation and normative acts, as well as policy documents and regional development plans of local and the EU importance give evidence on complicated situation. GC are protected according with regulations of the Birds Directive[1] of the EU (79/409/EEK), but from 1997 there is no demand to create specially protected areas for them. GC are not in the list of game birds, but in places where conflict with fishery is high regulation of birds is permitted on the basis of special rules. There is information that illegal hunting of birds sometimes takes place in Latvia, but there is no evidence for it. Theoretically the EU rules allow regulation of GC to protect fish population, but practically it is hard to implement this regulation due to the lack of research and other data and information. For example, there is no consensus and methods how to count and calculate optimal number of GC in a nesting place (Atkinson et. al. 2006; Skov 2007).

The only research of the impact of GC to the vegetation and soil in the RNP was done in the Siena Island in the Lake Ežezers in 2007 (Laiviņš and Čekstere, 2008). Specialists estimated that the island has already been used for nesting for about 20 years. GC made nests firstly in pines and spruces, and to a less extent in lime trees and oaks. Due to changes in substrate chemical properties spruce trees decay at first, while pines and broadleaves are more resistant against the excessive amount of bird droppings. Because of bird droppings the ground right under the trees with nests is completely stripped of vegetation. It increases substrate acidity and reduces the amount of exchange cations. Substrate acidification, disproportions of N and especially of P under the trees with nests affect over a wider area of the forest stand composition and the transformation of plant

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[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147

communities. Laiviņš and Čekstere (2008) also stated that the change of vegetation was observed as well on less impacted places.

Author finds that situation in the RNP is also very complex and contradictious. On one hand the park was created to protect unique nature values and fish resources, but on the other hand GC eliminated some of them. It is also necessary to take in account that GC obviously are under protection. GC can be considered as a threat to a local ecosystem and biological diversity or in some cases as a supplement to variety of nature, but no plans deal with the management of these birds and assessment of their impact to the environment.

Currently the number of GC in the RNP is not increasing, but anyway there is a need to elaborate the management plan of GC. It has to be based on scientific and research data, as well as taken into account viewpoints of general public. Several questions have to be answered and included in this plan – optimal number of GC, suitable places for nesting, methods of regulation of number and educational issues.

One of the reasons for decrease of the number of GC could be a fact that the RNP is situated relatively close to the only two places with fish pond complexes where the authorities permitted management of the GC population by shooting. At the moment shooting on the basis of permits is only regulation method in Latvia. Some other methods like disturbance, destroying nests or oiling of eggs are used in other countries (Guillaumet 2012). But it is too early to discuss methods of regulation if the methods of calculation of the optimal number of GC are unclear.

When GC were not observed on the island of the Lake of Razna in previous nesting place in 2013 it was a suspicion on human intervention. Detailed observation of the island gave evidence that nests had fallen down from the trees due to natural reasons. Trees were so impacted by droppings of GC that they dried up and lost almost all branches necessary for a support of nests.

Opinion poll of experts and population provides valuable information and confirms the need for necessity for raising awareness. Printed literature as well as TV or radio broadcasts on GC are very rarely available. It is possible to suggest that the most part of information respondents and public obtain from other persons and it forms the base for a negative attitude to GC. Of course, these birds destroy environment in their nesting places, but opinion that GC directly jeopardize and attack other birds is totally wrong. Also viewpoint that GC are the main reason to diminish fish population in the RNP is a myth. There are several research projects outside Latvia where it was noticed that in natural reservoirs (lakes, rivers, see) GC do not threaten significantly economically valuable fish stock (Dias 2011; Kumada 2012). Situation changes if the number of GC sharply increases.

Opinion poll demonstrates that there is the lack of knowledge and comprehension among population and also environmental specialists on issues related to GC. There is a need to work out

informative and educational materials to increase knowledge of society and have its reasoned standpoint in next opinion polls in Latvia.

The research gives evidence that at the moment number of GR in the RNP is stable, but it is a risk that it can grow. It is possible to conclude that comprehension of experts as well as general public related to GR is incorrect and it is a need to start educational activities as well as continue observations of GR. Situation is very complicated due to the fact that GR are in the list of protected species, but at the same time their population destroyed some parts of the RNP which is also protected area. Author has a viewpoint that the management plan of the RNP is very general related to management of GR and have to be improved. Experts have to calculate allowable number of GR in the RNP and information campaign among public related to GR have to be organised.

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IN THE SHADOW OF THE AMBER ROUTE

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Abstract

In the shadow of the Amber Route

Keywords: palaeogeography, amber deposits, source of raw amber, antiquity, fossil resins

In the Baltic region, the amber is not so much a commodity, but mostly a cultural value, even the part of national identity. Therefore the natural science studies are not very welcome in this particular area. Fossil resins are widely known around the world and only some of them are entitled as amber and recognised in a number of varieties representing different geological age, chemical composition and country of origin. The Baltic amber has some specifics in chemical composition, but this is valid only for the most of cases. Palaeogeographical reconstruction indicates that the Baltic amber originally accumulated in the deltas environment in the wide ancient strait area from Eastern Romania and the Crimea, covering the central part of Ukraine, Belarus, Poland and East Germany in the north. Later, the primary deposits were redeposited and the amber was moved, too. It happens repeatedly and new deposits are formed and are recognizable in nature, but the amber found here is hardly distinguishable from the amber in primary deposits. Most of amber deposits were known in antiquity and have been used and later abandoned.

Kopsavilkums

Dzintara ceļa ēnā

Atslēgas vārdi: paleoģeogrāfija, dzintara iegulas, izejvielu avoti senatnē, fosilie sveķi

Dzintars Baltijas reģionā ir ne tik daudz materiāla kā kultūrvēsturiska vērtība, pat zināms nacionālās identitātes elements. Tādēļ dabaszinātniski pētījumi ne vienmēr ir gaidīti šajā jomā. Fosilie sveķi dabā ir plaši izplatīti un tikai daļa no tiem tiek saukta par dzintaru. Tam ir vairāki desmiti paveidu, kas atšķiras pēc ģeoloģiskā vecuma, sastāva un ģeogrāfiskās izcelsmes. Baltijas dzintars ir viens no dzintara veidiem, tam ir atšķirības pazīmes, bet tās nav universālas. Paleoģeogrāfiskās rekonstrukcijas norāda, ka Baltijas dzintars sākotnēji ir uzkrājies deltās plašā senās jūras šaurumā zonā no Rumānijas austrumiem un Krimas, aptver Ukrainas centrālo daļu, Baltkrieviju, Polijas austrumus un Vācijas ziemeļus. Vēlāk šīs primārās iegulas tiek pārskalotas un dzintars tiek pārvietots, tas notiek vairākkārtīgi un jauni veidotās iegulas ir dabā atpazīstamas, bet šeit atrodamais dzintars gandrīz nav atšķirams. Daļa no tām ir zināmas senatnē un tikušas izmantotas un vēlāk pamestas.

Introduction

Almost in the whole Northern Europe the amber is relatively well recognized as a high-quality and value coloured gemstone and traditionally includes very substantial emotional components that are rooted in the cultural history of people living in the region, and the Earth and Environmental science element is highlighted only in individual cases. They are uncharacteristic pieces of amber shapes and inclusions, especially in those cases where fossilised insects, rarely other animals or visually attractive plant residues are recognized in the amber. Overall, amber is relatively cheap gemstone, though our region has strengthened the mistaken opinion about amber rarity in nature, the uniqueness of the Baltic amber and the important role of the amber in the ancient trade routes. Some of them are specially marked with a common name "Amber Route".

The study aims to identify the occurrence of amber and its natural diversity, as well as to evaluate the possibilities of finding new deposits of amber, and to assess development of the Baltic amber trade route in antiquity.

Materials and methods

The study is based on a very extensive literature analysis and evaluation, including the study of the Eastern Baltic region, Belarus and Ukraine, reports of regional studies, including the geological mapping and technical reports of mineral resources search and evaluation. There are more than 420 sources and they are given in details in the book of V. Seglins (2015). In this article it would not be appropriate to repeat that, and therefore it focuses on the evaluation of the results obtained from the scientific literature analysis.

Fossil resins and amber in the natural deposits

In the broad meaning the amber is a polymerized fossilised resin and, therefore, is referred to organic minerals, although amber is highly amorphous and has no crystalline structure- it is a semi-solid-polymer. Characteristics of the amber have been studied in detail for many centuries (Bogdasarov 2007). They have been changing over a wide range, because there are many tens of synonymous for the amber, but their names are used in about 50 more widespread varieties (colour, transparency, piece size, geographical location, chemical composition, inclusions etc., etc.). Natural amber may vary in colour - from almost black to milky white. In total, about 250 different shades of amber, including virtually colourless, are known. In Europe as the most appropriate variety of used for jewellery is a transparent amber in light tan shades and honey yellow colours. In the Eastern countries more highly valued is the red one, while the US - a bluish hue amber.

Resin fossilization takes place also today. The oldest known amber grains are found in the lignite deposits from the Carboniferous era, although in several cases the researchers have identified something quite similarl in the Devonian sediments, too. However, these are natural rarities and are found in a few granules only. Nowadays fossilised resins are found on all continents (except Antarctica yet), although the quantity and quality of the finds differ greatly. Very often the Baltic amber or *succinite* is related to one particular resins producer plant and the presence of succinic acid is traditionally considered to be the distinguishing feature of amber of this type. However, recent studies indicate that the number of the amber resin producing plants was larger and, probably, there were at least 3-4 of them (Wolfe et al. 2009). The presence of the characteristic succinic acid is typical also for a great number of fossil resins and amber types (Vávra 2009).

The beginning of amber recognition and use

The oldest reliably dated artefacts made from amber are known from Mesolithic and, in particular, the late Stone Age. These evidences are known from the Baltic and the Mediterranean countries. Among these finds it is definitely worth mentioning those, found by I. Loze at the Lubāna ancient settlements, including Sarnate, Gipka and many others in Latvia. No less richly Stone Age amber artefacts were found elsewhere, but especially in Lithuania, Poland and Denmark. This has created a certain one-sidedness picture of the amber recognition in other regions of Europe.

However, the characteristics of the amber artefacts found in England, Spain, Italy, and Asia Minor and north-east Africa should be mentioned as well. They are known there since at least 4,500 to 3,500 BC. That is earlier than in the Baltic region. Amber utilisation continued in the Bronze period, mostly in the Mediterranean region where the fossil resin amber was quite widely used mainly for the manufacture of cosmetics, incense, small jewellery and household decoration. Perhaps better known are many Etruscan amber artefacts, however it is less known fact that they are made of local amber. Similarly, there are many misunderstandings in relation to other European ancient cultures that used local amber raw material sources. The analysis indicates that there were many sources of amber in Europe (Fig. 1A) confirmed by the artefacts found in excavations.

Figure 1. *Widely known amber sources in Europe:*
A- known in Bronze period, B-natural occurrence

A   B
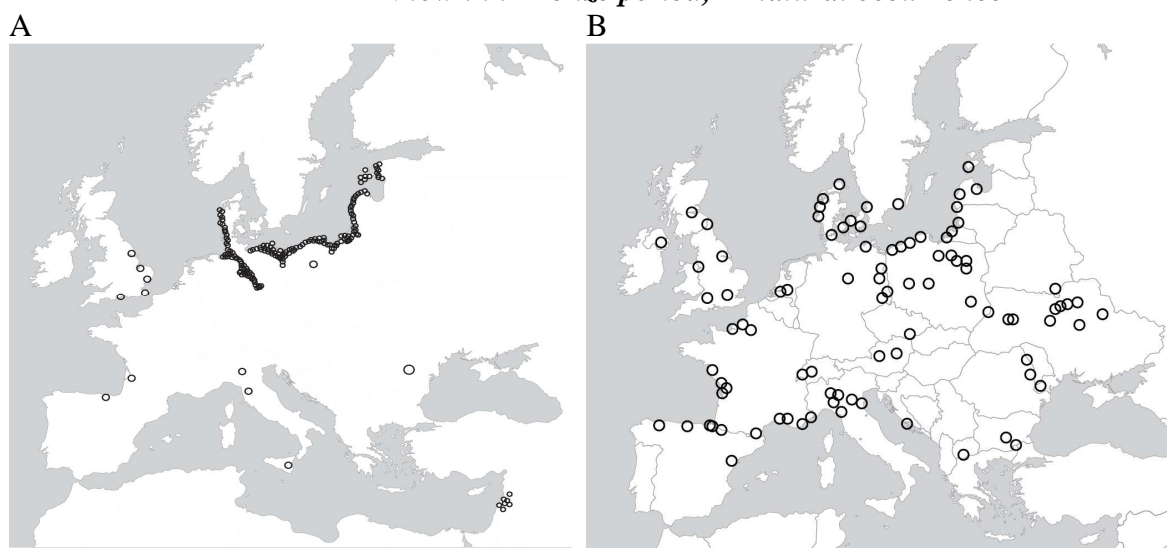
By contrast, geological studies indicate that in Europe the fossil resins and amber is found in nature in significantly greater amount (Fig. 1B). And there is a reason to believe that in the future other amber raw material sources known since antiquity will be recognised. At the same time it is noted that the geological studies identified amber containing deposits of sediments and they can be found rarely and only in a tiny grain form, but they may be deposits of sediments containing tens and hundreds of tonnes of valuable raw amber. Also occurring in amber geological age, the quality and utility of jewellery making is quite different. There are two largest amber containing deposit provinces distinguished which are also the richest ones with a high quality amber: one of them is located in the north of Italy and covers mainly the Po river valley, and the other – in the Baltic Sea region. Amber from these two provinces is distinct by different colour and the external shape of a piece, and chemical composition is also slightly different. However, there is a lot in common like the development time and its relationship with an ancient Tethys Ocean which existed during the Palaeogene and Neogene periods several tens of millions years ago.

Palaeogeographical reconstructions

Palaeogeographical reconstructions (Blakey 2004) indicate that during the Oligocene the ancient Tethys Ocean separated Africa from certain parts of southern Europe and Asia in still relatively large areas. During the Miocene the Tethys Ocean palaeobasin area significantly decreased and several semi-isolated ancient basin areas were formed .

In the coastal areas of the ancient basins the resin-producing plants grew and the resin containing chips or whole trunks were moved into ancient deltas by rivers. These ancient deltas are reconstructed in detail only in the Baltic amber deposits province yet (Fig. 2). Ancient deltas were significantly affected by the changes in the palaeobasin development, and part of them was redeposited. In this way, the initial or primary amber containing deposits were formed.

Figure 2. *The ancient delta areas with the amber containing deposits during the Oligocene period (33.9 - 23.0 Ma). Primary delta deposits at the beginning (A) and at the end of the Oligocene (B)*

A   B
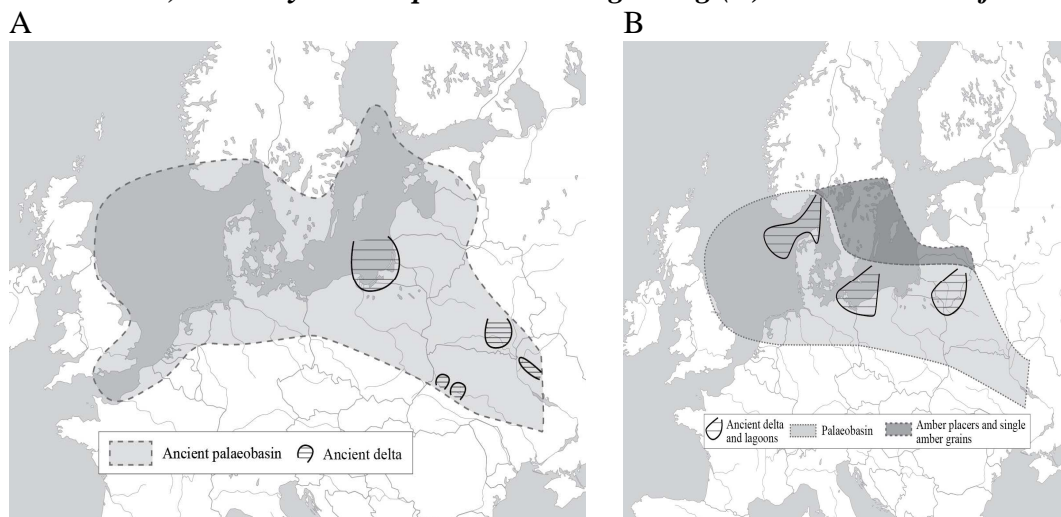
During the Miocene time (23.0 - 5.3 Ma), the ancient basin changes significantly. The initially deposited sediments and delta formations becomes the terrestrial areas which were transformed later by the rivers again, therefore creating a new delta with less rich amber containing sediments. However, the distribution area wasd noticeably wider (Fig. 3A) and such deposits should be entitled as the secondary amber containing deposits.

Figure 3. *The most notable areas of the secondary (A) and tertiary (B) amber containing deposits*

A   B

Secondary deposits are not large and rich, but there is possible to find the same high-valued amber pieces. The redeposition of the Baltic amber allowed to explore it in the entirely remote regions. Therefore, there is no reason for controversy about the analytical attempts to mutually distinguish amber from the Miocene sediments in England and Scotland from the same type of amber found, for example, in the Nemunas downstream region.

By time the secondary amber deposits were affected by erosion, partly destroyed, moved and once more redeposited, and the amber grains were moved again. Furthermore, they were relocated during the Quaternary period. The ancient deposits of glaciers and the edge formations of meltwaters often contain some grains of amber and even pieces, like in the central part of the Russian Plain (Fig. 3B). It is formed of the tertiary amber containing deposits, most of which, however, are associated with a relatively recent geological past, when the World Ocean level rise resulted in the Littorina Sea transgression in the ancient Baltic Sea basin. Raised sea level promoted coastal erosion, affecting also the primary and secondary amber-bearing deposits. Therefore, nowadays the ancient Littorina Sea deposits around the Baltic almost always contain rare and small amber grains.

The following geological processes that affected the ancient Littorina Sea amber containing sediments promoted further dispersion of the amber placers along the Baltic coast. Today, rare amber grains can be found at the Baltic Sea coast mostly northwards from the Sembia peninsula and the Curonian dunes transported by alongshore currents.

Development of the amber trade

In the case of the most ancient amber trade and processing centres, a broad overview was provided by the study of I. Loze (Loze 2008) and in this aspect of European regions this question was little studied. However, during the Bronze and subsequent Iron Age the amber role changed

significantly, and there is recognised a substantial decrease in the number of amulets or similar artefacts made of amber. In the Mediterranean region, amber becomes easily workable semi-precious gemstone and loses its role in jewellery and is replaced by much more valuable hard stone gems, becoming more widely known after the Macedonian Alexander's crusade to the east. During this time, the amber trade continues, but its role is very limited and substantially reduced by wider spread of Christianity because the amber was not mentioned among the high quality and important gemstones in the Bible. During the following centuries, the raw and processed amber is known from many places in the European area. However, there is a small number of such places and their linkage to a traditional sales network is not supported by archaeological finds, not hitherto known traders and tax register data.

Circumstances change after the Renaissance period when the amber is quite widely recognized as a relatively inexpensive decorative stone that is used for various craft inlays and is more widely used for solid amber beads. Only in the 17th century amber from the Baltic Sea coast becomes more demanded in European markets and it becomes fairly significant product in already established trade routes that continue to build more and more detailed distribution networks. With regard to the amber trade chains documented by historical documents the most completely they were identified in Germany, but those were relating to the reconstruction of the 18th century (Richter 2005). During the subsequent years, various amber collection and even fishing methods were developed which ensured slightly increased amber consumer markets. However, significant changes followed only in the second half of 19th century. Detailed geological studies confirm very rich amber deposits of Prussia, where the most expensive mining project was developed and in 1872 the company has already reached the design capacity – 300 tonnes of amber per year. It is more amber than so far was extracted throughout the world together during this century. Such huge amount of amber required a corresponding expanding of the amber trade and processing network, as well as the need and consumption stimulus measures. Many of them can nowadays be recognized as mythical stories, and the amber obtained hitherto unknown properties.

Nowadays, the amber is obtained approximately in 35-37 countries around the world in a total of about 380-420 tonnes, of which about 7% is suitable for jewellery and household item production, but only approx. 2.5% are useful for jewellery. The total market value of the amber is estimated to be about 1,5 billion euro per year and has a tendency to decrease and become more and more pronounced than a niche product to a limited customer base. Therefore, the new amber deposits in the world in recent decades are no longer demanded, but the extracting operations are focused directly on small deposit areas, where it is possible to obtain the amber pieces which are relatively more suitable for jewellery making directly for local consumption. In this case, the amber with a given higher value meant the link with local cultural and historical heritage. Therefore, it can

be not only the symbol of difference, but also a sign of belonging to a certain nation and the identity proof. At the same time it is noted that the following categories of emotional link with the same amber as a resource of raw materials or its geographical origin is quite comparative.

Conclusions

The current study demonstrates that the fossil resins part of which is called amber are quite widespread in the world. These substances are formed today, and only a small part of it remains during the fossilisation. The oldest known amber grains are known from the coal layers that were formed more than 350 million years ago. Most of the currently used amber was formed during Neogene and Paleogene time and to this day has remained in the ancient river delta sediments. During the geological past, they have been moved and partly redeposited for several times. Nowadays, the characteristic Baltic amber is naturally occurring in a very wide area in the North-East Europe, including the distant areas of the modern the Baltic Sea.

In ancient times, there have been many sources of amber known in other paerts of Europe, including the Mediterranean region. There is no evidence known that the amber collected at the coastal areas of the Baltic Sea has been used to the south of the Alps. This raw amber material and its products transported by the trade routes is known only since the end of the Middle Ages. The amber trade routes developed particularly during the 16th and 17th centuries, but significant flow of goods is known only since the second half of the 19th century.

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APPLICATION OF RUSLE EMPIRICAL MODEL FOR ESTIMATION OF POTENTIAL SOIL LOSSES FROM HEADWATER CATCHMENTS IN SOUTH-EASTERN LATVIA

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Abstract
Application of Rusle Empirical Model for Estimation of Potential Soil Losses from Headwater Catchments in South-Eastern Latvia

Key words: RUSLE model, soil erosion, GIS

During the past decades, many studies of soil erosion by water are based on the modelling techniques implemented in a Geographic Information System (GIS) environment. The rationale of such approach relates to the fact that variables required for the calculations of soil losses can be prepared in a GIS data format allowing effectively to perform modelling by GIS tools. However, only some GIS-based analogical studies have been conducted until now in Latvia. Hence, the aim of this research was to estimate potential soil erosion rates in south-eastern Latvia by application of GIS-based modelling. To reach this aim, empirical Revised Universal Soil Loss Equation (RUSLE) model and ArcGIS software were applied. Modelling was carried in several model territories, i.e. five headwater catchments drained by gullies. The results of the study reveal that considering the complexity of geographic distribution of different soil types within the gully catchments on the one hand, and mass movement and linear erosion processes in the gully channels on the other hand, the applied RUSLE model cannot provide reliable quantitative predictions of soil losses. However, results of GIS modelling can be reasonably used to estimate the spatial distribution of soil erosion risk and to identify potential erosion hotspots at a local scale.

Kopsavilkums
RUSLE empīriskā modeļa pielietojums augsnes erozijas potenciālo apjomu novērtēšanai nelielos sateces baseinos dienvidaustrumu Latvijā

Atslēgvārdi: RUSLE modelis, augsnes erozija, GIS

Pēdējās desmitgadēs daudzi ūdens izraisītās augsnes erozijas pētījumi ir balstīti uz modelēšanas paņēmieniem, kuri ir realizēti ģeogrāfisko informācijas sistēmu (ĢIS) vidē. Pamats šādai pieejai ir saistīts ar faktu, ka augsnes zudumu aprēķiniem nepieciešamie mainīgie lielumi var tikt sagatavoti kā ĢIS formātā dati, ļaujot efektīvi veikt modelēšanu ar ĢIS rīkiem. Tomēr līdz šim Latvijā ir tikuši realizēti tikai daži analoģiski pētījumi. Tādējādi šī pētījuma mērķis bija novērtēt augsnes erozijas potenciālos apjomus dienvidaustrumu Latvijā, pielietojot ĢIS bāzētu modelēšanu. Lai sasniegtu šo mērķi, tika izmantots empīriskais revidētais universālais augsnes zudumu vienādojums (RUSLE) un ArcGIS programmatūra. Modelēšana tika realizēta atsevišķās etalonteritorijās, t.i. piecos nelielos sateces baseinos, kurus drenē gravas. Pētījumu rezultāti parāda, ka, ņemot vērā atšķirīgu augsne tipu ģeogrāfiskās izplatības komplicētību gravu sateces baseinos no vienas puses, un nogāžu procesus un lineārās erozijas norisi gravu gultnēs no otras puses, pielietotais RUSLE modelis nenodrošina ticamas augsnes zudumu prognozes. Tomēr ĢIS modelēšanas rezultāti var tikt sekmīgi izmantoti, lai novērtētu ūdens izraisītās augsnes erozijas riska ģeogrāfisko izplatību un identificētu potenciālos erozijas areālus lokālā mērogā.

Introduction

Soil erosion by water is a natural exogenic geological process (Easterbrook 1999) which can be greatly accelerated by human activities and/or environmental changes, and which has been reported in the literature as the major cause of land degradation in the world (Lal 2003; Poesen et al. 2003; Valentin et al. 2005; García-Ruiz et al. 2015). Consequently, studies of soil erosion by water and associated on-site and off-site processes in different landscapes is crucial for obtaining data relevant to appropriate management of territory in terms of erosion risk assessment and sustainable using of soil resources (Montanarella and Vargas 2012). During the past decades, many of such studies had focused on the application of modelling techniques implemented in a GIS environment

(Mitasova et al. 1996), because the data required for the calculations of soil losses can be prepared in a GIS data format. That also allows to perform modelling by GIS tools and to predict erosion in a regular grid cell both at regional and local scales. The integration of erosion models, e.g. USLE or RUSLE models in GIS environment has been acknowledged to be an effective approach for assessment the potential rates and geographic distribution of soil losses (Molnar and Julien 1998; Fernandez et al. 2003; Fu et al. 2006). Moreover, considering that variables required for the calculations of soil losses can be obtained by automated or semi-automated procedures from remotely sensed data or referenced thematic maps, the availability of GIS instruments has greatly facilitated model application over areas from headwater catchments to much larger regions (Lu et al. 2004; Terranova et al. 2009). In such a context and regarding that protection of soils is the key objective of the EU draft Soil Framework Directive (European Commission 2006) attention of the scientific community and policy makers has understandably focused on matters of soil erosion modelling. In addition, the data reported by researchers suggest that soil erosion to great extent affects water quality too, because the main part of sediment delivery to rivers and lakes relates to transferring of soil erosion products from adjacent landscape (Collins et al. 2009; Rickson 2014). Hence soil erosion and its risk estimation can be related to protection of the water quality which is some of the major concerns in the European Union member states and is the main objective of the EU Water Framework Directive (OJEC, 2000). Thereby there is a trend approved by EU institutions and agencies (Van Der Knijff et al., 2000; Gobin et al., 2003; Panagos et al. 2004) to use soil erosion models that can be performed by GIS tools to assist sustainable management of soil resources and environmentally wise planning of land-use. Despite that, until now in Latvia only some studies on the GIS-based modelling of potential soil losses have been conducted (Grišanovs 2009; Soms and Grišanovs 2010a; Soms and Grišanovs 2010b; Soms 2014).

Considering that, the aim of this research was to estimate soil erosion rates in south-eastern Latvia by application of GIS-based modelling. For research purposes, empirical RUSLE model and ArcGIS software were applied, and five headwater catchments drained by gullies were chosen as model territories.

The specific objectives of the research outlined in this paper were (1) to collect, process and generate input data and variables required for the calculations of soil losses compatible with ArcGIS; (2) to apply GIS/RUSLE approach estimating potential soil loss from selected headwater catchments in the river Daugava spillway valley; (3) to assess the results of GIS/RUSLE modelling in terms of tolerable and critical soils erosion thresholds.

Material and Methods

The study area, i.e. the river Daugava spillway valley is located in south-eastern Latvia (Fig. 1A).The spillway valley is one of the regions in Latvia, where in many places gullies formed due to

the interaction of natural and human-induced factors. Hence, the spillway valley has been selected as a study area affected by soil erosion. Therefore, this is one of the most appropriate areas for the study of soil erosion processes in the south-eastern part of the country.

Small headwater catchments drained by gullies are characteristic features in this spillway valley. There are more than 340 permanent gullies of different size and morphology dissecting the main valley sides along its 50 km long stretch from Krāslava down to Krauja village, and total gully length per unit area in some places reaches 4.2 km km^{-2} (Soms 2006). Local altitudes range between circa 80 m a.s.l at the valley bottom and 150 – 180 m a.s.l at adjoining hummocky and undulated areas (Fig. 1B). That also determines the high location of headwater catchments over the local base level.

Figure 1. *Location of study area in Latvia (A) and digital elevation model (DEM) of the river Daugava spillway valley with model territories of selected headwater catchments (B). Source of DEM: NASA Shuttle Radar Topography Mission elevation data v.4 (Jarvis et al. 2008)*
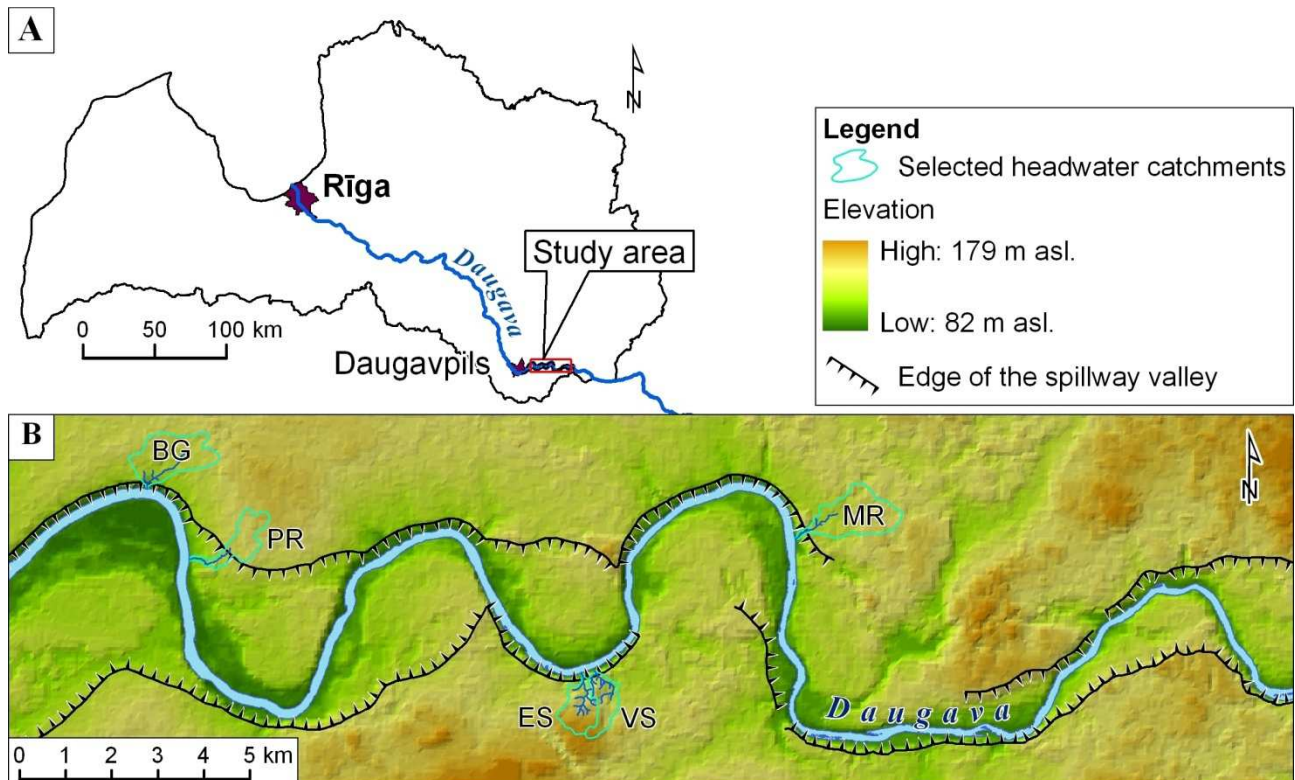
For research purposes, five headwater gully catchments were chosen as model territories. Such small catchments constitute the upper part of the hydrographic network in hummocky post-glacial landscape in SE Latvia and play a significant role as sources of eroded soil material. The local names of gullies which drain the corresponding catchments are Baznīcas grāvis, Pesčanij ručej, Moģiļnij ručej, Eitviniško strauts and Ververu strauts, hence model territories were named BG, PR, MR, ES and VS respectively (Fig. 1B). All the research procedures described further were performed for each catchment.

To perform modelling, first of all, appropriate model that can be integrated in the ArcGIS environment was selected. Review of literature reveals (see e.g. Merritt et al. 2003; de Vente et al. 2013) that the models used for the purposes of assessment of soil losses can be distinguished to three groups, i.e. (1) qualitative models; (2) empirical models and (3) quantitative models. Amongst the developed models, the empirical Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978), and its more recent version, Revised Universal Soil Loss Equation (RUSLE) (Renard et al. 1991), that quantifies the mean area-specific annual soil loss, is most frequently used worldwide at various spatial scales and different physiogeographic and landscape contexts (Renschler and Harbor 2002; Zhang et al. 2013). This is mainly because these models have a very simple structure of the equations, availability of input of data as well as a possibility to perform modelling by GIS tools. Hence, RUSLE empirical model was selected for estimation of potential soil losses from headwater catchments in south-eastern Latvia.

According to Renard et al. (1991) the potential soil erosion risk within the defined area under study can be predicted by the RUSLE model, which in mathematical form is written as follows:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

where A is the mean soil loss per year (t ha^{-1}y^{-1}); R is the rainfall erosivity factor (MJ mm ha^{-1}h^{-1}y^{-1}); K is soil-erodibility factor (t h MJ^{-1} mm^{-1}); L is the slope length factor and S is the slope steepness factor (both dimensionless); C is the cover management factor (dimensionless); and P is the support practice factor (dimensionless).

The value of R factor have been inferred from the literature (Sileika 1996), from the closest location where estimations of R factor is available, i.e. north-east Lithuania. The R factor was set to value 461.2 (MJ mm ha^{-1}h^{-1}y^{-1}).

The K factor values were obtained in two stages. Firstly soil texture types were derived from field survey data of Quaternary deposits in model catchments according to identified lithological units. After that values given in the literature (Panagos et al. 2014) were assigned for soils with corresponding texture type.

For the obtaining of L and S values, high-resolution 1 × 1 m DEM was generated by ArcGIS extension Spatial Analyst tool *Topo To Raster* on the basis of manually digitised contour lines and spot heights from the topographic maps at scale 1:10,000. The *LS* factor was calculated with the previously developed DEM according to the expressions used in RUSLE in details described by McCool et al. (1989). For that reason considering limitations of the length of the article, author omit the layout of this mathematical operations.

The C factor values were obtained from identification of land cover types on the basis of analysis of orthophoto maps (LGIA 2012). Then C factor was parameterised by assigning a uniform value given in the literature (Wischmeier and Smith 1978) to each land cover class.

The support practice *P* factor (dimensionless) was set to value '1' because there are no specific erosion control practices in the studied catchments, thus this factor has no impact on the resulting soil losses from model territories.

Due to RUSLE empirical model deals with geospatial input data, the ArcGIS tools facilitated the automatization of calculation procedures. Hence, the mean annual soil loss for the each of five model catchments were calculated *Raster Calculator* tool according to the SQL codes developed by Grišanovs (2009) for application in GIS environment. The summarised workflow diagram of the methodology followed in this study is presented in Fig.2.

Figure 2. *The summarised workflow of GIS/RUSLE approach*
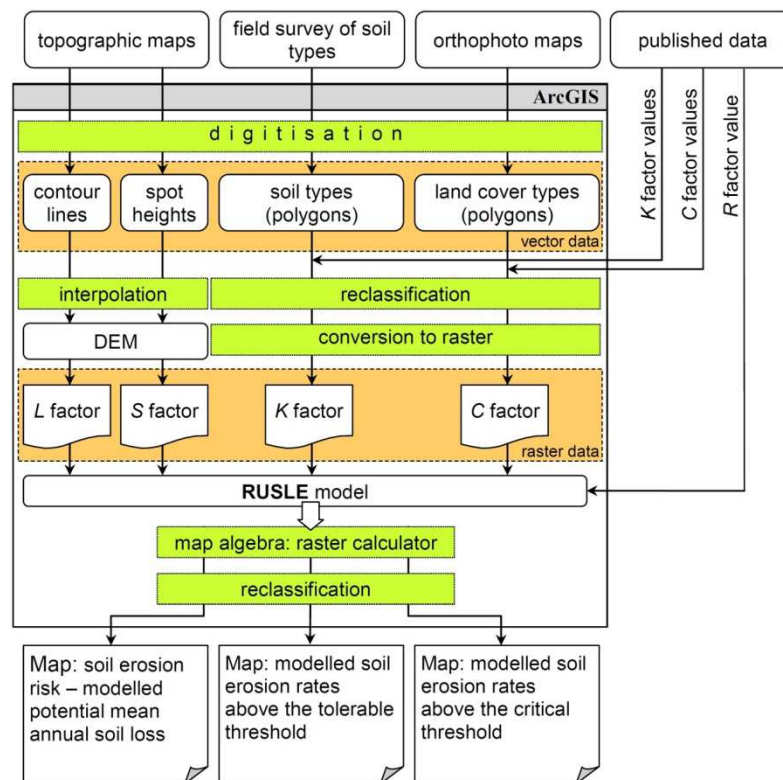
Results and Discussion

Considering a diversity of Quaternary deposits and a rough terrain of the spillway valley, a variety of soils can be identified within headwater catchments under study. Despite that, dominant types of soils are Albic Stagnic Podzols, Stagnic Albeluvisols and Albic Rubic Arenosols. Although the soils vary, the selected gully catchments have similar properties in respect of erodibility because glacial till derived soils with stony loamy – clayey diamicton and sand textures prevail in the selected catchments. Hence, values of erodibility K factor of the top-layer are rather similar in model territories.

Canopy vegetation in the headwater catchments is mainly represented by broad-leaved forests of wych elm and lime communities. The forests are growing primarily on gully slopes because these

landforms are unsuitable for human economic activities like tree cutting, grazing, soil processing, etc.

Review of literature indicates (Schwab et al., 1993) that the forest vegetation cover and land use also are significant factors that affect rates of soil erosion. Therefore, the spatial analysis of land cover patterns and calculation of a particular area for each land cover type was carried out. In Table 1, the calculated proportion of land cover classes for each of the headwater catchments are shown.

Table 1. *Land cover classes and their proportion in each headwater catchment*

Land cover (%)	Catchment				
	BG	PR	MR	ES	VS
forest	11.10	7.14	74.18	40.67	36.51
scrub	-	2.50	7.02	3.88	6.44
arable land	4.74	5.67	1.41	-	-
gardens	-	-	5.83	-	-
grassland and rangeland	83.95	84.28	11.45	46.76	53.72
orchard	-	-	-	8.69	2.27
pond	0.22	0.42	0.10	-	1.05

The protective forest canopy vegetation covers more than 30% of the area of three of headwater catchments. At the same time, the arable land in the model territories constitutes less than 5% of the total gully catchments. Thus, it can be anticipated less erosion risk and related delivery of eroded soil material from model territories MR, ES and VS. To verify this assumption, the GIS/RUSLE approach was applied to estimate potential soil loss from selected headwater catchments in the river Daugava spillway valley.

The obtained results indicate that modelled soil losses from the headwater catchments greatly varies from 0.001 to 150.6 t ha^{-1} yr^{-1}, but the average values predicted by RUSLE for the model territories ranges from 0.25 to 0.58 t ha^{-1} yr^{-1} (Fig. 3).

However, at the catchment scale potential soil loss values varies greatly depending on land cover type, e.g. $A = 0.12$ t ha^{-1}y^{-1} for forestland, $A = 0.27$ t ha^{-1}y^{-1} for grassland and rangeland, and $A = 5.59$ t ha^{-1}y^{-1} for cropland and arable land. The average soil loss modelled rates of cropland was about 20 times that of grassland, and 46 times that of forested land. The spatial distribution of the soil erosion risk is uneven and differs both among the catchments and at the each catchment (Fig. 3).

Figure 3. *Results or RUSLE modelling for selected headwater catchments: mean annual sediment loss (left column); erosion rates above the tolerable threshold (middle column); and above critical threshold (right column)*
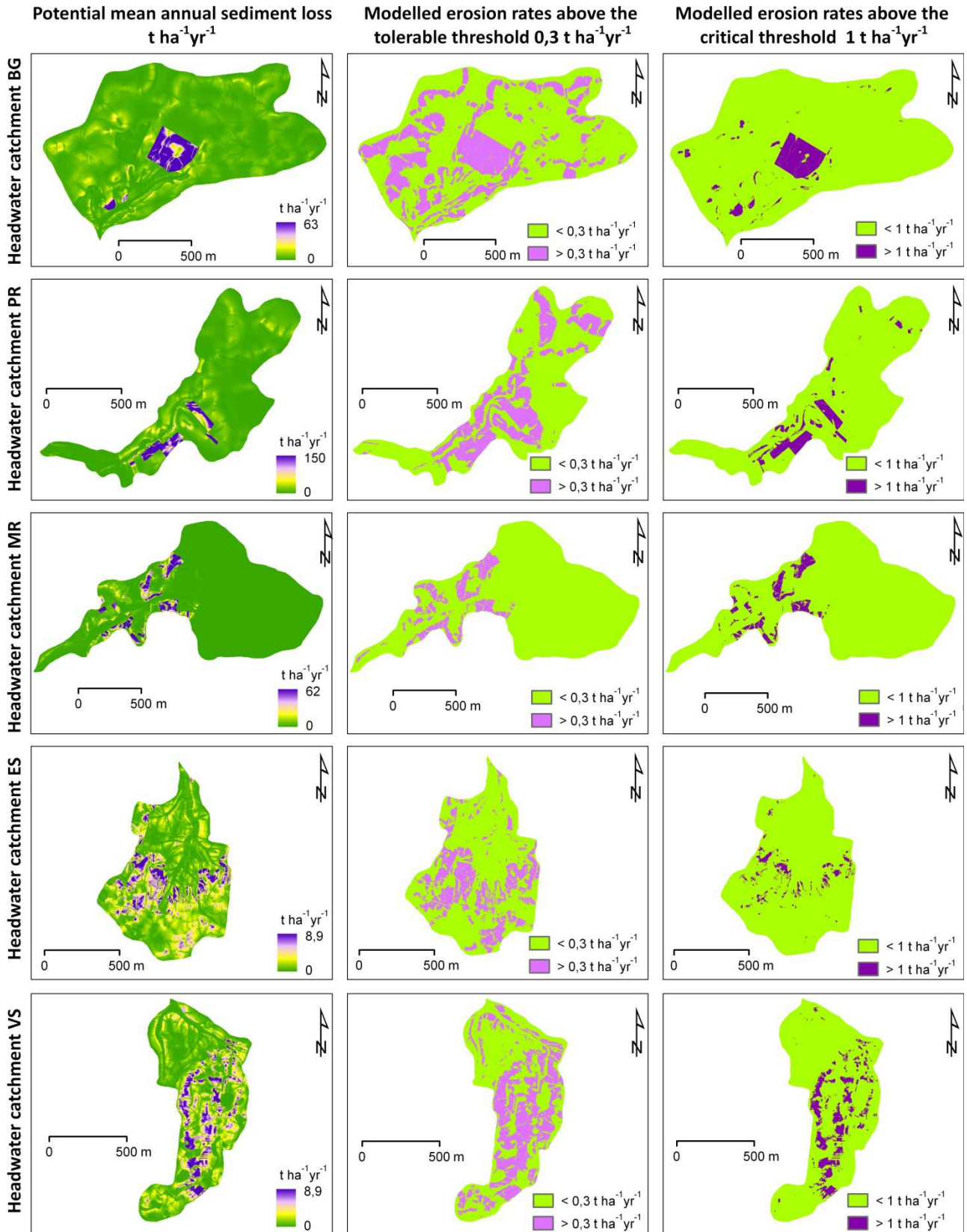
The regularity elucidated during the analysis of data indicates that the lowest soil erosion risk relates mostly to forested areas, whilst the higher soil erosion risk areas geographically coincide with arable land. Notably, despite the presence of forest vegetation that cover more than 30% of area of three of catchments under study, sizable plots of soils are potentially prone to erosion rates above the tolerable threshold calculated for Europe (Verheijen et al., 2009), i.e. 0.3 t ha^{-1} yr^{-1}. It is also necessary to note, that RUSLE modelling highlights substantial parts of model territories where erosion rates potentially can exceed the critical threshold 1.0 t ha^{-1} yr^{-1} (Fig. 3).

Comparison of modelled values of soil losses with published data on sediment delivery (Soms and Gruberts 2008) demonstrates that applied RUSLE model underestimates eroded material flux. This discrepancy occurs because RUSLE model omit possible impact of high-intensity rainfalls as well as the effects of concentrated linear erosion on sediment transfer from catchments. Both these facts as reasons of RUSLE errors also are indicated in the literature (Kinnel 2005). Also, the field observations indicate that the part of the eroded material is supplied from the erosion of gully sidewalls and by mass movement processes. It in turn also influences the precision of RUSLE estimations.

Conclusions

The results of the research presented in this paper permit to draw several important conclusions about the results of RUSLE modelling and estimation of potential soil losses from headwater catchments in the river Daugava spillway valley.

The application of GIS/RUSLE approach in different physiogeographic environmental conditions has some limitations. The obtained values of potential soil loss and corresponding erosion risk have to be appraised adequately, only for indicative and planning purposes, and not considered in absolute terms.

The analysis of data carried out in this study has showed that the current approach of RUSLE erosion model underestimates the proportion of the sediment load that is transferred from erosion sources associated with contributing surfaces of headwater catchments.

Although the results of RUSLE modelling, in general, can be used as a basis for soil losses estimation, until better models will be elaborated and adapted, policy makers and responsible institutions should handle the results of soil erosion risk assessment by GIS tools with some discretion.

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FIZIKA / FHYSICS

THE EFFICIENCY OF ARTIFICIAL INTELLIGENCE SYSTEMS OF AUTONOMOUS MOBILE ROBOTS AND TENDENCIES FOR DEVELOPMENT

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Abstract

The Efficiency of Artificial Intelligence Systems of Autonomous Mobile Robots and Tendencies for Development

Key Words: *mobile robot, control system, fuzzy logic, neuron net system, artificial intelligence.*

In all over the world, there is an increasing number of discussions about the newest and most actual science research object – artificial intelligent system development, i.e. there are many international seminars, scientific conferences and other form of meetings of scientists in which not only the new achievements, practical problems, but also development perspectives of artificial intelligent system. As consequences, it is necessary to systematic analysis of nowadays stage and problems of development of artificial intelligent systems. This article analyzes running effectiveness and development perspectives of artificial intelligent system of mobile autonomic robots. Research paper provides a brief analysis of differentiation of robot system definition in automatics and information technologies sciences. Nonetheless, the research object of this article is artificial intelligent system for robot control that is based on fuzzy logic and neuron net system methodic while genetic calculating and probability substantiation are not analyzed in this article. This articles analyzes the basic principles and existing systems of fuzzy logic, neuron networking peculiarities, and common architecture of artificial and specific neuron nets. Moreover, there is analysis of the most popular hybrid artificial intelligent system like neuro-fuzzy, fuzzy-genetic and other hybrid systems.

Kopsavilkums

Autonomo mobilo robotu mākslīgā intelekta sistēmu efektivitāte un attīstības tendences

Atslēgvārdi: *mobilais robots, vadības sistēma, miglotā loģika, neironu tīkli, mākslīgais intelekts.*

Visā pasaulē bieži tiek uzdots jautājums par patlaban jaunāko un aktuālāko zinātniskās pētniecības jomu – mākslīgā intelekta attīstību, t. n. tiek organizēti starptautiskie semināri, konferences, kas analizē ne tikai jaunākos mākslīgā intelekta sasniegumus, taču arī to attīstības perspektīvas. Tāpēc ir nepieciešama sīkāka mūsdienu mākslīgā intelekta sasniegumu, tā darbības iespēju un izmantošanas robotikā perspektīvu analīze. Šajā rakstā tiek analizētas autonomu mobilo robotu mākslīgā intelekta sistēmas un izvērtēta to darbības efektivitāte un attīstības tendences. Rakstā īsi tiek atklāta robotu sistēmas jēdziena diferenciācija automātikas un informātikas jomā, taču lielāka uzmanība tiek vērsta uz mākslīgā intelekta vadības robotu sistēmām, kas pēc būtības tiek pamatotas ar miglotās loģikas, neironu tīklu metodikām, bet šajā darbā netiek analizēti ģenētiskie aprēķini un varbūtības pamatojums. Rakstā tiek analizēti gan miglotās loģikas pamati, tās esošās sistēmas, gan neironu tīklu darbības īpatnības, mākslīgo un specifisko neironu tīklu kopīgā arhitektūra. Rakstā arī tiek analizētas populārākās hibrīdās mākslīgā intelekta sistēmas neurofuzzy (neironu – miglotās), fuzzy-genetic (miglotās – ģenētikas) un pārējās sistēmas.

Introduction

Thanks to the breakthroughs in computing and technologies, the progress of robotics has been given more and more importance in the specialised spheres of social activities as well as in the performance of various operations. In addition, the potential of robotics in improving the quality of people's daily life and making it more comfortable is underlined. Consequently, the development of an effective robot control system, which is currently the most urgent and topical question of this sphere, is being increasingly raised all over the world: international seminars and conferences [14] are held to analyse not only the latest achievements in robot control systems but also their development prospects.

Autonomous and mobile robots, which is a new direction in the sphere of robotics, is becoming more and more topical and attracts much attention. One of the most common robot control tasks encountered in this regard is the development of planning methods in an unknown environment. This task encompasses some major issues – the search for proper methods, which would allow the robot to plan its movements in an unknown environment, but also to take appropriate decisions in real-time mode, and especially in environments with unfamiliar moving obstacles. This paper therefore analyses the most recent fuzzy logic and neural network planning methods that deserve widest practical implementation. It also discusses the effectiveness of their potential hybrid decisions in mobile robot motion planning. The aim of this paper is to analyse the mobile robot motion planning methods in unknown environment by employing fuzzy logic and neural networks and to assess the effectiveness and capabilities of such methods. To this end, the paper aims to analyse and identify the research level of collision-free mobile robot motion planning by using neural networks and fuzzy logic, neural networks, and neural-fuzzy network methods. This paper analyses the performance characteristics and effectiveness of such methods in the sphere of mobile robot motion planning in an unknown environment.

1. Fuzzy logic in mobile robot motion planning

The fuzzy logic method is used in intelligent mobile robot motion and control planning systems. Fuzzy logic is the totality of methods of mathematical description of fuzzy sets with formalization of logical conclusions and fuzzy assumptions. The main fields of application of fuzzy logic algorithms are linear planning and process management, self-learning systems, investigation of risky and critical situations, image recognition etc. [13].

Currently, fuzzy logic methods are widely applied in the planning and management of technical systems in the production process, which allows improve the quality of production, reduce resource and energy costs, and ensure better resistance to the effects of dangerous factors when compared to traditional automatic control systems [8].

Fuzzy systems are designed based on the concept of the Mamdani and usually involves three stages: fuzzification, inference process, and defuzzification (Figure 1).
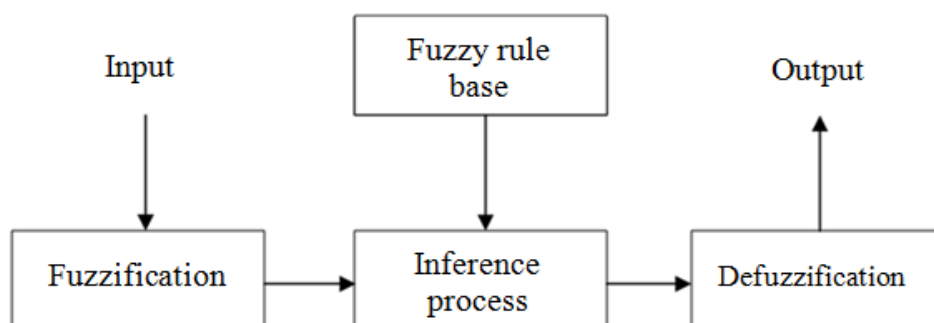

Figure 1. The stages of the fuzzy system

The fuzzification stage yields the values of assumptions of membership functions, which correspond to fixed values of all constituents of error vector signal. The stage of the inference process is the main stage of the fuzzy system. Without it fuzzy logic inferences cannot be obtained based on initial rules. They are formulated by using maximization and minimization operations, where individual assumptions are combined into one common assumption. Then, based on Mamdani algorithm, inference certainty is established for each rule and it cannot be greater than the certainty resulting from the common assumption of this rule. Furthermore, during this stage individual inferences are combined into one inference corresponding to the resulting membership function; this is done by using maximization operations. In the defuzzification stage, by applying the centroid method, the fixed value of normalized control action is calculated.

In addition to Mamdani fuzzy concept based systems, systems based on the Sugeno concept are also used. Here the specific values of control action are calculated in the same way as algebraic functions of input variables. In this case there is no need to perform defuzzification using the centroid method and the exact value of the resultant control action is calculated as a weighted value [13].

One topical issue in today's robotics is related to the simplification of real time calculations so that robots could quickly perform response movements in order to avoid collisions with obstacles. In this case, the goal of planning is to calculate robot's new path in real time and without considerable delay. This problem is dealt with by employing the capabilities of fuzzy logic. This is reflected in research into planning issues related to robot's movement both in known and unknown environments. However, the fuzzy-logic based decision-making mechanism is more commonly used under conditions of an unknown environment [10].

The use of fuzzy logic is directly linked to the use of traditional models that are applied in making decisions under the conditions of fast non-linear processes, where quantitative methods are not acceptable. The use of fuzzy logic in this case is characterized by relatively low price compared with other methods [11]. The following are also considered to be advantages of fuzzy logic: the ability to generate a quick response movement in real time, low cost of use, low time expenditure as well as the fact that it is applied only when the specific object or process control type is not determined [5].

S. Boonphoapichart, S. Komada and T. Hod examined the problems of robot motion planning in real time in an unknown environment and developed a two-tier fuzzy decision-making system, which consisted of the initial decision-making stage and the final decision-making stage, which was the initial step in the decision and the final decision phase, whose function was based on information obtained from two video cameras monitoring changes in the environment. This system was characterised by relatively low time expenditure and ability to adapt itself to different

modifications of control commands. In addition, these scientists believe that it could be applied to any off-line autonomous machine. The effectiveness of the application of the fuzzy system has been proven on the basis of computer simulation results [4].

Alessandro Saffiotti has developed a real-time fuzzy planner for robot's movements in an unfamiliar environment, which works according to the rules related to the geometric analysis of the robot's movements and its goal configuration analysis. This fuzzy planner created new "safe" trajectory points, when the robot's ultrasonic range finders detected an obstacle on its path [13].

Harmeet Singh and Arora Sanchit used fuzzy logic for the planning of robot's motion in real time and for on-line control. The solution of inverse kinematic problem was transformed into a fuzzy logic model, on which the robot's motion planning was based.

Leslie Astudillo, Oscar Castillo, Patricia Melin, and Arnulfo Alanis proposed to use fuzzy logic in a robot motion planning controller. The principle of this method is velocity control of a mobile robot based on input velocity signals. In this case, one fuzzy logic controller ensures the necessary torque for a mobile robot [2].

Various options of fuzzy logic systems for real time planning of mobile robots motions in unknown environment, which were presented in the papers by D. R. Parhi, Xu Dongyue, S. Bhowmik, S. K. Kashyap et al, have different designs of membership functions. This system was characterised by a relatively high speed and the fact that there was no need to solve the inverse kinematic problem. The main operation problem of the fuzzy system developed by these scientists was the complexity of adjustment of the input membership function when the robot found itself between obstacles in close proximity to each other. In addition, the robot lacked the required accuracy to reach the destination point [8]. Thus, upon analysing the operational characteristics of the fuzzy system, it is opportune to proceed to the next topical question – application of neural networks.

2. Application of neural networks in mobile robot motion planning in an unknown environment

Although roboticists started to use neural networks not so long ago, such networks proved to be useful in the development of robotic control systems. Neural networks are calculation structures built from a certain number single-type elements called neurons, which are simple converters. Each neuron performs rather simple functions. Connections between neurons determine the complexity and flexibility of the operation of the entire neural network. Each neuron consists of:

1.   Synapses, which ensure connections between neurons and multiply the signal by number, which describes connection strength – synaptic weight;

2.   The adder, which adds up the signals coming through synaptic connections from other neurons and the signals from external sources;

3.   The non-linear converter, which implements the linear functions of a single argument (i.e. adder output). The output value of a neuron belongs to range [0, 1] and the neuron itself strengthens first of all weak signals rather than strong ones [1].

Topologically, neural networks are classified into these three main types: fully connected networks, multilayer networks and loosely-coupled networks. Multilayer networks, in which neurons are connected in layers, are the most widely applied. Each layer has a set of neurons with common input signals. The number of neurons in each layer can be varied; in addition, it is not related to the number of neurons in other layers. Outer input signals are transferred into the neural inputs of the input layer, which usually is numbered zero. The output signals of the last layer are considered to be network outputs. In addition to input and output layers, a multilayer neural network has one or several hidden layers [4].

The creation of a neural network consists of the following stages: selection of the type of network architectures and selection of the network learning method. The following are considered to be the most popular and researched neural networks architectures: multilayer perceptron, neural network with common regression, Kohonen networks, and others. Special learning algorithms have been developed for most networks and they make it possible to coordinate the weight of the network in a certain way. The main learning algorithm of multilayer perceptrons, which are used in control systems, is the back propagation of error algorithm. Figure 2 gives an example of a three-layered neural network, where x 1 and y1are input and output signal vectors.

The use of neural networks to solve the problem of robot motion planning in an unknown environment has received considerable attention in modern research literature. The following is an analysis of research papers that deal with the application of neural networks under the conditions of an unknown environment [4].
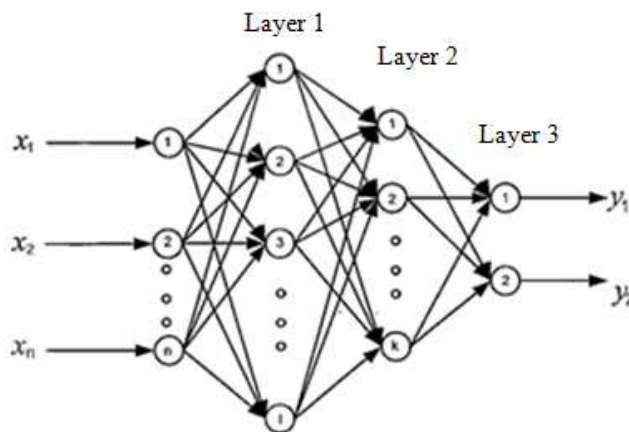

Figure 2. Three-layer neural network

Jasmin Velagic and Nedim Osmic proposed to use neural networks in the trajectory planning stage of a mobile robot equipped with range finders. Thanks to these neural networks, robots would

learn to move around in an unknown environment and avoid collisions with obstacles. A trained robot, moving from initial configuration to the target configuration, had to bypass obstacles in its work zone by using local information from range finders. This problem was solved by using a periodic single-layer neural network. It is taught the relationship between linear speeds and positions of a mobile robot by using the back propagation algorithm in the real time mode. This algorithm is performed in each iteration (sample time) for calculation of optimal input control signals [15].

R. Fierro and F. L. Lewis developed a model for planning a safe path for a robot in an unknown environment in which a multilayer feedforward neural network was used for the training of dynamic properties in real time mode. However, this planning model and neural network training algorithm are very complex and calculations are time-consuming [6].

Danica Janglova proposed a solution for the planning and intelligent control of an autonomous mobile robot's collision-free trajectory in a partially structured environment. This solution is based on the use of two neural networks: the first neural network is used to determine free space using ultrasound range finder data and the second neural network finds a safe direction for the next robot section of the path in the workspace while avoiding the nearest obstacles. Although this solution is quite efficient in a simple environment, it requires many sensors [9].

For neural network training purposes, scientists determined goal positions of the robot based on the fact that the movement strategies, which the neural network learned in certain environments, could be easily adjusted in a new dynamic environment. In the presence of moving obstacles in the workspace of a mobile robot, it could avoid collisions only when the speed of obstacles was such that the robot was able to stop in time and react accordingly. Another reason why there was a greater probability of collision with moving obstacles was that ultrasound range finders were not able to detect the sharp edges of the obstacles. For this reason, scientists decided to use obstacles with levelled edges in the robot's workspace during their experiments while noting the need for improvement in the design of range finders [12]. The neural network model was directly used for trajectory formation. The neural network state space was determined by a robot's configuration space and each neuron was described by the corresponding motion equation. This model allowed the implementation of a robot's multi-goal path planning in real time and planning in the presence of unpredictable changes in the environment. This process is based on variable neural network activity, reflecting the environmental instability. When determining a safe direction of robot motion, there was no need to optimize energy consumption, obtain beforehand information about the dynamic environment, and to train. There was a linear relationship between the complexity of the calculations and the size of the neural network in which each neuron had only a local lateral relationship with neighbouring neurons[6].

The previously examined methods correspond with the overall view on how the problem of mobile robot motion planning in an unknown environment should be solved, where local information read by range finders is used to generate response motions. It is therefore opportune to analyse this new approach by defining the above-mentioned combination of these both methods.

3. The application of a combination of neural networks and fuzzy logic in mobile robot motion planning

Many scientists proposed the use of the combination neural network and fuzzy logic method for solving the problems of robot motion planning in an undefined environment with random obstacles. H. R. Beom, H. S. Cho, Amir Massoud Farahmand, Caro Lucas et al proposed several different real-time methods for robot motion planning, which were based on the application of neural network and fuzzy logic rules, where the training algorithm worked in real-time mode and determined the formation of these basic rules. The transparency of the control system ensured the effectiveness of the training algorithm, which was represented by the back propagation of error algorithm. However, training under this algorithm is a relatively slow process, if it is realized in real time. Thus, because of basic fuzzy logic rule formation, which, as mentioned before, is a result of a network training process, the problem that emerged was related to the robot's ability to reach the goal. Despite the fact that the mobile robot reached its goal configuration area, the formed basic fuzzy logic rules not always allowed it to precisely reach the goal point. In cases where the robot did not reach this point, the training algorithm had to be restricted so that the basic rules could be changed without making any changes to the fuzzification stage. Scientists saw it possible to solve this problem by improving the training algorithm in a way that would enable it to adapt the fuzzification stage and thereby apply a hybrid neuro-fuzzy network with different types of membership functions [3].

At present, the combination of neural networks and fuzzy logic is not widely discussed in the scientific literature dealing with the problem of real-time mobile robot motion planning in an unknown environment. Neuro-fuzzy methods are used to solve the problems of trajectory formation and motion planning [3] and general case control [8].

Conclusions

Based on the foregoing analysis of solutions of the problem of mobile robot motion planning in an unknown environment by using fuzzy logic and neural networks, the following conclusions can be summarized:

1. In most research papers, the methods for collision-free mobile robot motion planning based on fuzzy logic and neural networks were applied under conditions of a known environment, whereas research related to the application of these methods in unknown environments has been limited, even though taking into consideration the potential for practical application of

such research, the solution of these problems would have greater significance both for the advancement of mobile robotic systems and for the solution of practical issues.

2. The solution of the problem of mobile robot motion planning in an unknown environment based on fuzzy logic is widely examined, because in this case the decision-making mechanism always allows generation of response movements caused by the emergence of obstacles in the robot's trajectory;

3. The efficiency of neural networks in solving mobile robot motion planning problems in an unknown environment largely depend on the level of training of the specific network;

4. As can be seen from this analysis of research literature, further search for solutions to the problem of mobile robot motion planning in an unknown environment is being carried out by using neural networks trained with fuzzy logic rules. Such neuro-fuzzy networks can learn more efficiently and better solve problems associated with non-linear systems.

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The 11th International Conference on Control, Automation, Robotics and Vision, ICARCV 2010, will be held in Singapore from 7 to 10 December 2010. The conference is organised by the Nanyang Technological University of Singapore. ICARCV focuses on both theory and applications mainly covering the topics of control, automation, robotics and vision. In addition to the technical sessions, there will be invited sessions, keynote addresses and plenary panel sessions.

Velagic J., Osmic N., Lacevic B. (2008). *Neural Network Controller for Mobile Robot Motion Control*. Proceedings of World Academy of Science, Engineering and Technology. Vol. 30. ISSN 1307-6884.

RESEARCH OF ROBOT LINKS ARTICULATED

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Abstract
Key Words: *1 DOF, 2 DOF, 3 DOF, control system, robot arm, manipulator, mathematical model, robot dynamics*
In robotics science there are two main trends of in the design of robotics. One of them is the design of specialized or special robots, that perform certain technological operations, serve specific devices they are accurate, quick-acting and reliable, but these robots have usually a few level mobility. Another trend of robot design is the design of universal multifunctional robots that perform more technological operations, have more levels of mobility, but they have more difficulties in achieving greater positioning accuracy, reliability and their design is expensive. This article provides the analysis of the most widely applied in practice robotic arms in order to reveal their diversity and perspective working peculiarities for their effective usage. Research paper analyzes the running parameters and difficulties of different robotic arms, which are similar in their design, but different in their control systems level, i.e. running of 1, 2 and 3 DOF (degrees of freedom) robotic systems. There is analysis of dynamic mathematical models of these three different kind of DOF robotic systems which are contained of mathematical models of DC motors that rotate robotic arm links and direct position-task models. After estimating the missing parameters of robotic arms' motors, 1, 2 and 3 DOF robotic arms' models have been created by software package "Matlab Simulink", which allows to set controlling voltages and observe the change of currents, torque, chain speed and trajectory over the current time.

Kopsavilkums
Robotu posmu kustības pētīšana
Atslēgvārdi: *ar vienu brīvības pakāpi, ar divām brīvības pakāpēm, ar trijām brīvības pakāpēm, vadības sistēma, robota roka, manipulators, matemātiskais modelis, robota dinamika.*
Robotu tehnikā ir divi izteiktākie robotu projektēšanas virzieni. Viens no tiem ir specializēto un speciālo robotu projektēšana, kuras laikā izveidotie roboti veic attiecīgās tehnoloģiskās operācijas, apkalpo attiecīgās iekārtas, kaut vai šādiem robotiem nav daudz brīvības pakāpju, tie ir precīzi, ātri darbojas un ir droši. Otrais robotu projektēšanas virziens – universālo daudzfunkciju robotu projektēšana, kuri veic vairāk tehnoloģisko operāciju, tiem ir vairāk brīvības pakāpju, taču ir daudz grūtāk sasniegt lielāku to pozicionēšanas precizitāti, darba uzticamību, kā arī šādu robotu projektēšana ir dārgāka. Šajā rakstā tiek veikta visplašāk pielietotu praksē robota roku analīze ar nolūku atklāt to dažādību un noteikt kopīgos visu šo robotu posmu kontaktpunktus. Šajā rakstā izpētītas robotu rokas, kurām ir līdzīga konstrukcija, taču vadības sistēmas ir atšķirīgas – to robotu sistēmas, kurām ir viena, divas un trīs brīvības pakāpes, darbības īpatnības un parametri. Rakstā tiek analizētas minētās robotu rokas sistēmas, kurām ir trīs atšķirīgas kustības pakāpes, dinamikas matemātiskie modeļi, kas aptver robota rokas posmus rotēšanas līdzstrāvas matemātiskos modeļus un tiešo stāvokļu uzdevuma modeļus. Aprēķinot eksperimentālo robota roku dzinēju trūkstošos parametrus, tika izveidoti robota rokas modeļi ar vienu, divām un trijām brīvības pakāpēm un ar „Matlab Simulink" programmatūras paketi, kas ļauj uzdot vadības spriegumus un vērot strāvas, momenta, posmu ātruma, trajektorijas un laika attiecību.

I. Material and Methods

Introduction

The production sector is expanding rapidly and product technologies and processes are getting more and more complex. These changes determine the development of robotics. Such systems must meet high demands, i.e. they must be both sufficiently accurate and fast. However, the demand for robots in the industrial and manufacturing sectors is growing uncontrollably, and, as a result, robotic arms are used in the most diverse industries because they can perform various tasks, such as assembly, loading, welding, grinding, painting etc. Such robots are widely used in practice, and this is why there is a need for more detailed studies on robotic arms.

This work analyses robotic arms and the purpose of such analysis is to examine the functional features of robotic arms of different design (i.e. with various degrees of freedom) and to compare

them with one another in order to identify the main advantages and disadvantages of one-, two-, and three-degree-of-freedom robotic arms as well as to identify the most optimal function of their structure in terms of its application. The aim of this work is, therefore, to examine and compare robotic arms having one, two and three degrees of freedom, and, to this end, the work seeks to review the scientific literature on the structure and control systems of robot manipulators and to carry out the mathematical modelling of one-, two-, and three-degree-of-freedom robotic arms. Finally, this work aims to compare the obtained data.

Analysis of the structures of manipulators

In 2000, the impressive **Slauerhoff Bridge (Figure 1) measuring** 15 x 15 m was built in the Netherlands. The main peculiarity of this bridge is that it is an enormous robotic arm having one degree of freedom (one link) holding a section of the road, which is raised to allow ships to pass in the river. It is a drawbridge of a simple design and its action is based on the long-known principle of a lever; a double-arm lever [7] is used to lift the section of the road into the air.

Figure 1. *The Slauerhoff Bridge* [7].

The Quanser company has designed a two-degree-of-freedom (i.e. two-link) robotic arm SFL 2DOF (Figure 2), which consists of two DC motors; the motor 1 is mounted on the base and turns link 1, while motor 2 is mounted at the end of link 1 and turns link 2 The tensometric sensors installed at rearmost positions of the links of the robotic arm act as protection against breakage during operation. High resolution optic incremental sensors are mounted on both motors. This manipulator features MIMO (Multi-Input and Multi-Output) system, which is supplied with a state feedback controller to reduce fluctuations caused by flexibility as well as the effects of the movements of the interface connection. This system has a completely open structure, which makes it suitable for designing any other desired controller [6].

Figure 2. *Two-degree-of-freedom robotic arm SFL 2DOF* [6].

Another excellent example of a three-degree-of-freedom robotic arm is the QTP 3DOF HI/R robotic arm designed by the scientists of University of British Columbia and the engineers of the Quanser company (Figure 3). The peculiarity of this robotic arm is the fact that it is a planar robot consisting of two mutually adjusted pantographs whose interfaces have three degrees of freedom and therefore allow the robot to move vertically and rotate on a single axis without restrictions. The adjustment ring is directly connected to the interface coupling of the first links of the pantograph and the intersecting interfaces of the links allow 360 degree unrestricted rotation of the end effector. The robotic arm is controlled by two DC motors whose shaft rotation position is measured using a high-resolution optical encoder. The system is controlled through a computer by using a Quanser Q8 HIL (hardware-in-the-loop) control card [4].

Figure 3. *QTP 3DOF HI/R three-degree-of-freedom robotic arm* [4].

The mathematical models of the dynamics of robotic links

When designing a control system for a robot with one or two links, it is necessary to analyse the dynamics of the robot by using the equations of motion that describe the forces and moments acting on mechanical links. The already existing systems of equation may be used [1]. When

designing and analysing a one-link robot, the dynamics is described by the following system of equations [3]:

$$\left(J_1 + l_1\right)\ddot{q}_1 + m_1\, g\, r_{1c}\cos\left(q_1\right) = T_1 \qquad\qquad (1)$$

where: $J_1 = 1/3\, l_1\, m_1$ – mass moment of inertia of a link, kg·m^2; $r_{1c} = l_1/2$ – distance to the centre of mass of link 1, m; m_1 – link mass, kg; l_1 – link length, m; q_1 – link twist angle, rad; $\ddot{q}_1$ – angular acceleration of a link, rad/s^2; g – acceleration, ms^{-2}; T_1 – torque at axis coupling of a link, Nm.

The kinematic diagram of a one-degree-of-freedom robot is presented in Figure 4. Since the arm of the robot works on a horizontal plane, its motion is not affected by gravitational forces.

Figure 4. *The kinematic diagram of a one-degree-of-freedom robot.*
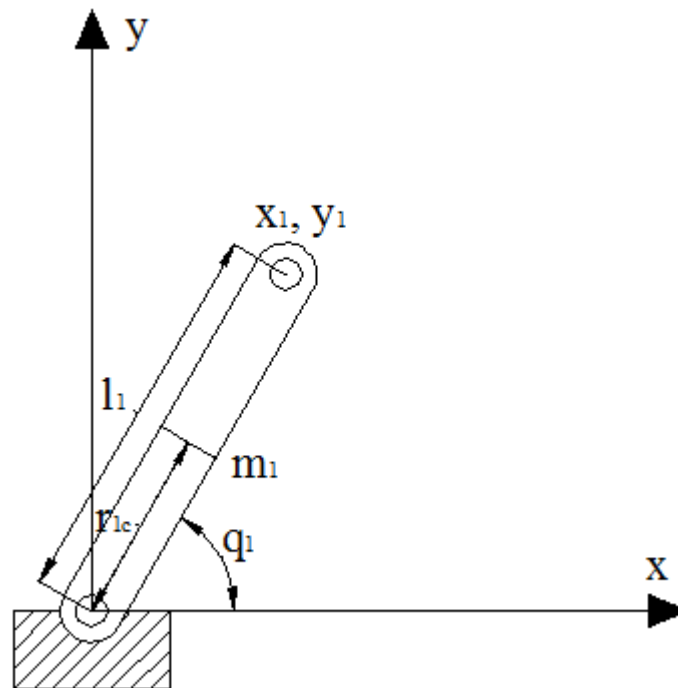
The dynamics of a two-link robot is described by the following system of equations [3]:

$$
\begin{cases}
\left(J_1 + m_2\, l_1^2\right)\ddot{q}_1 + m_2\, l_1\, r_{2c}\,\ddot{q}_2\,\cos\left(q_2 - q_1\right) - m_2\, l_1\, r_{2c}\,\dot{q}_2\left(\dot{q}_2 - \dot{q}_1\right)\sin\left(q_2 - q_1\right) \\
+ \left(m_1\, g\, r_{1c} + m_2\, g\, l_1\right)\sin q_1 = T_1; \\
J_2\,\ddot{q}_2 + m_2\, l_1\, r_{2c}\,\ddot{q}_1\,\cos\left(q_2 - q_1\right) - m_2\, l_1\, r_{2c}\,\dot{q}_1\left(\dot{q}_2 - \dot{q}_1\right)\sin\left(q_2 - q_1\right) \\
+ m_2\, g\, r_{2c}\,\sin q_1 = T_2
\end{cases} \qquad (2)
$$

where: $J_1 = 1/3\, l_1^2\, m_1$ and $J_2 = 1/3 l_2^2 m_2$ – mass moment of inertia of links, kg·m^2; $r_{2c} = l_2/2$ – distance to the centre of mass of link 2, m; $m_{1,2}$ – link masses, kg; $l_{1,2}$ – link lengths, m; $q_{1,2}$ – twist angles of links, rad; $\dot{q}_{1,2}$ – link angular velocities, rad/s; $\ddot{q}_{1,2}$ – link angular accelerations, rad/s^2; g – acceleration, ms^{-2}; $T_{1,2}$ – torques at axis couplings of links, Nm.

The kinematic diagram of a two-degree-of-freedom robot is presented in Figure 5.

Figure 5. *The kinematic diagram of a two-degree-of-freedom robot.*
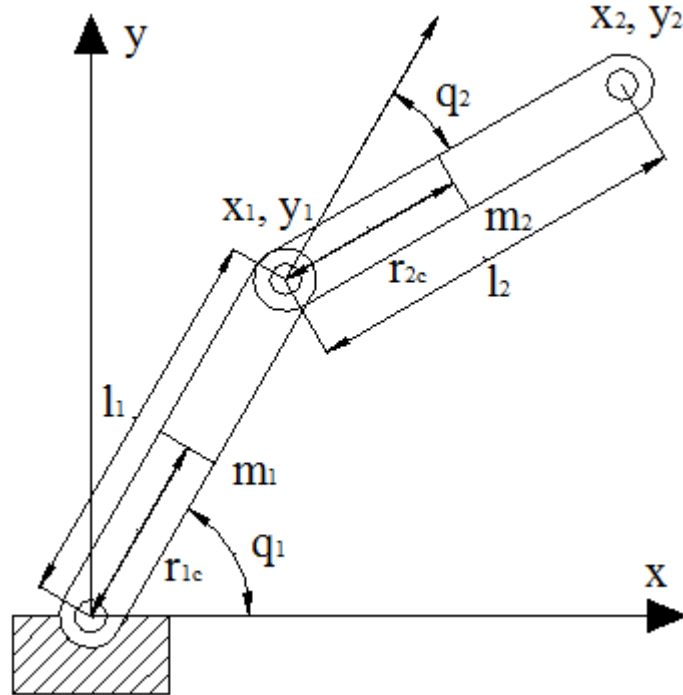
The dynamics of a three-link robot is described by the following system of equations [3]:

$$
\begin{cases}
\left(J_1 + m_3\, l_1^3\right)\ddot{q}_1 + m_3\, l_1\, l_2\, r_{3c}\, \ddot{q}_2\, \ddot{q}_3\, \cos(q_3 - q_2 - q_1) - m_3\, l_1\, l_2\, r_{3c}\, \ddot{q}_2\, \ddot{q}_3\left(\dddot{q}_3 - \dddot{q}_2 - \dddot{q}_1\right) \\
\sin(q_3 - q_2 - q_1) + (m_1\, g\, r_{1c} + m_2\, g\, l_1 + m_3\, g\, l_1)\sin q_1 = T_1; \\
J_2\, \ddot{q}_2 + m_3\, l_1\, l_2\, r_{3c}\, \ddot{q}_1\, \ddot{q}_3\, \cos(q_3 - q_2 - q_1) - m_3\, l_1\, l_2\, r_{3c}\, \ddot{q}_1\, \ddot{q}_3\left(\dddot{q}_3 - \dddot{q}_2 - \dddot{q}_1\right) \\
\sin(q_3 - q_2 - q_1) + m_2\, g\, r_{2c}\sin q_2 = T_2; \\
J_3\, \ddot{q}_3 + m_3\, l_1\, l_2\, r_{3c}\, \ddot{q}_1\, \ddot{q}_2\, \cos(q_3 - q_2 - q_1) - m_3\, l_1\, l_2\, r_{3c}\, \ddot{q}_1\, \ddot{q}_2\left(\dddot{q}_3 - \dddot{q}_2 - \dddot{q}_1\right) \\
\sin(q_3 - q_2 - q_1) + m_3\, g\, r_{3c}\sin q_3 = T_3
\end{cases}
\qquad (3)
$$

where: $J_1 = 1/3\, l_1^3\, m_1$, $J_2 = 1/3 l_2^3 m_2$ and $J_3 = 1/3\, l_3^3\, m_3$ – mass moments of inertia of links, kg·m^2; $r_{2c} = l_2/2$ and $r_{3c} = l_3/2$ – distance to the centre of mass of link 2, m; $m_{1,2,3}$ – link masses, kg; $l_{1,2,3}$ – link lengths, m; $q_{1,2,3}$ – twist angles of links, rad; $\ddot{q}_{1,2,3}$ – link angular accelerations, rad/s^2; $\dddot{q}_{1,2,3}$ – triple inverted angles of links, rad/s^3; g – acceleration, ms^{-2}; $T_{1,2,3}$ – torques at axis coupling of links, Nm.

The kinematic diagram of a three-degree-of-freedom robot is presented in Figure 6.

Figure 6. *The kinematic diagram of a three-degree-of-freedom robot.*
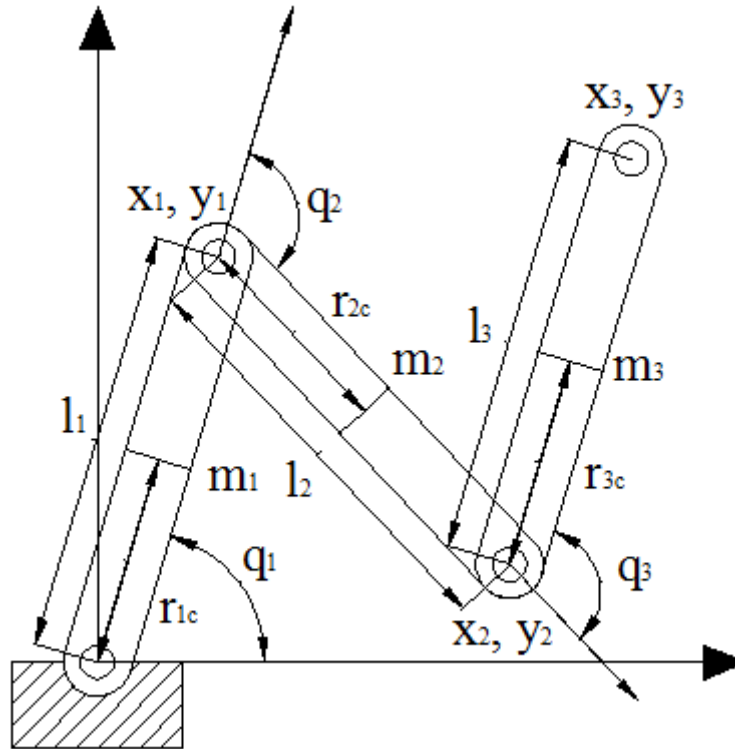
The position of the end point of a robot is changed through control of DC motors, which produce torques and thereby turn specific robotic links around their axes. The DC engine has its own electrical and electrical mechanical time constants. Their impact in the robot's movement may be assessed by adding a DC motor mathematical model to the robot's mathematical model. It is necessary to assess friction forces and liquid friction forces, which affect motion at the time of reverse movement and at maximum speeds. A DC motor mathematical model that takes into account friction forces [1, 2]:

$$\begin{cases} L\dfrac{\mathrm{d}i}{\mathrm{d}t} = u - i\,r - \omega\,C_E\,; \\[2mm] J\dfrac{\mathrm{d}\omega}{\mathrm{d}t} = i\,C_M - M_A - \omega\,f_S - \big[T_C\,\mathrm{sign}(\omega) + (T_S - T_C)\,exp(-\alpha\,|\omega|)\,\mathrm{sign}(\omega)\big]; \end{cases} \qquad (4)$$

where: L – total inductance of motor anchor link, H; i – intensity of electrical current in the anchor chain A; u – voltage connected to anchor chain, V; r – total resistance of anchor chain, Ω; ω – motor shaft angular rotation speed, rad/s; C_E – generator electromotive force constant, V·s/rad; J – mass moment of inertia of motor anchor, kg·m^2; C_M – electromechanical transfer coefficient, Nm/A; M_A – moment of resistance, Nm; f_S – moment of liquid friction resistance, Nm·s/rad; T_C – dry friction torque, Nm; T_S – static friction torque, Nm; α – time constant, s.

Robotic links perform only rotary motions. However, the end movement of a robotic end effector is linear. The position of robotic end points x and y in a Cartesian coordinate system is calculated according to the number of constituent links [5]:

1.   The position of end points x and y of a one-link robot in a Cartesian coordinate system is calculated as follows:

$$\begin{cases} x = l\cos(q); \\ y = l\sin(q) \end{cases} \tag{5}$$

2.   The position of end points x and y of a two-link robot in a Cartesian coordinate system is calculated as follows:

$$\begin{cases} x = l_1\cos(q_1) + l_2\cos(q_1 + q_2); \\ y = l_1\sin(q_1) + l_2\sin(q_1 + q_2) \end{cases} \tag{6}$$

3.   The position of end points x and y of a three-link robot in a Cartesian coordinate system is calculated as follows:

$$\begin{cases} x = l_1\cos(q_1) + l_2\cos(q_1 + q_2) + l_3\cos(q_1 + q_2 + q_3); \\ y = l_1\sin(q_1) + l_2\sin(q_1 + q_2) + l_3\sin(q_1 + q_2 + q_3) \end{cases} \tag{7}$$

Generalized dynamic models of one-, two-, three-, and four-of-freedom robotic arms are presented in Figures 7, 8 and 9.

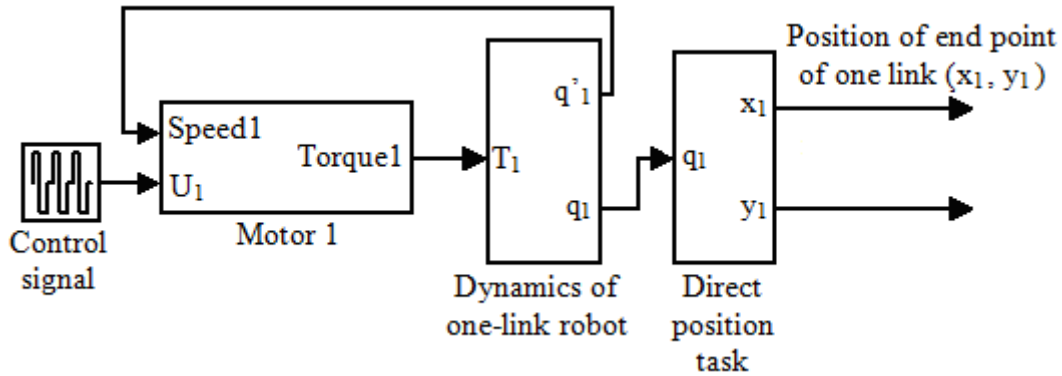Figure 7. ***The model of a one-degree-of-freedom robotic arm.***

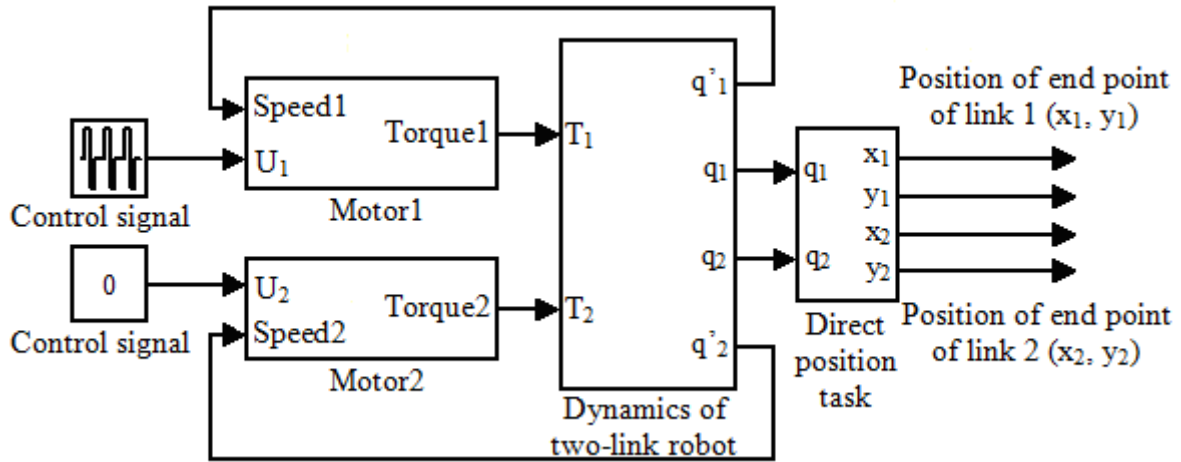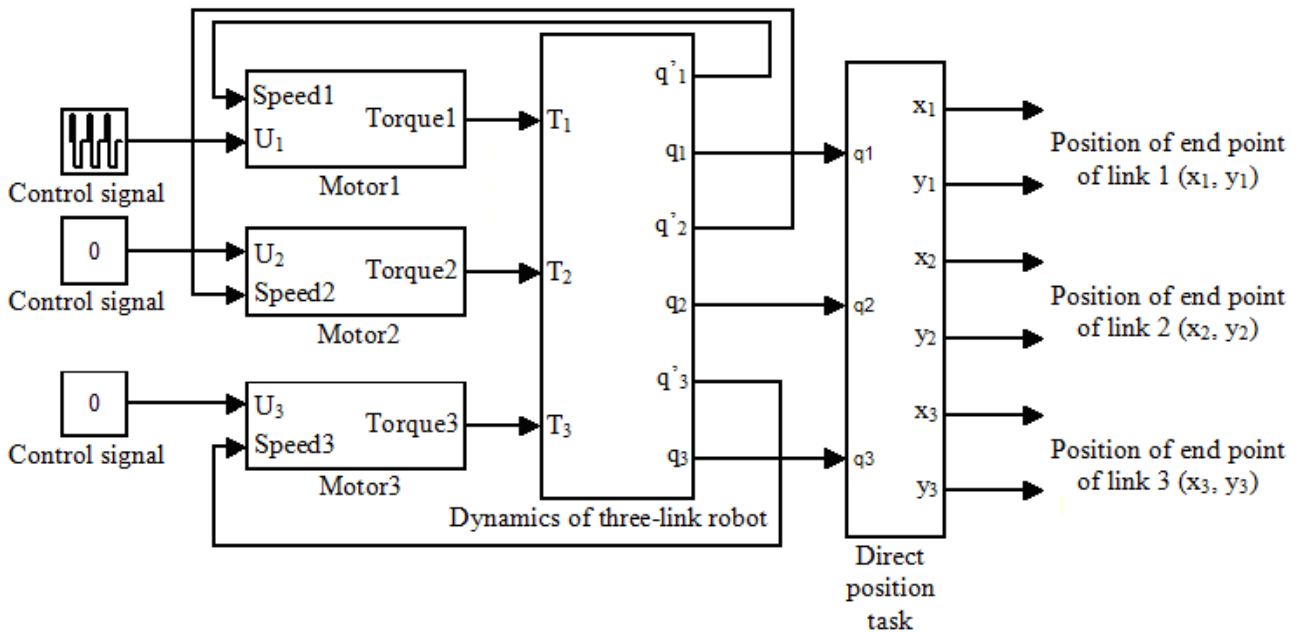Figure 8. ***The model of a two-degree-of-freedom robotic arm.***

Figure 9. ***The model of a three-degree-of-freedom robotic arm.***

The models of one-, two-, three- and four-link robotic arms created using MatLab Simulink software consist of several main building blocks (Figures 7, 8, and 9):

- *Motor1*, *Motor2* and *Motor1* blocks are DC motor models developed according to formula (4). The input signal of this block is a control voltage and torque is produced in the outlet. In addition, angular velocity feedback is used in the model of DC motors.

- The blocks *The Dynamics of a Single-Link Robot, The Dynamics of a Two-Link Robot* and *The Dynamics of a Three-Link Robot* have been drawn up in accordance with formula (1, 2, 3). Their input signals are torques produced by motors, while angular rotation velocities and link twist angles of a robotic arm are obtained in the outlet. In these models, the constants are link masses and lengths.

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- In the *Direct Position Task* block, the position of robotic arm's end points x and y is obtained in a Cartesian coordinate system based on the relative coordinates of the links of the robotic arm, according to formulas (5, 6, and 7). The existing angles of links are provided in the input of this block and in the position coordinates of the end point of the robotic arm are generated in a Cartesian system in the output.

II. Results

The study of the dynamics of the model

In order to simulate the dynamics of a robotic arm having one or more degrees of freedom, it is necessary to transfer the mathematical model described in the first part of this chapter to the Matlab Simulink software package.

All estimated parameters of DC motors needed for creation of models are given in Tables 1, 2, and 3.

Table 1. *Characteristics of DC motors of a one-link robot*

Name of parameter and unit of measurement	Designation	Meaning
		Motor 1
Electrical time constant, s	T_E	0.00144
Electromechanical time constant, s	T_M	0.0056
Inductance, H	L	0.00216
Resistance, Ω	R	1.5
Inertia moment, kg·m^2	J	0.0062
Electromechanical coefficient, N·m/A	C_M	0.625
Emf of the generator. constant, V · s / rad	C_E	2.64

Table 2. *Characteristics of DC motors of a two-link robot*

Name of parameter and unit of measurement	Designation	Meaning	
		Motor 1	Motor 2
Electrical time constant, s	T_E	0.00122	0.00144
Electromechanical time constant, s	T_M	0.0410	0.0056
Inductance, H	L	0.00183	0.00216
Resistance, Ω	R	1.5	1.5
Inertia moment, kg·m^2	J	0.057	0.0062
Electromechanical coefficient, N·m/A	C_M	0.625	0.625
generator electromotive force constant, V·s/rad	C_E	3.34	2.64

Table 3. *Characteristics of DC motors of a three-link robot*

Name of parameter and unit of measurement	Designation	Meaning		
		Motor 1	Motor 2	Motor 3
Electrical time constant, s	T_E	*0.00166*	0.00122	0.00144
Electromechanical time constant, s	T_M	0.0764	0.0410	0.0056
Inductance, H	L	0.00150	0.00183	0.00216
Resistance, Ω	R	1.5	1.5	1.5

Name of parameter and unit of measurement	Designation	Meaning		
		Motor 1	Motor 2	Motor 3
Inertia moment, kg·m^2	J	0.1078	0.057	0.0062
Electromechanical coefficient, N·m/A	C_M	0.625	0.625	0.625
generator electromotive force constant, V·s/rad	C_E	4.04	3.34	2.64

For the dynamic model simulation of a robotic arm having one or several links, the lengths and masses of the links are also needed: $l_1 = 0.2$ m; $m_1 = 3.42$ kg; $l_2 = 0.2$ m; $m_2 = 3.42$ kg; $l_3 = 0.2$ m; $m_1 = 3.42$ kg; $l_4 = 0.2$ m; $m_2 = 0.36$ kg.

Nominal voltage is connected for one second to the motor of a one-link robotic arm (Fig. 10). The voltage polarity is then reversed and thus the motor reverses, i.e., changes its direction of rotation. After another second, the voltage connected to the first motor becomes equal to zero – the motor is stopped. This experiment enables sequential monitoring of the processes of acceleration, reverse and stopping. Simulation results are presented in Figures 11 and 12:

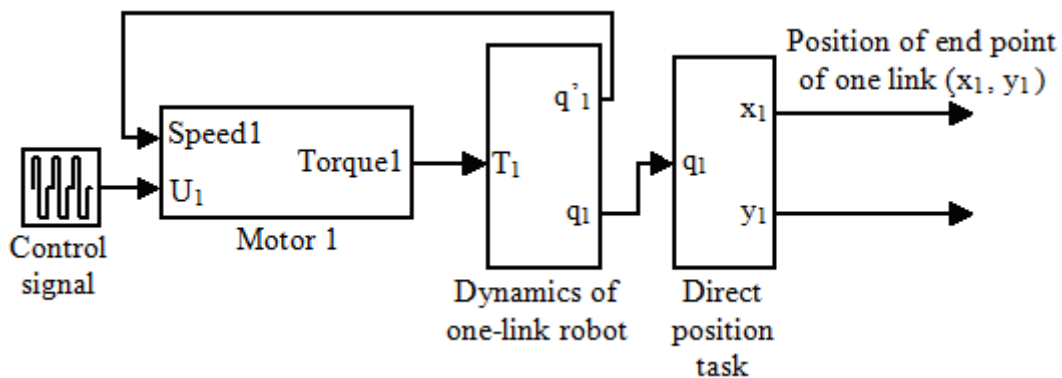Figure 10. *The model of a one-degree-of-freedom robotic arm*

Figure 11. *Robotic arm simulation results: U – motor control voltage variation T – torque produced by the motor, ω - motor angular velocity variation, I – motor current variation*
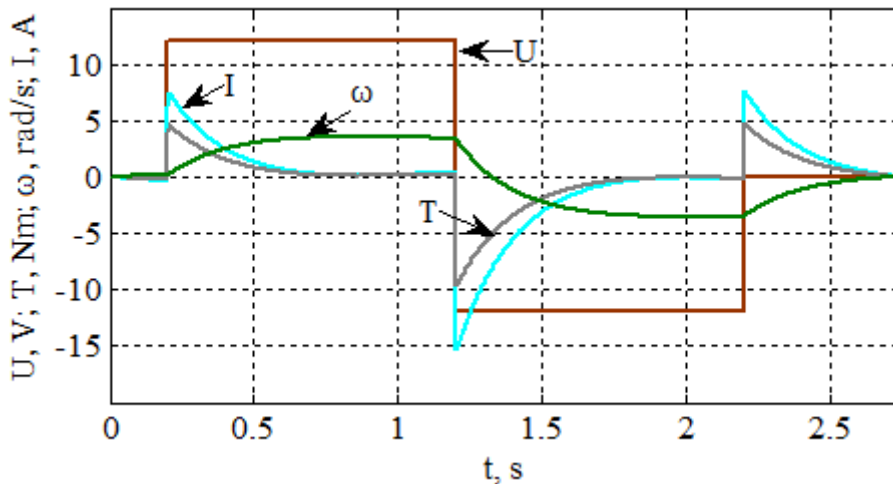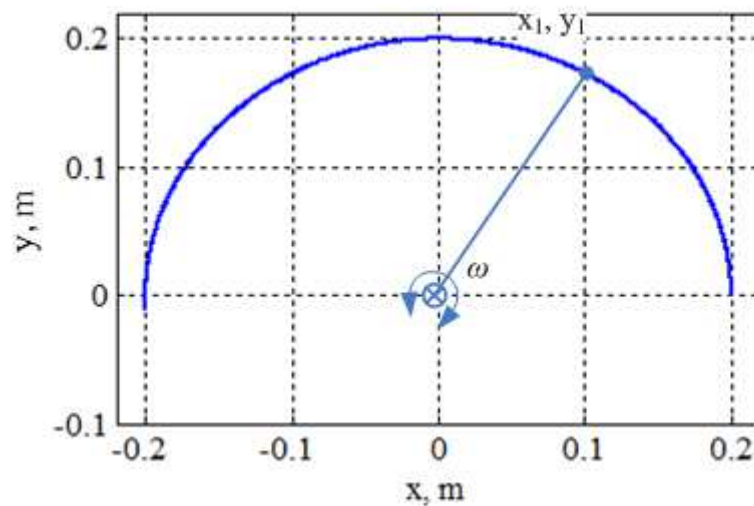
Figure 12. ***End point trajectories of a one-link robotic arm in a Cartesian coordinate system***

The next study examines the dynamics of two connected links of a two-degree-of-freedom robot. The dynamics of each link has been studied separately. Nominal voltage is connected to the motor of link 1 for one second. The voltage polarity is then reversed and thus the motor reverses, i.e., changes its direction of rotation. After another second, the voltage connected to the first motor becomes equal to zero – the motor is stopped. This experiment enables sequential monitoring of the processes of acceleration, reverse and stopping. During the entire simulation experiment, the voltage of the motor of link 2 is equal to zero (Fig. 13). Simulation results are presented in Figures 14 and 15:

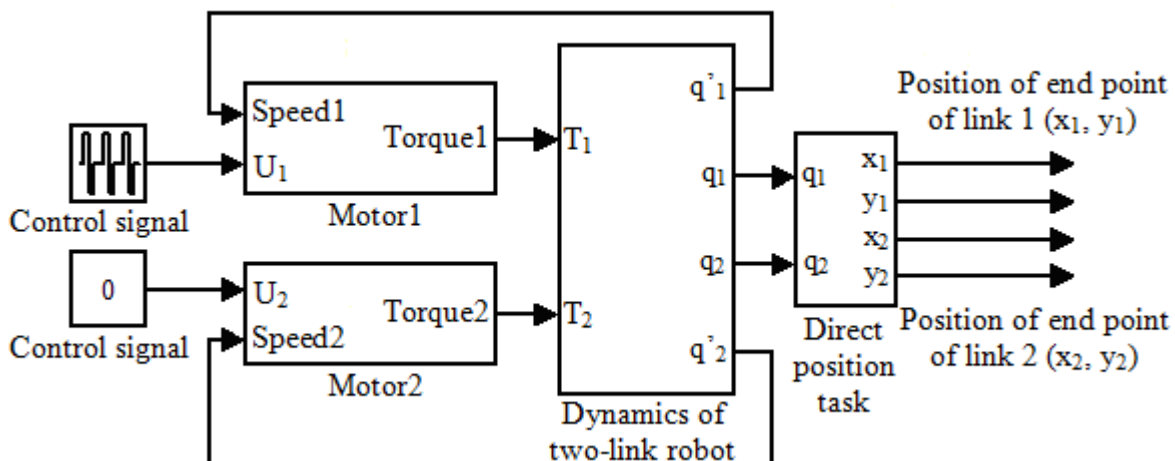Figure 13. ***The model of a two-degree-of-freedom robotic arm***

Figure 14. *Robotic arm simulation results: U_1, U_2 – motor control voltage variation,*
ω_1, ω_2 – motor angular velocity variation, T_1, T_2 – torques produced by motors,
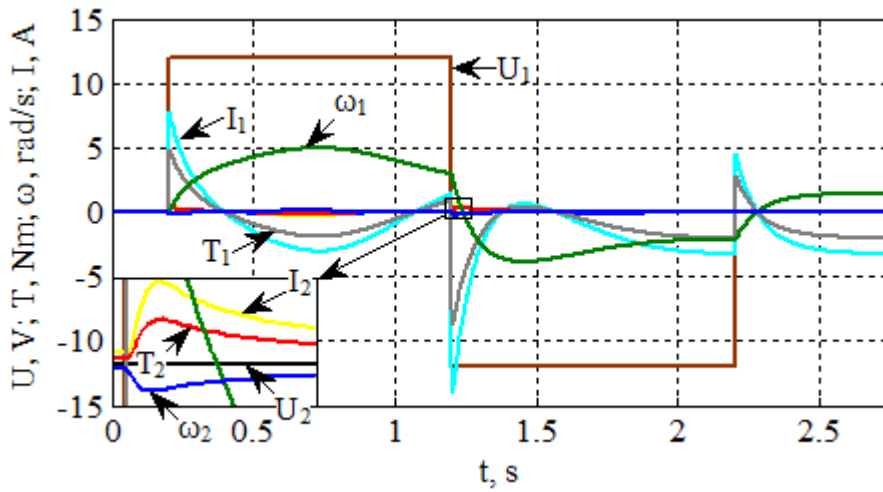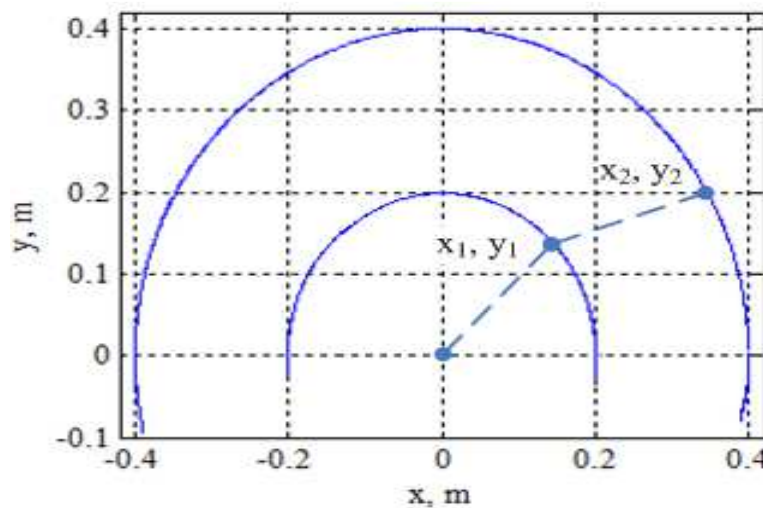*I_1, I_2 – motor current variation*

Figure 15. *End point trajectories of links 1 and 2 of a robotic arm*
in a Cartesian coordinate system

The dynamics of link 2 was examined in the same way. Nominal voltage is connected for one second to the motor of link 2. The voltage polarity is then reversed and thus the motor reverses, i.e., changes its direction of rotation. After another second, the voltage connected to motor 2 becomes equal to zero – the motor is stopped. During the entire simulation experiment, the voltage of the motor of link 1 is equal to zero (Fig. 13). Simulation results are presented in Figures 16 and 17:

Figure 16. *Robotic arm simulation results: U_1, U_2 – motor control voltage variation, ω_1, ω_2 – motor angular velocity variation, T_1, T_2 – torques produced by motors, I_1, I_2 – motor current variation*
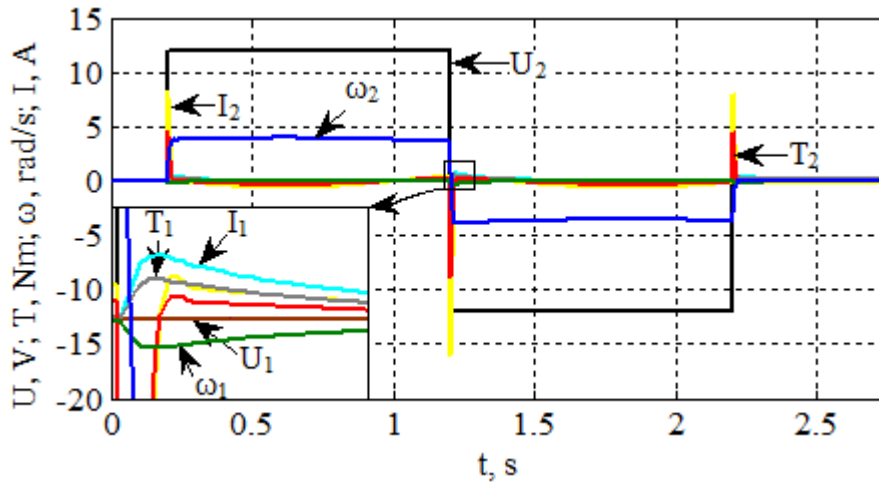
Figure 17. *End point trajectories of links 1 and 2 of a robotic arm in a Cartesian coordinate system*

The next study examines the dynamics of three connected links of a three-degree-of-freedom robot. The dynamics of each link has been studied separately. Simulation results are presented in Figures 19 and 20:

Figure 18. *The model of a three-degree-of-freedom robotic arm*

Figure 19. *Robotic arm simulation results: U_1, U_2, U_3, U_4 – motor control voltage variation, ω_1, ω_2, ω_3, ω_4 – motor angular velocity variation, T_1, T_2, T_3, T_4 – torques produced by motors, I_1, I_2, I_3, I_4 – motor current variation*
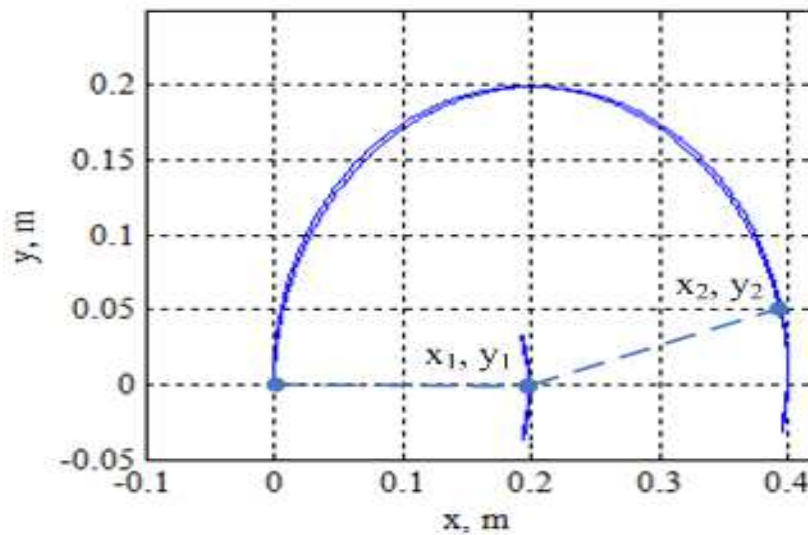

Figure 20. *End point trajectories of links 1 and 2 of a robotic arm in a Cartesian coordinate system*

The dynamics of link 2 was examined in the same way. Simulation results are presented in Figures 21 and 22:

Figure 21. *Robotic arm simulation results: U_1, U_2, U_3, U_4 – motor control voltage variation, ω_1, ω_2, ω_3, ω_4 – motor angular velocity variation, T_1, T_2, T_3, T_4 – torques produced by motors, I_1, I_2, I_3, I_4 – motor current variation*
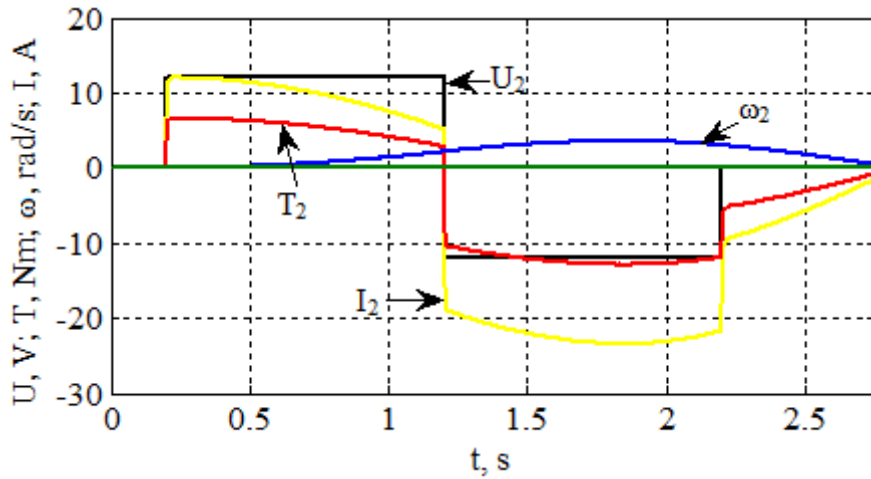
Figure 22. *End point trajectories of links 1 and 2 of a robotic arm in a Cartesian coordinate system*
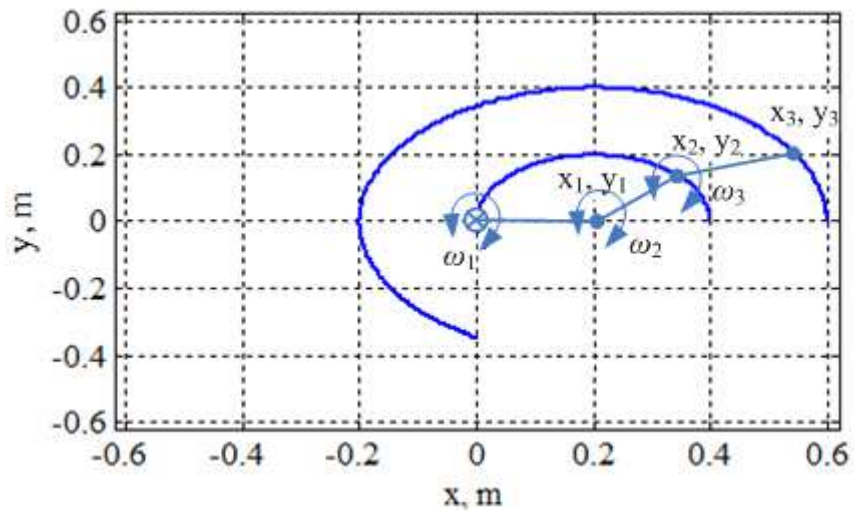
The dynamics of link 3 was examined in the same way. Simulation results are presented in Figures 23 and 24:
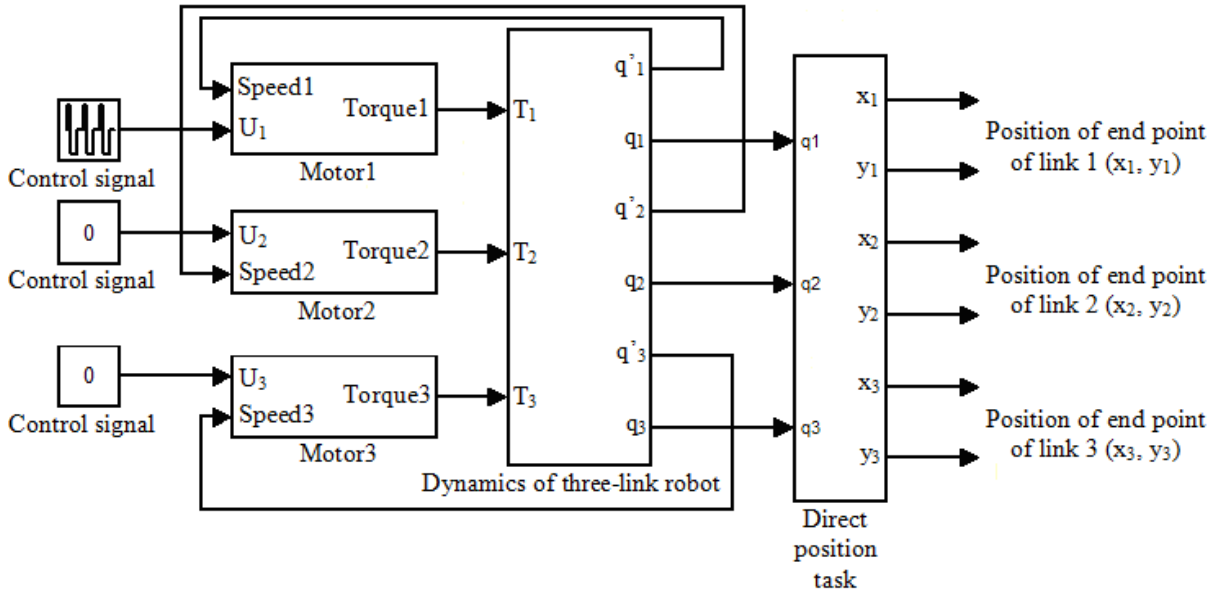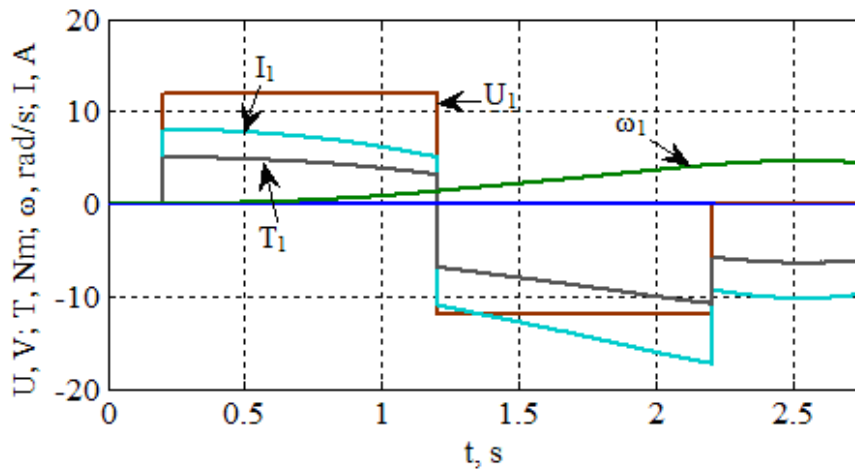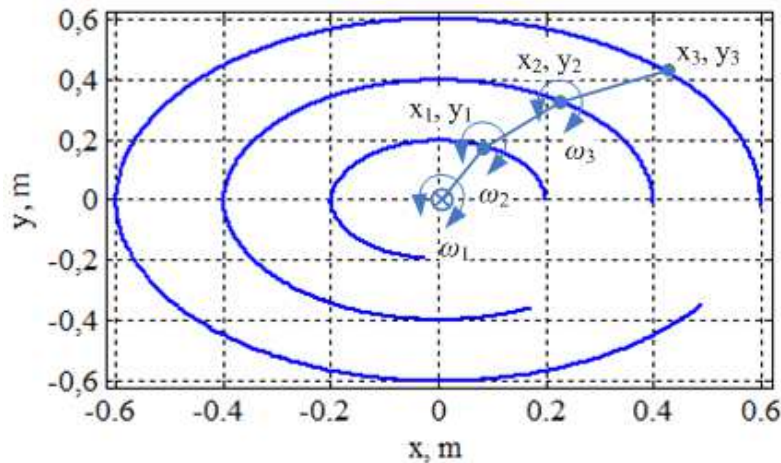
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Figure 23. ***Robotic arm simulation results: U_1, U_2, U_3, U_4 – motor control voltage variation, ω_1, ω_2, ω_3, ω_4 – motor angular velocity variation, T_1, T_2, T_3, T_4 – torques produced by motors, I_1, I_2, I_3, I_4 – motor current variation***
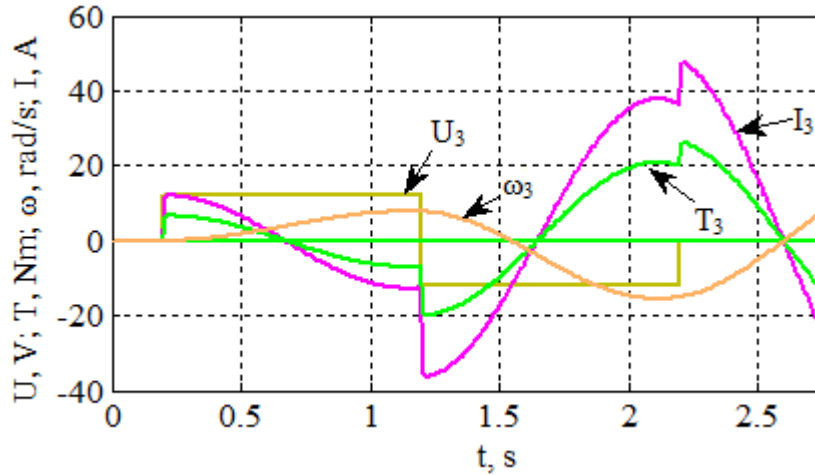
Figure 24. ***End point trajectories of links 1 and 2 of a robotic arm in a Cartesian coordinate system***
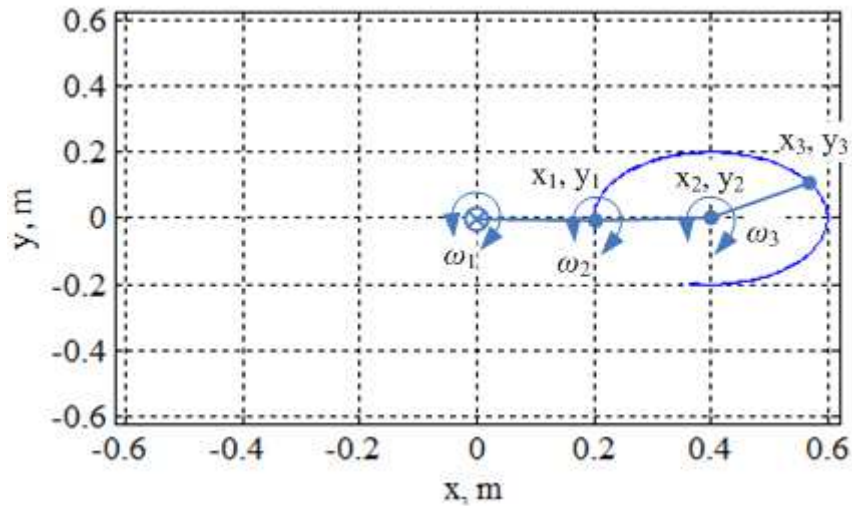
Conclusions

1. The analysis of literature on robotic structures has shown that the control of link motion can be realised through different methods and various motors, drives and encoders may be used, depending on the number of kinetic links, motion transmission mechanisms and their applicability.

2. This article presents the mathematical models of the dynamics of one-, two-, three- and four-degree-of-mobility robotic arms created with Matlab Simulink software package that makes it possible to set control voltages and monitor currents, torque, link velocity, and trajectory over time. In addition, the mathematical models and direct position models of DC motors that rotate the links of robotic arms have also been included in these models.

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VESELĪBAS ZINĀTNES / HEALTHY SCIENCES

FREQUENCY OF JOINT HYPERMOBILITY OCCURRENCE AMONG SWIMMERS

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Abstract

Frequency of joint hypermobility occurrence among swimmers

Key Words: joint hypermobility, swimming, Beighton score

Joint is called hypermobile if its range of motion exceeds the norm, taking into account the age and gender of the person. Joint hypermobility is primarily caused by more flexible tissue, which is determined by genetic inheritance. Joint hypermobility is considered as an advantage, and at the same time as a disadvantage. For many it is a value, which gives increased ability in sport. The aim of the study was to assess the frequency of joint hypermobility occurrence among swimmers. A prospective study was conducted, involving swimmers of Riga who were in the age group of 14-23 years, engaged in swimming for at least 5 years and have reached at least III Sports class. 9 joints were assessed after Beighton score and the range of their movement was measured with goniometer. Study involved 53 swimmers, 41.5 % (n = 22) women and 58.5 % (n = 31) men. The average age of 17.2 ± 2.5 years, with an average 9.91 ± 2.9 years of swimming experience. 71.7% of respondents had a joint hypermobility. Hypermobility was occurring the least frequently among Brass swimmers, hypermobility was occurring in 46.7% of them (p = 0,011). There is no statistically reliable data that suggests, that continued occupation with swimming increases joint movement range. Control group - 30 young people of the same age, 33.3 % of the respondents had joint hypermobility. In conclusions, joint hypermobility is more common among swimmers than the rest of the population. Swimmers who swim in Brass, compared to swimmers who use other styles, have less flexible joints.

Kopsavilkums

Locītavu hipermobilitātes sastopamības biežums peldētāju vidū

Atslēgvārdi: locītavu hipermobilitāte, peldēšana, Beightona skala

Ja locītavas kustību amplitūda pārsniedz normu, to sauc par hipermobilu. Locītavu kustību apjoms ir atkarīgs no personas vecuma un dzimuma. Locītavu hipermobilitāti primāri izraisa elastīgāki audi, kurus nosaka ģenētiskā iedzimtība. Palielināts kustību apjoms tiek uzskatīts reizē kā priekšrocība un trūkums. Daudziem tā ir vērtība, kas piešķir lielāku izveicību sportā.

Darba mērķis bija novērtēt locītavu hipermobilitātes sastopamības biežumu peldētāju vidū. Tika veikts prospektīvs pētījums, iesaistot pētījumā Rīgas peldētājus vecuma grupā 14 – 23 gadi, kuri nodarbojušies ar peldēšanu vismaz 5 gadus un sasnieguši vismaz III sporta klasi. Pēc Beightona skalas novērtētas 9 locītavas, kuru kustību apjoms mērīts ar goniometru. Hipermobilitāte definēta, ja ≥ 4 locītavās tests pozitīvs. Pētījumā iesaistīti 53 peldētāji, 41,5% (n = 22) sieviešu un 58.5% (n = 31) vīriešu. Vidējais vecums 17.2 ± 2.5 gadi, ar peldēšanu nodarbojušies vidēji 9.91 ± 2.9 gadus. No respondentiem 71.7% bija locītavu hipermobilitāte. Brasa peldētāju vidū hipermobilitāte bija sastopama visretāk, 46.7% no tiem bija hipermobilitāte (p = 0,011). Nav statistiski ticamu datu, ka ilgstoša nodarbošanās ar peldēšanu palielinātu locītavu kustību apjomu. Kontroles grupā bija 30 tā paša vecuma jaunieši, no kuriem 33,3% respondentu bija locītavu hipermobilitāte. Tika secināts, ka peldētāju vidū locītavu hipermobilitāte ir biežāk sastopama kā populācijā. Peldētājām sievietēm hipermobilitāti novēro biežāk. Brasa peldētāji, salīdzinot ar cita stila peldētājiem, ir ar mazāk elastīgām locītavām.

Introduction

Joint hypermobility means that person can move some or all your joints more than most people can. It's often known as being double-jointed and doctors sometimes refer to it as joint

hyperlaxity. For some, like dancers and swimmers and musicians, having a wide range of movement can have its advantages.

Joint hypermobility results from ligamentous laxity (Soep 2013). The main symptom of joint hypermobility is having an unusually large gange of movement in joints. Usually it is an isolated finding, although it may also occur in individuals with a primary genetic disorder of connective issue matrix proteins (Tobias et al. 2013).

People with joint hypermobility may have been aware from an early age that their joints were more supple than usual, and this might not have caused any further problems or symptoms. In the majority of individuals joint hypermobility exists in isolation and may be associated with musculoskeletal symptoms such as pain. This has been labeled as "generalized ligamentous laxity" or "non-pathologic hyper- mobility" (Bin Abd Razak et al. 2014).

Joint hypermobility is most frequently assessed using the Beighton score, which was devised in South Africa based on assessments of 1083 Tswana Africans (adults and children). The Beighton score is a modification of the Carter and Wilkinson scoring system (Beighton et al. 1973).

The prevalence of asymptomatic generalized hypermobility in children has been variably and widely reported, between 3% and 30%. Generalized joint hypermobility is said to be more prevalent among girls than boys (Smits – Engelsman et al. 2011).

In UK among the 6,022 children evaluated, the prevalence of hypermobility in girls and boys age 13.8 years was 27.5% and 10.6% (Clinch 2011). There are also some variations in the races, with the African ethnic group having an estimated prevalence as high as 57% (Remvig et al. 2007).

Many normal people have hypermobile joints with no other symptoms. However, a small number of people with hypermobile joints experience pain or other symptoms, and this is called joint hypermobility syndrome (Elsevier et al. 2011). Medical diagnosis of this syndrome requires symptoms which can include chronic joint pain, backache, injured of dislocated joints, impairment of proprioception, and temporomandibular joint dysfunction (Hakim et al. 2005).

Diagnosis of joint hypermobility syndrome depends on having symptoms as well as hypermobile joints and is made using the Brighton criteria (Grahame et al. 2000).

Joint hypermobility is commonly found in a group of conditions called Hereditary Disorders of Connective Tissues (HDCT). The most common of these is joint hypermobility syndrome. This group of conditions also include Ehlers-Danlos Syndrome and Marfan Syndrome. The clinical expressions ranges from morbidity because of musculoskeletal, skin, ocular and visceral pathologies to mortality from acute vascular collapse (Hakim et al. 2006).

Hypermobility-related disorders, in particular the benign joint hypermobility syndrome are among the most frequently encountered rheumatologic disorders in clinical practice in UK. But still

many patients with this syndrome passes unheedes, undiagnosed and, presumably, untreated (Grahame 2008).

Screening gymnasts, swimmers and dancers at the start of their careers may be very important to warn them about avoiding certain high-risk activities and indicate physiotherapy.

The aim of the study was to assess the frequency of joint hypermobility occurrence among swimmers.

Material and methods

This was a prospective case-control study conducted from December 2014 to January 2015. A study was conducted, involving swimmers of Riga who were in the age group of 14 – 23 years, engaged in swimming for at least 5 years and have reached at least III Sports class.

A structured questionnaire was administered to all participants attending the research. The surveyed factors included personal history, swimming workout frequency, duration of the trainings, achievements in the sport of swimming. Participants were asked whether they had any aches or pains that had affected the knee, hip, shoulder, lower back and had lasted longer than 3 months.

Hypermobility was assessed in all participants attending the research. The modified Beighton 9-point scoring system, with each joint assessed separately, was used. The fifth metacarpophalangeal joint was classified as hypermobile if it could be extended >90º, the thumb was classified as hypermobile if it could be opposed to the wrist, the elbows and knees were classified as hypermobile if they could be extended >10º, and the trunk was classified as hypermobile if both palms could be placed flat on the floor with the knees straight. Assesments were performed fot the 9 individual joints (both thumbs, both little fingers, both elbows, both knees, and the trunk), and the total number of hypermobile joints was recorded as the Beighton score. Participants eigth joint hypermobility were those who had a Beighton score of ≥4 (Tobias et al. 2013).

Goniometry was used to measure the passive bilateral dorsiflexion of the fifth metacarpophalangeal joint and the passive bilateral hyperextension of the elbow and knee. The scores were recorded and tabulated on the questionnaire.

Controul group comprised of age matched individuals who were not engaged in swimming. A significance level of $p < 0.05$ was selected for analysis. All statistical analyses were performed using the Statistical Package for the Social Sciences (*IBM SPSS Statistics*). Average rates were presented as mean [±standard deviation], while the incidence – as percentages (n – in absolute quantity).

Informed written consent was obtained from all participants and under-aged participant's parents. Ethics approval was obtained from Riga Stradins University ethics committe.

Results

The prospective study involved 53 swimmers, 41.5 % (n = 22) women and 58.5 % (n = 31) men, the average age of 17.2 ± 2.5 years. Swimmers, included in the research, had reached at least III sports class.

The swimmers, who were involved in the study, had at least five years of experience, on average 9.91 ± 2.9 years of experience. From the swimmers involved in the study 37.7 % (n = 20) were swimming for more than 11 years, 32.1 % (n = 17) for nine to 10 years, 18.9 % (n = 10) for seven to eight years and 11.3 % (n = 6) for five to six years (Fig. 1).

Attending swimming exercise seven days a week were 39.6 % (n = 21) of the swimmers involved in the study, , 52.8 % (n = 28) of the swimmers were practicing swimming five to six days a week, 3.8 % (n = 2) devoted three to four days for exercise, and 3.8 % (n = 2) had one to two swimming exercises a week.

At the moment of joint hypermobility evaluation 7.5 % (n = 4) swimmers complied with the regulations of the International Sports Master, 24.5 % (n = 13) of the swimmers complied with the regulations of Sports Master, 26.4 % (n = 14) of the swimmers were Sports Master candidates, 34% (n = 18) swimmers complied with I sports class regulations, 5.7 % (n= 3) swimmers complied with the II sports class and 1.9 % (n = 1) swimmers complied with the III sports class regulations.

From the respondents included in the study 47.2 % (n = 25) had achievements in freestyle swimming, and 22.6 % (n = 12) were successful at backstroke, successful at swimming in brass were 22.6% (n = 12), while 18.9 % (n = 10) of the respondents were successful, using butterfly swimming technique and 5.7 % (n= 3) in individual medley.

Swimmers' health condition assessment: Back pain, which lasted for more than three months was indicated by 15.1 % (n = 8) of the surveyed swimmers. Pain in one of the other joints for longer than three months was indicated by 15.1 % (n = 8) of the respondents.

Beighton Hypermobility test results: Joint hypermobility was observed for 71.7 % of the respondents, but for 28.3 % of the respondents (p = 0.01) it was not present (Fig. 2). For 95.4 % of the female respondents hypermobility was observed and 54.8 % of the male respondents had joint hypermobility.

For 53.3 % of swimmers who used brass technique, joint hypermobility was not occurrent, but for 46.7 % of brass swimmers the hypermobility was observed (p = 0.011) (Fig.3). Brass swimmers had the most inelastic joints, compared with swimmers who were gaining achievements in other swimming styles.

There was no statistical reliability, proving that hypermobility frequency among swimmers would depend on their age. As well as there is no statistically reliable data, proving, that increase of years spent in swimming exercises changes the frequency of hypermobility among swimmers.

A control group was selected, containing people of the same age, which were not involved in swimming in everyday life. Among the young people for 33.3 % joint hypermobility was observed, but 66,7 % of respondents did not have this condition (p = 0.01).

Discussion

The majority of the respondents involved in this study were male, because in this age group, males are more common to be occupied with swimming. Respondents have been trained in swimming for a long time, two-thirds of the respondents have been attending a swimming pool on a regular basis, for more than nine years.

Hypermobility was more common among swimmers than any other people. Joint hypermobility is more common for females (Smits – Engelsman et al. 2011); this study shows these results as well. Joint hypermobility was observed for almost all (95%) female swimmers.

Since there was no statistical reliability, that the incidence of hypermobility among swimmers would depend on their age or the number of years spent on exercising, it seems reasonable to think that the best swimmers have joint hypermobility due to selection. Joint elasticity takes precedence in swimming sports, if it is combined with muscle strength and good coordination. This study included swimmers who were swimming for many years. Groups of younger swimmers were not observed for incidence of joint hypermobility among them, which would allow to gain more specific information about the selection of swimmers with hypermobile joints.

Most of the cases of joint hypermobility is an isolated finding, which is not related to other pathological conditions (Tobias et al. 2013). If, in addition to increased joint elasticity, pain in the joints or back pain for more than three months is observed, as well as dislocation or subluxation in joints, it needs to be assessed by diagnostic criteria, whether the person has joint hypermobility syndrome (Grahame et al. 2000). Part of swimmers noted pain in joints or back pain for periods longer than three months. This means that there could be swimmers with joint hypermobility syndrome, which would require to draw additional attention to their health (Grahame 2008). However, back pain may also occur from the fact that all swimming strokes require maintained hyperextension of the lower back to achieve a streamlined position. Increased intensity can increase the risk of damage of the lower back (Wanivenhaus et al. 2012). Part of the people who have joint hypermobility, also have syndromes such as Ehlers-Danlos Syndrome and Marfan Syndrome, the presence of which have not been excluded for these swimmers.

Additional attention should be paid to the exercises, which swimmers carry out before and after swimming practice, to avoid shoulder, knee, spine injuries (Wanivenhaus et al. 2012). Longtime athletes' health checks for swimmers should require particular attention to joints, assessing joint elasticity, as well as assessment of the possible injury risks. Also, in the assessment of joint hypermobility for swimmers, an in-depth examination of whether swimmer has one of the

conditions of the group called Hereditary Disorders of Connective Tissues should be carried out as well.

Conclusions

- The findings of this study suggest that joint hypermobility was more common among swimmers than the rest of the population.

- Joint hypermobility was more common among female swimmers.

- Swimmers who used brass, compared to swimmers who used other styles, had less flexible joints.

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A STUDY OF SURVIVAL RATE AFTER CARDIOPULMONARY RESUSCITATION (CPR) IN CLINICAL CENTRE "GAIĻEZERS"

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Abstract
A study of survival rate after cardiopulmonary resuscitation (CPR) in Clinical Center "Gaiļezers"
Key Words: Cardiopulmonary resuscitation. Clinical Center "Gaiļezers"
The aim of the research is to evaluate the CPR pace and the patient's vital functions after the CPR and also through analyzing the examinations performed to evaluate the most frequent complications analyzing case histories. Data was gathered from 55 patients on whom in 2012 was performed CPR, medical information available in the archives of Clinical Centre "Gailezers". The data was analyzed using IBM SPSS Statistics 20 and Microsoft Excel 2013 program. Study involved 55 patients. The average age of 61,6 [20;86] years. Discharged were 54.5% patients, dead 45.5% patients. During the CPR occurring heart rhythms: asystole with 1.8% patient, ventricular fibrillation 43,6% patients, ventricular tachycardia 52,7% patients. When analyzing the ECG before the CPR 10,9% patients had sinus rhythm, 1 day after the CPR sinus rhythm – 27,3% patients, after being discharged - 34,5% patients. From early complications the most frequent is CNS lesion, developed in 40% patients. Of late, the most frequent complication is pneumonia noted in 21, 8% patients. Most of the CPR are made in EMA stage and there is the lack of data on the patient's condition prior to the CPR. The most frequent early complication is the damage to the CNS, which is the most common complication after a total of the CPR. As the most frequent late complication can occur pneumonia, which tend to develop more often in patients with MV.

Kopsavilkums
Izdzīvotības datu analīze pacientiem pēc kardiopulmonālās reanimācijas (KPR) stacionārā "Gaiļezers"
Atslēgas vārdi: Kardiopulmonālā reanimācija. Klīniskais centrs "Gaiļezers"
Mērķis ir novērtēt sirds un plaušu reanimācijas efektivitāti un pacienta vitālās funkcijas pēc reanimācijas, kā arī izanalizēt veiktās pārbaudes, lai novērtētu biežāk sastopamās komplikācijas. Dati ņemti par 55 pacientiem, kuriem 2012. gadā tika veikta sirds un plaušu reanimācija, medicīniskā informācija pieejama Klīniskā centra "Gaiļezers" arhīvos. Dati tika analizēti izmantojot IBM SPSS programmu un pētījumā tikai iesaistīti 55 pacienti. Vidējais vecums 61,6 [20;86] gadi. 54,5% pacienti tika izrakstīti, 45,5% pacientu nomira. Sirds un plaušu reanimācijas laikā fiksētie sirds ritmi: 1,8% pacientu ir asistolija, 43,6% ventrikulārā fibrilācija, 52,7% ventrikulārā tahikardia. Analizējot EKG pirms reanimācijas 10,9% pacientiem ir sinuss ritms, dienu pēc reanimācijas sinuss ritms ir 27,3% pacientu un pēc izrakstīšanās - 34,5%. No agrīnajām komplikācijām visbiežākās ir CNS bojājums, tas parādās 40% pacientiem. No vēlīnajām komplikācijām visbiežākā ir pneimonija, novērota 21,8% pacientiem. Lielākā daļa sirds un plaušu reanimāciju ir veiktas EMA stadijā; ir datu trūkums par pacienta stāvokli pirms reanimācijas. Biežākā agrīnā komplikācija ir bojājums CNS, kas ir biežākā komplikācija kopumā.

Introduction

Cardiopulmonary resuscitation (CPR) is a technique used to provide blood flow when heart has stopped. It is a life saving procedure that can be carried out by a person who doesn't have any medical education. These are basic steps in CPR, which are usable in any situation by someone for any reason is unconscious which were published by European Resuscitation Council (ERC) in ERC Guidelines for cardiopulmonary resuscitation (2010):

1. Make sure you, the victim and any bystanders are safe.

2. Check the victim for a response

3. If he does not respond:
   - shout for help
     - turn the victim onto his back and then open the airway using head; tilt and chin lift;
     - place your hand on his forehead and gently tilt his head back;
     - with your fingertips under the point of the victim's chin, lift the chin to open the airway.
4. Keeping the airway open, look, listen and feel for breathing
5. If the breathing is not normal or absent:
   - get help
   - start chest compression – press down on sternum for 5 cm and repeat at rate of at lieast 100 times in one minute
6. Combine chest compression with rescue breaths. After 30 compressions give 2 effective rescue breaths, this should not take more than 5 s." (Nolan et al. 2010:1224)

However there are guidelines that are meant for emergency medical treatment team. These guidelines include defibrillation, intubations and use of different medicaments to restore spontaneous blood circulation (Nolan et al. 2010: 1229-1244).

Leader organizations in resurrection and life support training are American Heart Association (AHA) European Resuscitation Council (ERC), the Heart and Stroke Foundation of Canada (HSFC) and other related organizations. The first international cardiopulmonary resurrection (CPR) Guidelines were published in year 2000. Since then, an updated list of guidelines is published every five years. Last guidelines for CPR where published in 2010 and this year there are expectations for new CPR guidelines. Discussions are over the rate of chest compressions. For now recommended are 100 chest compressions in a minute, but new guidelines possibly will be corrected and they might be recommending 100 – 120 chest compressions in one minute (Lee 2015). This discussion is about the fact that many studies such as Lee (2015), Idris (2012) and Field (2012) proved that slower compression may not provide adequate blood perfusion, but on the other hand faster compressions could put providers at risk of performing less effective compressions. There may change recommendations about hypothermia, because there were studies provided evidence confirming no difference existed in patient outcomes when body temperatures were cooled to 33 degrees Celsius, as compared to 36 degrees Celsius (Nolan et al. 2003) The duration for CPR performance will be a topic of discussion, referencing a 2012 study which found increased percentages occurrence for inpatients receiving CPR for a period of up to 45 minutes (Rapp 2013). If cardiopulmonary resuscitation is early initiated, it increases the chances of survival by 2-3 times (Mani et al. 2015). However, short-term cardiac arrest episode is characterized by multi-organ damage in connection with ischemia. Post–cardiac arrest care has significant potential to reduce

early mortality caused by homodynamic instability and later morbidity and mortality from multiorgan failure and brain injury (Peberdy et al. 2010). Subsequent objectives of post–cardiac arrest care are:

1. Control body temperature to optimize survival and neurological recovery

2. Identify and treat acute coronary syndromes (ACS)

3. Optimize mechanical ventilation to minimize lung injury

4. Reduce the risk of multiorgan injury and support organ function if required

6. Objectively assess prognosis for recovery

7. Assist survivors with rehabilitation services when required (Peberdy et al. 2010: 5678).

To avoid multiorgan failure after cardiac arrest, the provider of CPR should mechanically support breathing immediately after the return of spontaneous circulation. They should also evaluate head of the bed 30° if tolerated to reduce the incidence of cerebral edema, aspiration, and ventilatory – associated pneumonia. Providers should titrate inspired oxygen to the lowest level required to achieve oxygen saturation more than 94%, so as to avoid potential oxygen toxicity. Hyperventilation increases intrathoracic pressure and inversely lowers cardiac output. After return of spontaneous circulation ECG monitoring should be continued because of recurrent cardiac arrhythmias. (Peberdy et al. 2010: 5679).

For all patients who are unable to follow verbal commands after return of spontaneous circulation should be considered therapeutic hypothermia because it is the only intervention to improve neurological outcome (Peberdy et al. 2010: 5680).

Significance of this study is to acknowledge efficiency of intensive medical care quality in Latvian Clinical Center "Gaiļezers" comparing to other country hospitals. There is no study so far that would analyze outcome treating patients after performed CPR in Clinical Center "Gaiļezers" which is one of most overloaded hospitals with patients in Latvia. This information would help to make improvement and would help avoid most common death causes in intensive care.

This study was performed to acknowledge patient condition after performed CPR, late survival rate after CPR and most common complications after CPR and how common they are found. Using medical case reports, information about performed examinations was analyzed, to make conclusions about common organ injuries such as neurological injury, lung injury and myocardial injury.

Material and methods

Study was performed retrospectively in Clinical Center "Gaiļezers" analyzing medical information from patient's medical case reports available in the archives of Clinical Centre "Gailezers". There were gathered information on 55 patients on who in 2012 was performed CPR and on whom were restored spontaneous blood circulation. Information that was analyzed included

data on patient's basic information (sex, age), patient's condition during CPR, and patient's condition after CPR Analyzing how many patient's where discharged after CPR and inferring late survival rate after CPR and analyzing late complications that accrued after CPR. The data was analyzed using IBM SPSS Statistics 20 and Microsoft Excel 2013 program.

Results

Study involved 55 patients, 20 women and 35 men. The age range was 20-86 years with the average age of patients 61.6 ± SD CPR was initiated to 1 patient before emergency medical treatment (EMT) arrival, 30 in EMT and patients 24 at the hospital.

Discharged from hospital were 54.5% patients, dead 45.5% patients. 9.09% patients died in the 1st hour after CPR. 7.27% patients died around 2nd - 6th hour. 12.73% patients died till 24th hour. 25.45% of patients died on 2nd day or later.

Figure 1. *Distributions of patients on time of death*
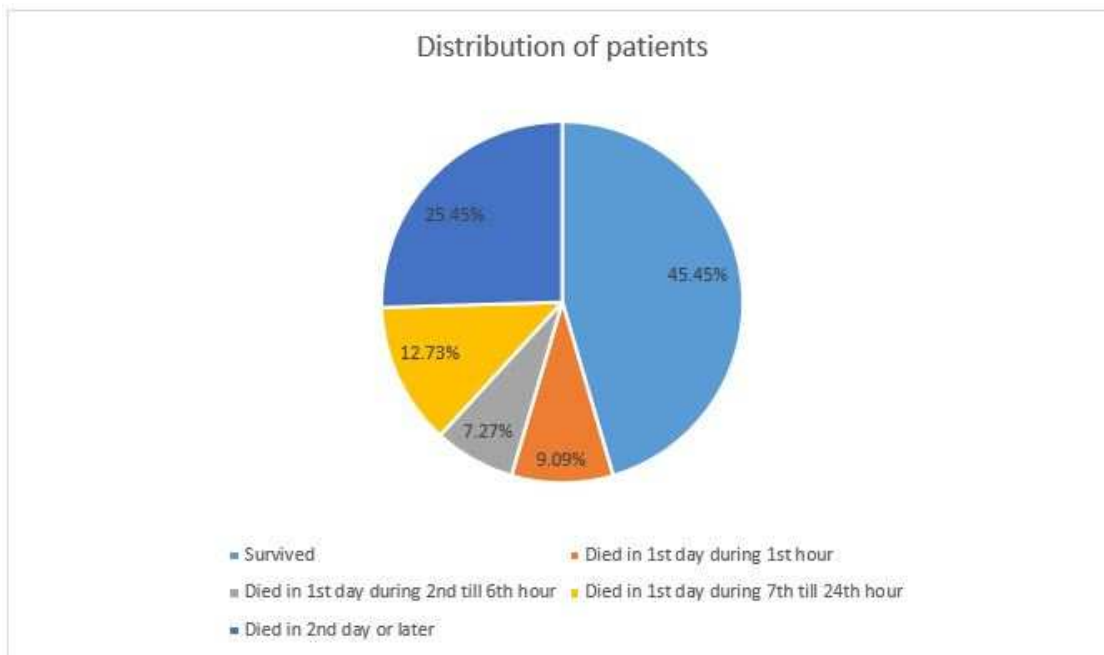
During the CPR occurring heart rhythms were: asystole with 1.8% patient, ventricular fibrillation 43.6% patients, ventricular tachycardia 52.7% patients. Defibrillation was initiated to 41.6% patients and most commonly on 18.9% patients defibrillation was performed one time, 5.7% patients had 2 defibrillations, 9.4% patients had 3 defibrillations, 1.9% patient had 4 defibrillations, 3.8% patients had 5 defibrillations and 1.9% patient had 6 defibrillations.

Figure 2. *Cont of defibrillation performed on patients*
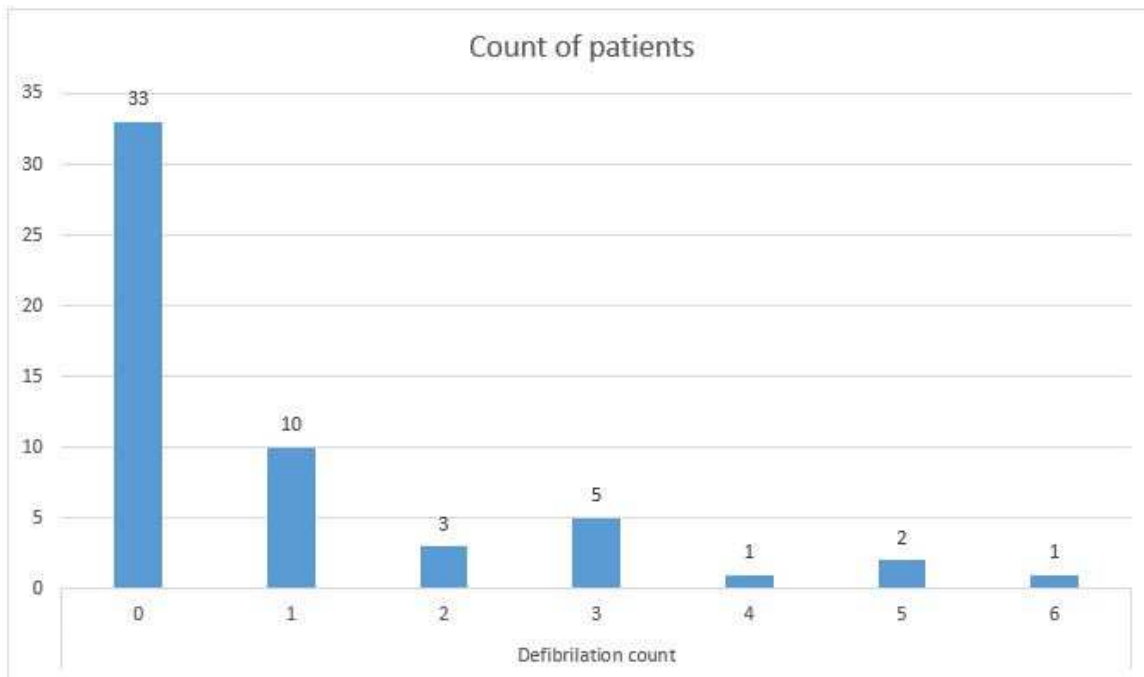
After cardiac arrest and CPR spontaneous breathing was found in 18.9% patients and 81.1% had mechanical ventilation.

After cardiac arrest and CPR hypotension was found in 54.55% of patients. 21.82% of patients had hypertension with either systolic or diastolic hypertension.

After cardiac arrest and CPR 7% of patients had bradycardia with heart rate frequency lower than 60.56% of patients had tachycardia with heart rate frequency higher than 90.

Figure 3. *Heart rate after CPR*
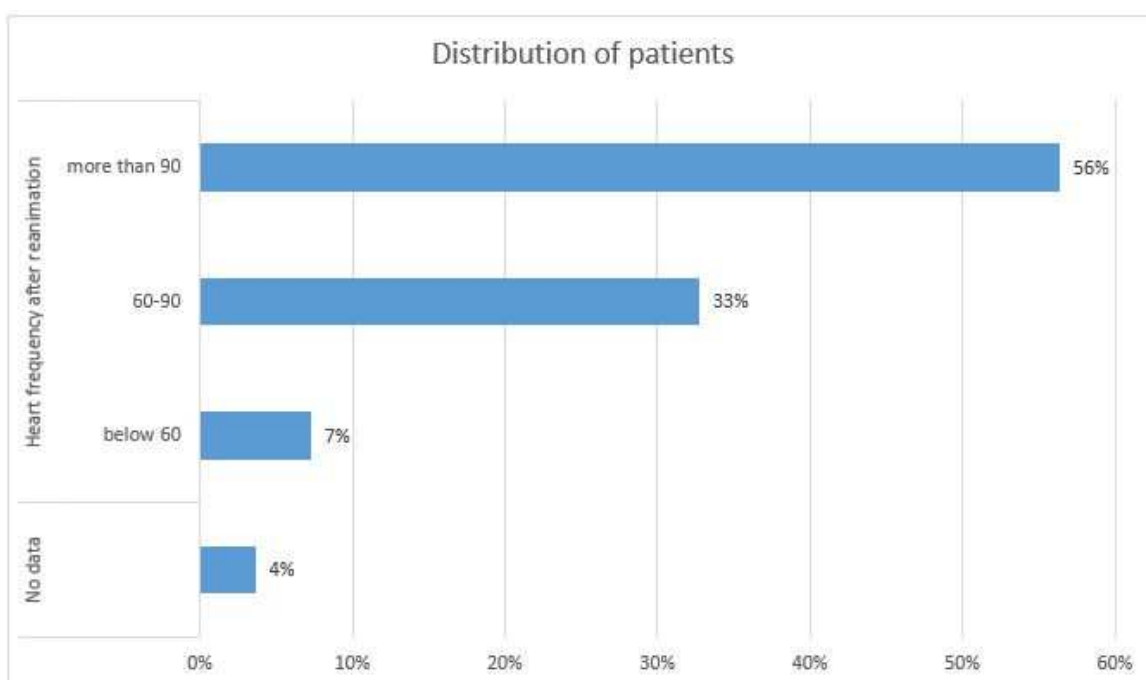
When analyzing the ECG before the CPR 10.9% patients have sinus rhythm. Acute coronary syndrome was found in 43.6% patients and it most likely provoked cardiac arrest. 18.2% patients had bradycardia before cardiac arrest.

1 day after the CPR sinus rhythm was found in 27.3% patients. Atrial fibrillation was found in 21.8%. Bradicardia was found in 3.6% patients. Tachycardia was found in 32.7% patients.

After being discharged – 34.5% patients had sinus rhythm. Atrial fibrillation was found in 3.6% patients. Bradycardia was found ir 3.6% patients and tachycardia was found in 3.6% patients.

Of early (found in first 48 hours) complications the most frequent is CNS lesion, developed 40% patients. Myocardial injury was found in 43.6% patients, this was found using ECG and finding acute coronary syndrome, which most likely was cause of cardiac arrest not an early developed complication. Pneumonia as an early complication was found in 7.2% patients.

Of late (found after 48 hours), the most frequent complication is pneumonia, noted in 21.8% patients. CNS lesion after 48 hours was found in 5,4% patients. Acute coronary syndrome was found in 12.7% patients.

Discussion

Similar study was made in MD Anderson Cancer Center Department of Emergency Medicine, University of Texas on cancer patients. One hundred twenty-six cancer center patients received CPR in 2003-2007 (Group 1) and 2008-2012 (Group 2). In year 2010. CPR guidelines were updated. The aim was to analyze how many cancer patients after cardiac arrest and CPR have been discharged from hospital. Results were similar in both groups. Survival to hospital discharge was 11% Group 1 vs. 10% Group 2. (Miller 2015) Results are much lower than in Clinical Center "Gaiļezers" and reasons for such difference is that in MD Anderson Cancer Center were included only patients with cancer, who have particularly low rates of return of spontaneous circulation, but in Clinical Center "Gaiļezers" patients were unselected and profile of this hospital is very extensive. And in study at MD Anderson Cancer Center Department of Emergency Medicine were included all performed CPR but in Clinical Centre "Gaiļezers" patients who did not restore spontaneous blood circulation were excluded.

The American Heart Association published the Heart Disease and Stroke Statistics - 2013 Update. Statistical update in year 2013 shows that survivor rate was 9.5% for patients who had out of hospital cardiac arrest and underwent CPR. For patients who had cardiac arrest in hospital care, survival rate was 23.9% (AHA 2012). These results are lower than results in Clinical Center "Gaiļezers" and reason was that in the heart and stroke statistics – 2013 Update analyzed was survival rate after CPR but in Clinical Centre "Gaiļezers" patients who didn't restore spontaneous blood circulation were excluded and patients who had restored spontaneous blood flow would had higher survival rate later.

In Iran Department of Anesthesiology, Baqiyatallah University of Medical Sciences was performed a study on 290 patients and as result 35 patients (12%) were alive at discharge. Majority of patients who had participated in study, were more than 60 years old. Study included patients with different clinical cases (***Saghafinia 2010***). Study is very similar to the study performed in Clinical Center "Gaiļezers" but results were much lover, because in Iran discharges alive where 12%, but in Clinical Center "Gaiļezers" 54.5%. Study in Clinical Center "Gaiļezers" was performed on 55 patients, which is much less than study performed in Iran. But results are still very different.

Lund University Hospital made a study about CNS lesions after CPR. Results showed that the largest number of diffusion changes on MRI was found in 16 patients who died. Perfusion changes, compared with healthy volunteers from a previously published cerebral perfusion study, were found in seven out of eight patients. (Järnum H et al. 2009) In Clinical Center "Gaiļezers" of early complications the most frequent is CNS lesion, developed 40%, which is lower result. Patients who participate in Clinical Center "Gaiļezers" study where 55 and in Lund University Hospital 24 patients.

In Medical Intensive Care Unit, Cochin Hospital, Paris was performed a study researching how often does pneumonia occur after cardiac arrest and CPR. Results were that in the first 3 days, 419 (65%) presented early-onset pneumonia. (Perbet 2011) In Clinical Center "Gaiļezers" is pneumonia, noted in 21, 8%.

Results which were revealed in Clinical Center "Gaiļezers" are more "optimistic" than in other studies. Late survival rate is much greater than in similar studies and rate of complications after CPR is lower. To find out reasons for these differences there should be held a prospective study with similar aims, so it would be possible to examine reasons for different results than in other hospitals. It would be valuable to perform similar study in a different hospital in Latvia to compare results.

Conclusions

- Most of the CPR are made in EMA stage and there is the lack of data on the patient's condition prior to the CPR.

- Late survival after cardiac arrest and CPR is 54.5%. But 44.5% die after CPR in hospital. These are high results because in similar studies patients who survive CPR are 10% - 23.9%. And rate of discharge after CPR has been 12%.

- Most of patients (25.45%) die on 2nd day or later after cardiac arrest and CPR.

- The most frequent early complication is the damage to the CNS, which is the most common complication after a total of the CPR. As the most frequent late complication can occur pneumonia.

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ACUTE SIDE EFFECTS FOR NURSES AND NURSING ASSISTANTS OCCUPATIONALLY EXPOSED TO ANTINEOPLASTIC DRUGS

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Abstract
Key words: antineoplastic drugs, hazardous drugs, occupational exposure, health professionals, acute side effects.
Introduction. Not only patients but also healthcare workers are exposed to antineoplastic drugs (cancer chemotherapy drugs). Due to their adverse effects, antineoplastic drugs are considered as potential health risk for nurses and nursing assistants, especially development of short-term and long-term side effects is possible.
Aim. The aim of this research was to collect and summarize information about acute side effects of antineoplastic drugs in two major cancer centers in Latvia and the possible correlation between acute effects and work experience.
Material and methods. In total 51 nurses and nursing assistants responded to the research. All the participants of the research were women working in chemotherapy ward at least for 12 months. The research was conducted in Pauls Stradins Clinical University Hospital, Department of Chemotherapy (DC) and Riga East University Hospital, Oncology Centre of Latvia, DC. All information was reviewed with MS Excel and IBM SPSS software.
Results. The average of work experience in DC was 8,63 ($\pm$ 7,109) years. 56,9 % of respondents stated at least one side effect since working in DC. An acute side effect such as headache is the most common one (37.3%), followed by irritation of eyes (25,5%), irritation of skin (19, 6%), dizziness (13,7%), irritation of mouth and throat (7,8%).
Headache ($p = 0.021$), dizziness ($p = 0.018$), irritation of mouth and throat ($p = 0.043$) and irritation of eyes ($p = 0.004$) had statistically significant positive association with years of working in DC.
Conclusions. More than half of respondents had at least one acute side effect since working in DC. The most common complaints were headache and irritation of eyes.
Nurses and nursing assistants working for longer time in DC were more likely to have headache, dizziness, irritation of mouth and throat and irritation of eyes.

Kopsavilkums
Atslēgvārdi: antineoplastiskās vielas, bīstamās vielas, aroda ekspozīcijas, veselības aprūpes speciālisti, akūta blakus efekti.
Ievads. Ar antineoplastiskām vielām (ANV), kas tiek izmantotas ļaundabīgo audzēju ārstēšanā ķīmijterapijas veidā, saskaras ne tikai pacienti, bet arī veselības aprūpē strādājošie.Šo vielu izraisītu blakus efektu dēļ, antineoplastiskie līdzekļi tiek uzskatīti par potenciāliem veselību apdraudošiem riskiem māsām un māsu palīgiem, īpaši liela iespēja ir attīstīties īstermiņa un ilgtermiņa blakus efektiem.
Mērķis. Šī pētījuma mērķis bija savākt un apkopot informāciju par antineoplastisko vielu izraisītiem akūtiem blakus efektiem divos lielākos onkoloģijas centros Latvijā un novērtēt iespējamo korelāciju starp akūtiem blakus efektiem un darba stāžu.
Materiāli un metodes. Tika aptaujātas 51 māsa un māsu palīgi. Visi pētījumā iekļautie respondenti bija sievietes, kuras ķīmijterapijas nodaļā strādāja vismaz 12 mēnešus. Aptauja tika veikta Paula Stradiņa klīniskās universitātes slimnīcas Onkoloģijas klīnikas ķīmijterapijas nodaļā (ĶN) un Rīgas Austrumu klīniskās universitātes slimnīcas stacionārā Latvijas Onkoloģijas centra ĶN. Iegūtie dati tika apkopoti un apstrādāti, izmantojot MS Excel un IBM SPSS programmas.
Rezultāti. Vidējais darba stāžs nodaļā bija 8,63 ($\pm$7,109) gadi. 56,9% respondentu atzīmēja vismaz vienu blakni kopš darba uzsākšanas ĶN. Biežāk minētās akūtās sūdzības bija galvassāpes (37.3%), acu kairinājums (25,5%), ādas kairinājums (19, 6%), reibonis (13,7%) un mutes un rīkles kairinājums (7,8%). Galvassāpes ($p = 0.021$), reibonis ($p = 0.018$), mutes un rīkles kairinājums ($p = 0.043$) un acu kairinājums ($p = 0.004$) uzrādīja statistiski ticamu pozitīvu saistību ar darba stāžu ĶN.
Secinājumi. Vairāk nekā puse respondentu saskārās ar vismaz vienu akūtu blakus efektu kopš darba uzsākšaans ĶN. Visbiežākās sūdzības bija galvassāpes un acu kairinājums. Māsām un māsu palīgiem, kam darba stāžs ĶN ir lielāks, ir lielāka iespēja attīstīties galvassāpēm, reibonim, acu kairinājumam, mutes un rīkles kairinājumam.

Introduction

Antineoplastic drugs have been used in the treatment of cancer for more than 50 years. These powerful drugs are used clinically to destroy or control the growth or spread of cancer cells, cure

the cancer or put it in remission, ease symptoms such as pain or pressure from a tumor when a cure is not possible. (Ontario Nurses' Association 2012) Their pharmacological property to kill tumor cells is by interfering with cell division. However, their action is not specific to cancerous cells, and non-cancerous cells may also get damaged. (Shahrasbi A.A. et al. 2014)

Antineoplastic drugs are part of a larger group called hazardous drugs. Hazardous drugs are drugs that pose a potential health risk to health care workers who may be exposed during preparation or administration. Most drugs are considered hazardous if they are cytotoxic, it means they inhibit or prevent cell function. These include biologic, antiviral, and immunosuppressive agents, as well as drugs from other classes. (Ontario Nurses' Association 2012) Hazardous drugs are drugs manifesting genotoxicity, carcinogenicity, teratogenicity, fertility impairment, serious organ or any other toxic manifestation at low doses in animal or human experiments. (Shahrasbi A.A. et al. 2014)

Despite their therapeutic and beneficial effects in cancer patients with life-threatening conditions, both acute or short-term and chronic or long-term adverse effects are associated with antineoplastic drugs treatment. (Villarini M. et al. 2012) All antineoplastic drugs have side effects associated with patient use. Workers who handle antineoplastic drugs may be at risk of suffering the same effects as their patients without reaping any of the benefits. (Ontario Nurses' Association 2012)

The likelihood of an adverse event resulting from occupational exposure to antineoplastic drugs can vary with the dose and frequency of the exposure, and the extent to which the drug is absorbed into the body. (Ontario Nurses' Association 2012)

Epidemiological studies of personnel who handle antineoplastic drugs, performed on a global scale, showed detectable levels of genotoxic drugs in the work environment and a statistically significant increase in DNA damage and chromosomal aberrations in the exposed population versus the reference group. (Buschini A. et al. 2013) Other studies have found increased chromosomal aberrations and evidences of mutagenic/ carcinogenic risks in exposed nurses' urine samples. (Shahrasbi A.A. et al. 2014)

Occupational exposure to antineoplastic drugs occurs directly and non-directly through skin absorption, ingestion, inhalation, or accidental injection. Both clinical and non-clinical workers may be exposed to antineoplastic drugs during the preparation, administration, or disposal of these toxic agents. (Ontario Nurses' Association 2012)

Also important is whether or not safe work practices have been followed and in the case of a pregnant health care worker, the point during a pregnancy and/or fetal development at which the exposure occurs. Exposure to even very small concentrations of certain drugs may be hazardous for

all workers who handle them. In these cases there are no safe limits. (Ontario Nurses' Association 2012)

In a recent study conducted in 2011 in Canada, researchers reported that nearly 17 per cent of nurses who work in outpatient chemotherapy infusion centers reported being exposed on their skin or eyes to the antineoplastic drugs they deliver. (Ontario Nurses' Association 2012)

Acute exposure generally causes transient symptoms such as headache, nausea, malaise, dizziness, rash, dermatitis, skin and mucous membrane irritation or ulceration and eye or throat irritation. (Shahrasbi A.A. et al. 2014) Cases of abdominal pain, hair loss and liver damage related to cytotoxic drug exposure were also reported. (Keat C.H. et al. 2013)

There are a number of long-term or chronic effects that have been identified in health care workers working with or near these potent drugs. These health effects include: liver and kidney damage, damage to the bone marrow, damage to the lungs and heart, infertility (temporary and permanent), effects on reproduction and the developing fetus in pregnant women, learning disabilities in offspring, hearing impairment and cancer. (Ontario Nurses' Association 2012)

Only a limited number of epidemiological studies have addressed occupational cancer risks related to handling of antineoplastic drugs. The main results reported in these studies are an increased risk of leukemia among oncology nurses and physicians occupationally exposed to antineoplastic drugs and an elevated risk of cancer for long-term pharmacy personnel. (Villarini M. et al. 2012) Fetal loss induced by chronic exposure to cyclophosphamide, doxorubicin and vincristine, in nursing personnel was also observed. (Shahrasbi A.A. et al. 2014)

During the past 30 years, numerous guidelines have been issued to protect health careworkers in Western countries. Although these safety precautions are advanced to reduce worker exposure, recent studies have demonstrated that workplace contamination and occupational exposure continues. (Yu Wen H. et al. 2012)

Material and Methods

Site observation. The report was conducted at two specialized cancer centers in Riga, capital city of Latvia, in order to determine the acute side effects of antineoplastic drugs. These two centers were Pauls Stradins Clinical University Hospital, Department of Chemotherapy and Riga East University Hospital, Oncology Centre of Latvia, Department of Chemotherapy. There was large variability in antineoplastic drug usage in both centers as they did not specialized in narrow oncologic fields.

Population recruitment. A total number of 68 nurses and nursing assistants were provided with the questionnaire, all of them were women who were working in department of chemotherapy at least for 12 months. Exclusion criteria were active drinkers or smokers, known uncontrolled chronic medical conditions (cardiac problems, diabetes, arthritic related disorders and respiratory

diseases), bleeding disorders, any past cancer diagnosis or active complicated medical or surgical therapies in the past 12 months. The aim of this stringent selection in terms of health and years of experience was to avoid any bias or any unrelated symptoms reporting by the nursing and nursing assistants' staff.

Questionnaire. The questionnaire was in two parts and based on the most reputable international guidelines such as American Society of Health System Pharmacists, the Occupational Safety and Health Administration and the Health & Safety Executive guidelines for handling cytotoxic drugs in clinical settings. First part was aimed to establish the knowledge on the hazardous effects, ways of exposure to cytotoxic drugs, personnel protective equipment use and safe handling measures. The second part was aimed at gathering any reported side effects that may be due to acute or chronic exposure to cytotoxic. Acute side effects were classified as irritation of eyes, irritation of skin, irritation of mouth and throat, dizziness, headache, nausea, vomiting, diarrhea. The questionnaire had to be specific without causing any concerns for participants when answering the questions. The questions had to be translated from English to Latvian without any loss of meaning.

Data processing. All information was reviewed with MS Excel and IBM SPSS software. Descriptive statistics measured the central tendency including the mean parameters and the variability including the standard deviation, the minimum and maximum values of the variables. With inferential statistics correlations were made to grasp the connection between acute side effects and participant's understandings of hazards associated with their jobs and existence or lack of resources to help to minimize the risks, p-value were used to quantify the idea of statistical significance of correlations.

Results

Based on questionnaire responses and inclusion and exclusion criteria, the total number of participants included in research was 51. Of them were 29 nurses and 22 nursing assistants, 100% were women, with a mean age of $43,39 \pm 11,105$ years (range $21 - 63$ years). The average of work experience in department of chemotherapy was $8,63 \pm 7,109$ years, suggesting chronic exposure to a wide spectrum of antineoplastic drugs. The most frequent ways of exposure of antineoplastic drugs were cleaning of procedure room (60,8%), drugs' preparation for usage in procedure room (58,8%) and administering medication to patients (41,2%), as shown in Diagram 1. 97,1% of respondents were informed about hazards associated with their jobs.

Diagram 1. The most frequent ways of exposure of antineoplastic drugs

Diagram 1. The most frequent ways of exposure of antineoplastic drugs
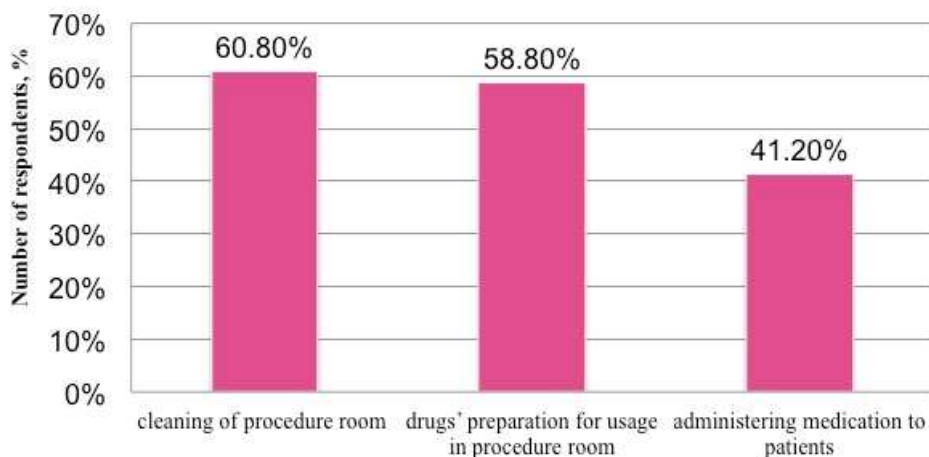
This information was obtained from classes and training held by the hospitals in 58,8%, from coworkers in 54,9%, from individual studies using various texts and internet in 47,1%, from participation in conferences in 13,7% and from nursing associations and previous university training (during undergraduate training) in 11,8%, as shown in Diagram 2.

Diagram 2. Sources of information about occupational hazards
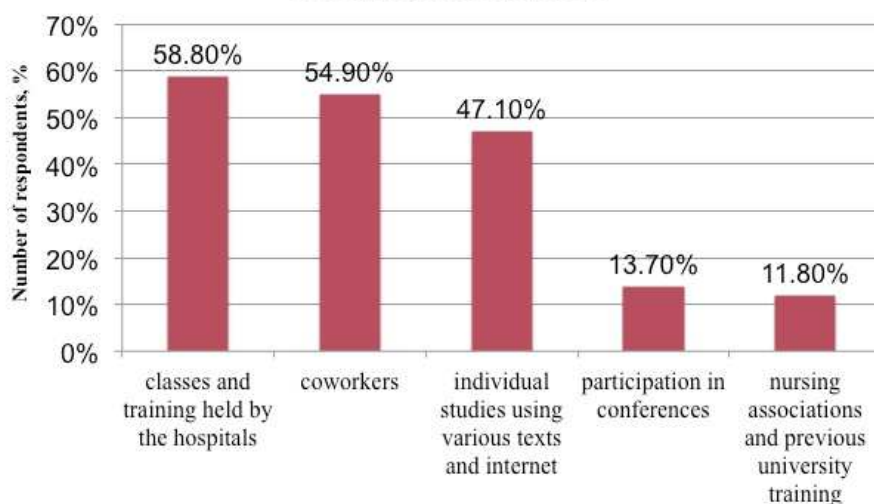
Diagram 2. Sources of information about occupational hazards

All respondents were informed about available resources to help minimize occupational hazardous risks but only 90,2% regularly used protective equipment during work. 31,4 % of respondents noticed overall decreasing of health status since working in department of chemotherapy but there were no statistically significant association with ways of exposure of antineoplastic drugs ($p \geq 0,05$), information status about hazards associated with their jobs ($p \geq 0,05$) and regular usage of protective equipment during work ($p \geq 0,05$).

56,9% of respondents stated at least one side effect since working in department of chemotherapy. Using the validated questionnaire, we aimed to investigate the prevalence of acute adverse effects. An acute side effect such as headache is the most common one, reported in 19 cases (37,3 %), followed by irritation of eyes, reported in 13 cases (25,5 %), hair loss, reported in 11 cases (21,6%) irritation of skin, reported in 10 cases (19,6 %), dizziness, reported in 7 cases (13,7 %), irritation of mouth and throat, reported in 4 cases (7,8 %), as shown in Diagram 3. Skin irritation could be any rash and skin redness (dermatitis like reactions) while working with cytotoxic agents. In all cases nurses confirmed that they had no other reasons or life style changes to be the cause for such reactions. The questions presented to the nurses were "In general, have you experienced more episodes of hair loss while working in your current wards?" and "In general, have you experienced more episodes of nausea and vomiting while working in your current ward?"

All reported side effects had positive association with years of working in department of chemotherapy, showing higher frequency of side effect in nurses and nursing assistants with longer occupational exposure to antineoplastic drugs. Headache (p=0,021), dizziness (p=0,018), irritation of mouth and throat (p=0,043) and irritation of eyes (p=0,004) had statistically significant positive association with years of working in department of chemotherapy while other side effects had not (p≥0,05). None of respondents reported newly discovered reproductive challenges or oncological diseases since working in department of chemotherapy.

Discussion

The aim of this investigation was to collect and summarize information about acute side effects of antineoplastic drugs in two major cancer centers in Latvia and the possible correlation between antineoplastic drugs and work experience. This study was based on questionnaire and was carried out in two different parts: to assess the level of training and knowledge of the nurses and nursing assistants on risks associated with cytotoxic drugs; to investigate the level of acute side effects that were associated with occupational exposure to chemotherapy agents.

This study appears to be the first local investigation of the nurses' safety-related knowledge, attitude and practices in cytotoxic drug handling in a general hospital. To our knowledge, it is also the only study, which demonstrates the possible acute side effects, which are related to handling cytotoxic drugs.

Although there was possibility to compare level of training and knowledge of the nurses and level of acute side effects between two hospitals, limited number of nurses and nursing assistant included in this research disallowed further investigation.

This research revealed moderate level of knowledge of the nurses and nursing assistants about possible occupational exposure to antineoplastic drugs. The most common source of information was classes and training held by the hospitals, followed by coworkers and individual studies using

various texts and Internet. Comparing these facts with studies from other countries, hospitals are the main providers of information about safe handling of drugs and risks associated with that.

Although all respondents were informed about available resources to help minimize occupational hazardous risks, only 90,2% regularly used protective equipment during work and this difference may be even bigger if we take into account subjectivity of survey. We found slightly higher incidence of overall decreasing of health status since working in department of chemotherapy in respondents who did not regularly used protective equipment but it was not statistically significant association.

More than half of respondents stated at least one side effect since working in department of chemotherapy. Rarely there was only one marked side effect. The most frequents stated acute side effect was headache, followed by irritation of eyes, hair loss, irritation of skin and dizziness. There were no reported cases about nausea, vomiting and diarrhea. Comparing these facts with studies from other countries, irritation of skin was the most frequent one, which could be explained by lower level of protective equipment usage. Although we need to mention that headache is less reliable side effect to reveal occupational risk of cytotoxic drugs due to broad spectrum of other conditions, which can cause this symptom.

All reported side effects were more common in respondents with longer working experience in department of chemotherapy, showing possible cumulative effect of cytotoxic drugs on human organism. This association was statistically significant with four side effects: headache, dizziness, irritation of mouth and throat and irritation of eyes.

The most acknowledged chronic side effects of antineoplastic drugs associated with occupational exposure are reproductive challenges (infertility, spontaneous abortions and congenital malformations) and oncological diseases (leukemia, Non-Hodgkin lymphoma, breast, bladder and liver cancers). In our research none of respondents reported newly discovered reproductive challenges or oncological diseases since working in department of chemotherapy.

Conclusions

More than half of respondents had at least one acute side effect since working in department of chemotherapy.

The most common complaints were headache and irritation of eyes.

Nurses and nursing assistants working for longer time in department of chemotherapy were more likely to have headache, dizziness, irritation of mouth and throat and irritation of eyes.

Acknowledgement

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DEEP VEIN THROMBOSIS AND PULMONARY EMBOLISM: THE KNOWLEDGE OF GYNECOLOGISTS, OBSTETRICIANS AND PUERPERAL WOMEN ABOUT PROPHYLAXIS

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Abstract
Deep Vein Thrombosis and Pulmonary Embolism: the Knowledge of Gynecologists, Obstetricians and Puerperal Women about Prophylaxis
Key words: thrombosis, pregnancy, knowledge, prevention, prophylaxis
The risk of venous thromboembolism increases 10 times during pregnancy, childbirth and postpartum periods. Deep vein thrombosis and pulmonary embolism (DVT/PE) are a serious pregnancy and postpartum complications, which can be fatal. Nowadays, correctly assessing risk factors and under medication or/and non-drug prevention, it is possible to avoid completely these complications.
Aim was 1) to find out the awareness of gynecologists and obstetricians of what is DVT/PE risk and prophylaxis; 2) to clarify awareness of the puerperal women of DVT/PE prophylaxis.
Questioning gynecologists, obstetricians and puerperal women, and analyzes of information was used as a research tool. The data were collected and processed in a computer programs MS Word, Excel. Data analyzes were carried out through descriptive statistical methods.
100 gynecologists and obstetricians and 104 puerperal women were interviewed. 85% gynecologists, obstetricians informed the pregnant woman about DVT/PE risk and provided the following recommendations: graduated compression socks - 67%, physical activity - 44%, fluid intake - 25%, a phlebologist consultation - 22%. 54% of the surveyed had a DVT/PE guidelines. 68% know that in Latvia there are developed guidelines for DVT/PE. 37% of medical practitioners of puerperal women informed them about the increased risk of venous thrombosis, of which 22% told how to reduce the risk. 46% were able to name at least one preventive measure.
In Latvia there is an insufficient assess of DVT/PE risk and compliance control during pregnancy when occurring the maternity and after giving birth, which leads to increased risk of maternal morbidity and mortality. In health care facilities there are often no DVT/PE guideline which could evidence doctors low knowledge about DVT/PE. Pregnant women are aware of DVT/ PE and prophylaxis measures far too little.

Kopsavilkums
Dziļo vēnu tromboze un plaušu embolija: ginekologu, dzemdību speciālistu un nedēļnieču zināšanas par profilaksi
Atslēgas vārdi: tromboze, grūtniecība, zināšanas, prevencija, profilakse
Grūtniecības, dzemdību un pēcdzemdību periodos venozās trombembolijas risks pieaug 10 reizes. Dziļo vēnu tromboze un plaušu embolija ir nopietnas grūtniecības un pēcdzemdību komplikācijas, kuras var būt letālas. Mūsdienās pareizi izvērtējot risku un ievērojot medikamentozo un nemedikamentozo profilaksi, ir iespējams pilnībā izvairīties no šīm komplikācijām.
Mērķis bija noskaidrot, kāda ir ginekologu un dzemdību speciālistu informētība par DzVT/PE riskiem un profilaksi. Noskaidrot, kāda ir nedēļnieču informētība par DzVT/PE profilaksi.
Kā pētījuma instruments izmantota ginekologu un dzemdību speciālistu anketēšana un to analizēšana, nedēļnieču anketēšana, anketu analizēšana. Dati tika apkopoti un apstrādāti datorprogrammā MS Word, Excel. Datu analīzi tiek plānots veikt ar aprakstošās statistikas metodēm.
Tika aptaujāti 100 ginekologi un dzemdību speciālisti un 104 nedēļnieces. 85% informētu grūtnieci par DzVT/PE risku, sniegtu šādas rekomendācijas: kompresijas zeķes - 67%, fiziskās aktivitātes - 44%, šķidruma uzņemšana - 25%, flebologa konsultācija – 22%, profilaktiska medikamentoza terapija – 15%. 54% aptaujāto iestādē ir DzVT/PE vadlīnijas. 68% zina, ka Latvijā ir izstrādātas DzVT/PE nacionālās vadlīnijas. 37% nedēļnieču ārstniecības persona bija stāstījusi par paaugstināto vēnu trombozes risku, no kurām 22% stāstīja kā risku samazināt. 46% varēja nosaukt vismaz vienu profilakses pasākumu.
Secinājumi: Latvijā nepietiekoši tiek izvērtēti DzVT/PE riski un ievērota profilakse grūtniecības laikā, iestājoties dzemdību nodaļā un pēc dzemdībām. Veselības aprūpes iestādēs bieži nav DzVT/PE vadlīnijas/algoritmi, kas varētu skaidrot ārstu neziņu par DzVT/PE profilaksi. Grūtnieces pārāk maz tiek informētas par DzVT/PE profilakses pasākumiem, puse anketēto nedēļnieču nevar nosaukt nevienu.

Introduction

Pregnancy and the puerperium are well-established risk factors for deep vein thrombosis (DVT) and pulmonary embolism (PE), which are collectively referred to as venous thromboembolic disease (VTE). The risk of venous thromboembolism increases 4 - 5 times during pregnancy (Pomp ER, 2007). Risk during postpartum period is up to 15 times higher (Heit JA, 2005). Deep vein thrombosis and pulmonary embolism (DVT/PE) are serious pregnancy and postpartum complications, which can be fatal. In year 2014 after UNICEF data in the world, thromboembolism was the cause of maternal morbidity in 3 %. (Say L et al, 2014). Nowadays, correctly assessing risk and under medication or/and non-drug prevention, it is possible to minimize risk of these complications.

Venous thromboembolism (VTE) may occur at any time during gestation. Studies report conflicting data as to the timing in pregnancy. Although most reports suggest that VTE can occur at any trimester in pregnancy, some studies suggest that VTE is more common during the first half of pregnancy. One study of 165 episodes of VTE in pregnancy documented a higher incidence in the first trimester (Gherman RB et al, 1999). Other studies have not confirmed an association between gestational age and frequency of VTE (O'Connor DJ et al, 2011). Note that most evidence suggests that VTE is more common in the postpartum period (Perrier A et al, 2005).

Pregnancy is a state characterized by Virchow's triad (1 - hypercoagulability, 2 - venous stasis and turbulence, 3 - endothelial injury and dysfunction). Pregnancy is a state of hypercoagulability due to alterations of coagulation proteins. Factors I, II, VII, VIII, IX, and X increase in pregnancy. Pregnancy increases resistance to the anti-thrombotic factors such as protein C and protein S. Thrombophilia can exacerbate these changes in coagulation proteins, further increasing the patient's risk for VTE. Venous stasis also increases as dilation of lower extremity veins occurs followed by venous compression by the gravid uterus and enlarging iliac arteries. Situations of decreased mobility (e.g., surgery, cesarean delivery, bed rest, prolonged travel or air travel) may exacerbate these factors. Endothelial injury may transpire at time of delivery. These factors work together to increase risk of VTE in the pregnant and postpartum patient.

The need for thromboprophylaxis should be assessed antepartum, postpartum and at any time the patient transitions from the outpatient to the inpatient setting (Bain E et al, 2014). When it is determined that thromboprophylaxis is warranted, an appropriate strategy should be selected and prescribed. Thromboprophylaxis can be pharmacologic (ie, anticoagulation with LMWH) (Greer IA, 2005) or mechanical (e.g., intermittent pneumatic compression devices or graduated compression stockings) (Norgren L, 1995).

In Latvia specific DVT/PE in pregnancy guidelines are developed that helps to evaluate DVT/PE risk factors. These guidelines help physicians to choose the right prophylactic measures to

apply for each woman during pregnancy, labor and after delivery. Each physician, using the guidelines, should evaluate DVT/PE risk factors and educate the women about appropriate prophylaxis.

Materials and Methods

100 gynecologists and obstetricians were interviewed during several sessions of "The Latvian Association of Gynecologists and Obstetricians". There were no exclusion factors. As a research tool were used specially designed questionnaires. Interviews were held from February year 2015 to March year 2015.

Gynecologists and obstetricians were asked whether they provide the antenatal care, whether they work at hospital labor ward, about their work experience. They were asked whether they inform the women during pregnancy about the increased deep vein thrombosis and pulmonary embolism risk and if they give any recommendations, and if so, what they recommend to lower the risk. There was a question whether there is a guideline at the health care facilities they work at. Specialists were asked if they know that in Latvia there is a national guideline made. Next questions were specifically for obstetricians. They were asked, whether they evaluate deep vein thrombosis and pulmonary embolism risk before the labor and if they evaluate the risk after the delivery. They were asked what thromboprophylaxis they would choose for patients with low thromboembolism risk and for patients with medium thromboembolism risk.

104 puerperal women from several different hospitals in Latvia were interviewed: 50 from Riga Maternity Hospital, 34 from Pauls Stradins Clinical University Hospital and 20 from Vidzeme Hospital. All puerperal women were included and there were no exclusion factors. As a research tool were used specially designed questionnaires. Interviews were held from January year 2015 to February year 2015.

Puerperal women were asked whether the care provided gynecologist, midwife of family physician. They were asked if they used any anticoagulants during pregnancy and after delivery (LMWH – low molecular weight heparins of aspirin). They were asked whether they were told during pregnancy about importance of physical activity and adequate fluid intake. They were asked whether medical personnel urged them to early activate after delivery and whether medical personnel told her to have an adequate fluid intake. They also were asked whether they were recommended to wear the graduated compression stockings during pregnancy, during labor and after delivery and if they did or did not wear them. They were asked if the specialist that provided the maternity care told them about the increased DVT/PE risk during pregnancy, and if they were told what to do to decrease the risk. Puerperal women were asked to name three prophylactic measurements to decrease the DVT/PE risk during pregnancy.

The data were collected and processed in a computer programs MS Word, Excel. Data analyzes were carried out through descriptive statistical methods.

Results

All of the gynecologists and obstetricians do provide the antenatal care and 28 of them work also at hospital labor ward. Work experience: 11 (0 – 9 years), 50 (10 – 29 years), 39 (30 and more years).

85 gynecologists and obstetricians inform women during pregnancy about the increased DVT/PE risk and give recommendations, 15 not. They recommend: 55 – graduated compression stockings, 36 – physical activity, 20 – adequate fluid intake, 16 – prophylaxis with medicaments, 14 – phlebologist consultation, 8 – standard recommendations (n= 85).

Figure 1. *Recommendations specialists give women during pregnancy*
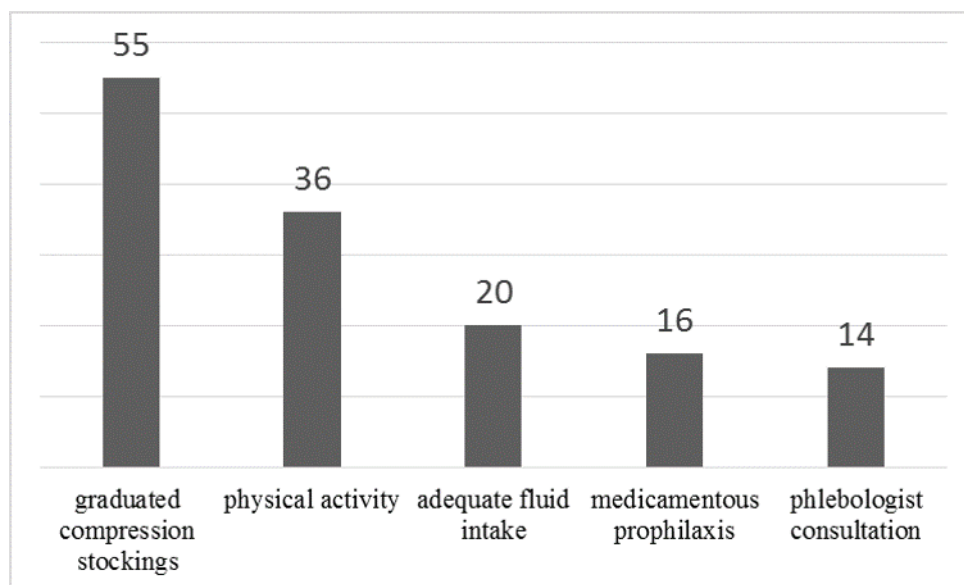
The DVT/PE guidelines, that helps to evaluate risk factors and choose the appropriate prophylaxis, use in their daily praxis 57 specialists, don't use – 43. The knowledge that the national DVT/PE guidelines are developed had – 68, did not know that the guidelines are available – 32.

Intrapartum risk assessment for all women undertake 14 obstetricians, only for high risk patients (e.g. previous single/recurrent VTE, thrombophilia) – 13, does not evaluate risk – 1 (n = 28). Postpartum risk assessment for all women undertake 11 obstetricians, only for high risk patients (e.g. previous singe/recurrent VTE, thrombophilia) – 16, does not evaluate risk – 1 (n = 28).

Intrapartum prophylaxis of choice when the DVT/PE risk ir low: early activation after delivery - 4, adequate fluid intake - 6, graduated compression stockings - 19, aspirin - 5, LMWH - 3

(n = 28), (Fig. 2.) Postpartum prophylaxis of choice when DVT/PE risk is intermediate: graduated compression stockings – 8, LMWH – 15, Aspirin – 7 (n = 28).

Figure 2. *Intrapartum prophylaxis with low risk*
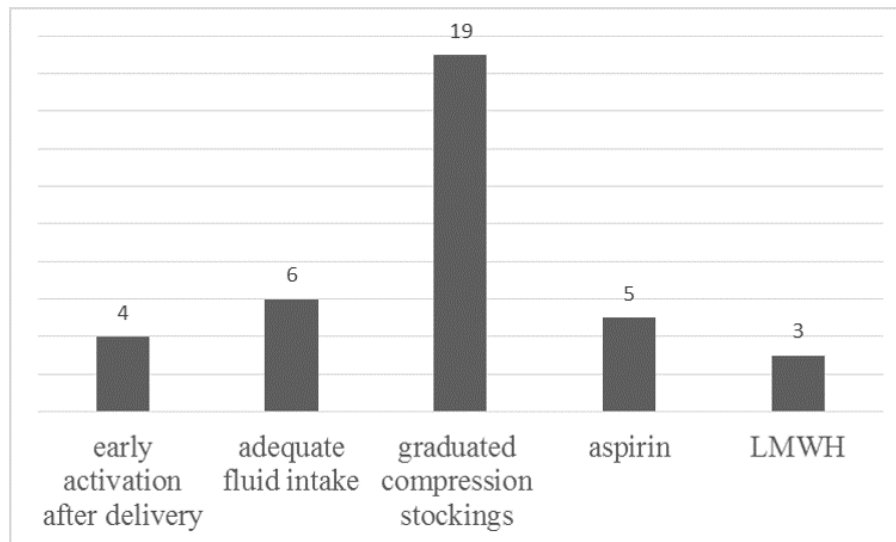
From puerperal women for 93 antenatal care provided gynecologist/obstetrician, for 11 care provided midwife. During pregnancy 101 women did not use aspirin or LMWH, 2 used aspirin and 1 used LMWH. In postparum period 99 women did not use aspirin or LMWH, 1 used aspirin and 4 used LMWH. During maternity care 80 specialists informed women about necessity for adequate fluid intake, 84 specialists about necessity for physical activity. After delivery medical personal informed women about importance of early activation in 46 cases, about importance of adequate fluid intake in 77 cases. Graduated compression stockings (GCS) during pregnancy were recommended for 13 women, from which 9 used them, in 91 cases GCS were not recommended. Intrapartum GCS were recommended for 10 women, from which 6 used them, in 94 cases GCS were not recommended. In postpartum period GCS were recommended for 14 women, were used in 10 cases, were not recommended in 90 cases.

During pregnancy 39 specialists told women about the increased thrombembolism risk, 23 of them told about appropriate thrombembolism prophylaxis, 65 specialists did not spoke with women about DVT/PE.

At least 3 prophylactic measures to decrease DVT/PE risks could name 48 women, could not name any measures – 56. Most frequently as a DVT/PE prophylactic measure, women named GCS – 23, physical activity – 24, leg lifting – 16 and adequate fluid intake – 8 (n = 48) (Fig. 3.)

Figure 3. *Prophylactic measures puerperal women can name*
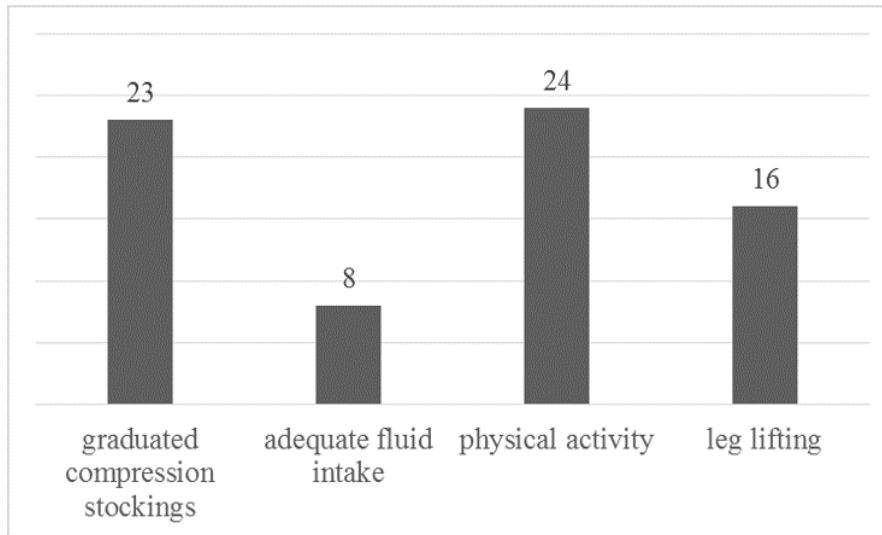
Discussion

It is questionable, whether it is necessary to inform women about DVT/PE risk, it could be unnecessary stress. Royal College of Obstetricians and Gynaecologists recommends, that VTE should be discussed with women at risk and the reasons for individual recommendations explained. (RCOG Green-top Guideline No. 37a, 2015)

Specialists are using aspirin for thromboprophylaxis during pregnancy and in postpartum period, although it is not recommended in guidelines (RCOG Green-top Guideline No. 37a, 2015). There are no controlled trials on the use of aspirin for thromboprophylaxis in pregnancy. Conclusions about its efficacy have been extrapolated from trials in the nonpregnant population. In the NICE guideline reviewing VTE prevention in hospitalised patients, the benefit was modest in comparison to heparin and aspirin was not recommended for postoperative thromboprophylaxis. The Women's Health Study140 found low dose aspirin no better than placebo for long-term primary prevention of VTE in older women. Any benefit of aspirin in VTE prevention appears uncertain and significantly less than that of LMWH, so LMWH should be used instead (NICE clinical guideline 92. London: 2010).

Risk assessment should be repeated again intrapartum or immediately postpartum and all women should be evaluated. (RCOG Green-top Guideline No. 37a, 2015). Risk for all women evaluate less then half gynecologists and obstetricians, therefor special forms, focused to DVT/PE risk assessment and prophylaxis, should be made and introduced in maternity wards in Latvia.

The use of LMWH are not recommended when DVT/PE risk is low, adequate hydration and early activation are recommended instead.

When interviewed, women, who were recommended to wear graduated compression stockings during pregnancy, but did not wear them, in most cases admitted, that it is hard and even impossible to put stockings on due to the size of the stomach, especially in the third trimester.

Often women can not name any DVT/PE decreasing measurement, and usually they say, that they don't have varicous veins, therefor they don't have an interest in DVT/PE risks and prophylaxis. It is a common misconception and women should be educated, that there are many other risk factors.

Conclusions

1. In Latvia there is an insufficient access of DVT/PE risk and compliance control during pregnancy when occurring the maternity and after giving birth.

2. In health care facilities there are often no DVT/PE guidelines / algorithms which could explain the fact that doctors do not know about DVT/PE prophylaxis.

3. Although doctors try to evaluate the DVT/PE risk factors before and after delivery, the used approach is often inaccurate, which could be due to none existent guidelines in the health care facility.

4. Pregnant women are aware of DVT/PE and prophylactic measures far too little.

5. The knowledge of puerperal women is direct proportional of the knowledge of physicians.

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RISK FACTORS FOR PULMONARY EMBOLISM IN PATIENTS OF LATVIAN CARDIOLOGY CENTER

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Abstract
Risk factors for pulmonary embolism in patients of Latvian Cardiology Center
Key Words: *pulmonary embolism, risk factors, frequency.*
Pulmonary embolism (PE) is an acute cardiovascular pathology which can be fatal if not diagnosed in time. There are several risk factors which should be recognized in order to prevent the development of PE or to help arrive at the diagnosis. The aim of the research is to clarify the risk factors and their frequency for PE in patients of Latvian Cardiology Center. The information is collected from medical archive of Pauls Stradins Clinical University Hospital about 190 patients of Latvian Cardiology Center who were treated with the diagnosis of PE from 01.01.2013.–31.10.2014. From 190 patients 66% (126) are women and 33% (64) men. The average age is 74 (66;79) years for women and 64 (52;76) years for men. The main risk factor is deep vein thrombosis (DVT), occurring in 34% (43) of women vs. 50% (32) of men. DVT occurs more frequently on the right side – 49% (17) vs. 59% (17), and in lower leg veins – 50% (8) vs. 75% (12), respectively. Essential hypertension occurs in 61% (77) vs. 39% (25), chronic heart failure – 64% (80) vs. 58% (37). Atrial fibrillation occurs in 28% (35) vs. 33% (21), but old myocardial infarction – 15% (19) vs. 28% (18). Diabetes mellitus appears in 18% (23) vs. 14% (9). Other risk factors occur rarely <10%. High density lipoprotein cholesterol (HDL-C) is decreased for both genders – in women 1.02 (0.87;1.34) vs. in men 0.95 (0.76;1.19) mmol/L with a statistically significant difference (p=0.045) between them. In conclusion, PE non-modifiable risk factors are age ≥ 64 years and female gender (two times more occur in women). Modifiable risk factors are deep vein thrombosis, essential hypertension and chronic heart failure, as well as atrial fibrillation, old myocardial infarction, decreased HDL-C and others.

Kopsavilkums
Plaušu artērijas trombembolijas riska faktori Latvijas Kardioloģijas centra pacientiem
Atslēgvārdi: *plaušu artērijas trombembolija, riska faktori, biežums.*
Plaušu artērijas trombembolija (PATE) ir akūta sirds-asinsvadu patoloģija, kas var būt fatāla, ja netiek savlaicīgi diagnosticēta. Ir vairāki nopietni riska faktori, kurus, savlaicīgi atklājot, var preventīvi novērst PATE attīstību vai palīdzēt tikt līdz diagnozei. Darba mērķis ir noskaidrot riska faktorus un to biežumu PATE pacientiem Latvijas Kardioloģijas centrā. Apkopota Paula Stradiņa Klīniskās universitātes slimnīcas medicīniskajā arhīvā pieejamā informācija par 190 Latvijas Kardioloģijas centra pacientiem, kas ārstējušies ar diagnozi PATE no 01.01.2013.–31.10.2014. No 190 pacientiem 66% (126) ir sievietes un 33% (64) vīrieši. Pacientu vidējais vecums ir 74 (66;79) gadi sievietēm un 64 (52;76) gadi vīriešiem. Galvenais riska faktors ir dziļo vēnu tromboze (DzVT), kas sastopama 34% (43) sieviešu un 50% (32) vīriešu. DzVT biežāk ir labajā pusē – 49% (17) un 59% (17), un apakšstilbu vēnās – 50% (8) un 75% (12), attiecīgi. Primāru arteriālu hipertensiju sastop 61% (77) un 39% (25), hronisku sirds mazspēju – 64% (80) un 58% (37). Ātriju fibrillācija sastopama 28% (35) un 33% (21). Vecs miokarda infarkts ir 15% (19) un 28% (18). Cukura diabēts novērojams 18% (23) un 14% (9). Citi riska faktori sastopami retāk <10%. Augsta blīvuma lipoproteīnu holesterīns ir samazināts abiem dzimumiem – sievietēm 1.02 (0.87;1.34) un vīriešiem 0.95 (0.76;1.19) mmol/L ar statistiski ticamu atšķirību (p=0.045) starp viņiem. Rezumējot PATE neietekmējamie riska faktori ir dzimums (sievietēm 2x biežāk) un vecums (>64g). Modificējamie riska faktori ir dziļo vēnu tromboze, primāra arteriāla hipertensija un hroniska sirds mazspēja, kā arī pastāvīgas formas ātriju fibrillācija, veci miokarda infarkti un citi.

Introduction

Pulmonary embolism (PE) is a cardiovascular pathology which belongs to venous thromboembolism (VTE) and most often results from deep vein thrombosis. Venous thromboembolism is the third most common cardiovascular disease (after heart attack and stroke) with the annual incidence 100-200 per 100'000 inhabitants (Konstantinides et al. 2014: 3037). The exact epidemiology of PE is difficult to determine, since PE can pass asymptomatic and may also

be as an incidental finding during examinations for other reasons (Konstantinides et al. 2014: 3037). Approximately one third of VTE results in pulmonary embolism (Kaberich et al. 2014; Machlus et al. 2011). In most cases PE is the consequences of deep vein thrombosis, so most of the existing data on epidemiology and risk factors are derived from studies that have examined VTE as a whole. PE is one of the main causes of mortality and hospitalization in Europe, so it is important to diagnose it in time and to start the appropriate treatment (Konstantinides et al. 2014: 3037). From all patients with a primary diagnosis of PE this diagnosis is confirmed in 8-39%. In one study from 696 patients with a primary diagnosis of PE it was confirmed in 21% (145) and the most common complaint (59%) was shortness of breath (Ozakin et al. 2014).

Mortality of patients with untreated PE can be as high as 30-35%, but if PE is diagnosed in time and the proper treatment is started, mortality can be reduced to 2-8% (Komissarova et al. 2013). Still PE is the most common cause of death after surgery (Stryjewski et al. 2011). The highest risk of VTE is in the first two weeks after surgery, but remains increased for two to three months (Konstantinides et al. 2014: 3038). Obviously it is important to recognize the risk factors (and know their frequency) in order to get to the proper diagnosis as early as possible.

Since the risk of venous thromboembolism increases with age (> 40 years, the risk doubles with every decade) and the demographic trend shows that population is getting older in general, it means that the number of patients with PE will increase (Kaberich et al. 2014). In other surveys it is stated that PE risk doubles with each decade after the age of 60 years (NHLBI 2011). Several studies show that the average age of the PE patients is 61-79 years and PE occurs with equal frequency in both women and men (Stamm et al. 2014; Stryjewski et al. 2011). According to clinical data, the average age of PE incidence is 60-70 years, but by data from autopsies, the highest incidence is in the age of 70-80 years (Belohlavek et al. 2013). Analyzing data from autopsies, it shows that before death PE was diagnosed in only 30-45% of patients (Belohlavek et al. 2013).

The majority of patients with symptomatic deep vein thrombosis have proximal clots and the complication of PE occurs in 40-50% of patients, often without clinical manifestations (Konstantinides et al. 2014: 3038). In other research similar statement is done: the prevalence of DVT is higher (58.5%) in patients with PE than in patients without PE and PE is more likely to occur in patients with proximal DVT, and more embolic lung segments is detected in patients with proximal DVT (Shao et al. 2012). There are also anatomical variants that lead to venous stasis, for example, left common iliac vein passes under the right common iliac artery during its normal course and this vein more often gets compressed by this artery resulting in VTE (Patel et al. 2014).

Atrial fibrillation may be both the contributing factor and the consequence of pulmonary embolism. Atrial fibrillation causes hypercoagulable state in left and right atrium which can result in stroke or pulmonary embolism, respectively (Kukla et al. 2015). In one research atrial fibrillation

was detected in 24% (231) of patients with PE, but thrombus in right heart in 5% (50) (Kukla et al. 2015).

There are several risk factors (environmental and genetic, patient-related or permanent and setting-related or temporary) which should be recognized in order to prevent the development of PE or to help to get to the diagnosis. Temporary or reversible risk factors are surgery, trauma, immobilization, pregnancy, oral contraception use or hormone replacement therapy within six weeks to three months before diagnosis of PE (Konstantinides et al. 2014: 3037). Still PE may also be present in the absence of any known risk factor. It is important to know the presence of persistent risk factors because of the duration of anticoagulation therapy (Konstantinides et al. 2014: 3037).

Strong provoking factors for VTE are major surgery, trauma, lower limb fractures, joint replacements and spinal cord injury, as well as cancer (Rogers et al. 2012). The risk of VTE varies with different types of cancer, for example, the highest risk have haematological, lung, gastrointestinal, pancreatic and brain cancers (Timp et al. 2013). In fertile women the most often risk factor for VTE is oral contraception (Blanco-Molina et al. 2010). VTE is a major cause of maternal mortality if it occurs in pregnancy.

Infection can be as a trigger for hospitalization for VTE, but blood transfusion and erythropoesis-stimulating agents are associated with an increased risk of VTE (Rogers et al. 2012; Clayton et al. 2011).

Patients with diabetes mellitus have a hypercoagulable state that may increase their risk for thromboembolism. Stress-hyperglycemia is associated with VTE, with a clear linear relation between glucose levels and risk of VTE (Sechterberger et al. 2012). This hyperglycemia can result from physical stress response (inflammatory, hormone action) induced by VTE itself or is present because of previously undiagnosed impaired glucose tolerance (diabetes mellitus). In great cohort research there is a conclusion that patients with diabetes mellitus have significantly higher prevalence of PE independently of coronary artery disease, hypertension, congestive heart failure or smoking (Movahed et al. 2015). The explanation for this is that diabetes mellitus includes coagulation and metabolic abnormalities involving lipids, endothelial dysfunction, fibrinolytic system and platelets.

Also these risk factors which influence cardiovascular system in general are important as predisposing factors for VTE – smoking, hypertension, hypercholesterolaemia, obesity, diabetes mellitus (Piazza et al. 2010; Konstantinides et al. 2014: 3037). Myocardial infarction and heart failure increase the risk of PE, but also conversely – patients with VTE have increased risk of myocardial infarction, heart failure and stroke (Sorensen et al. 2011).

The aim of the research is to clarify the risk factors and their frequency for pulmonary embolism in patients of Latvian Cardiology Center in order to increase the possibility of detecting the right diagnosis in time as well as for the prevention and prophylaxis.

Material and methods

This study is retrospective. The information (risk factors, co-morbidities, blood analysis) is collected from medical archive of Pauls Stradins Clinical University Hospital about 190 patients of Latvian Cardiology Center who were treated with the diagnosis of PE from 01.01.2013.–31.10.2014. Patients are divided into two groups by genders and then compared with each other. The survey includes 126 women and 64 men.

Data were analyzed using *MS Excel* and *IBM SPSS Statistics* programs. Average rates are presented as arithmetic mean (± standard deviation) or as median [I; III quartile] for nonparametric factors, while the incidence – as percentages (n – in absolute quantity).

Results

From 190 patients 66% (126) are women and 34% (64) men. The average age is 74 (66;79) years for women and 64 (52;76) years for men. The main and direct risk factor is deep vein thrombosis (DVT), occurring in 39.5% of PE patients – women 34% (43) and men 50% (32). DVT occurs more frequently on the right side – 49% (17) in women and 59% (17) in men, but on the left side the frequency is 43% (15) and 24% (7), respectively (Figure 1). In 8% (3) of women and 17% (5) of men DVT is found on both sides. More often DVT appears in lower leg (shank) veins – 50% (8) and 75% (12), than in upper leg (thigh) veins – 44% (7) and 6% (1), respectively. In shank and thigh together (in the whole lower limb) DVT occurs in 6% (1) of men and in none of women, but more proximal – in pelvis 6% (1) of women and 13% (2) of men (Figure 1).

Figure 1. *Deep vein thrombosis localization*
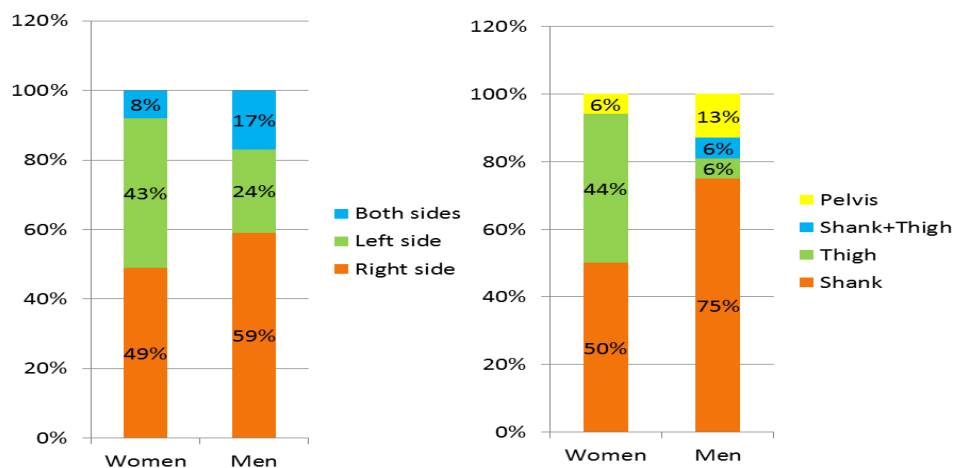
Essential hypertension occurs in 61% (77) of women and 39% (25) of men (Figure 2). More often appears Grade 2 hypertension – 79% (61) in women and 68% (17) in men, but Grade 1 – 13% (10) and 24% (6), respectively, Grade 3 – 8% in both genders (in absolute numbers – 6 women and 2 men) (Figure 2).

Figure 2. *Frequency of essential hypertension*
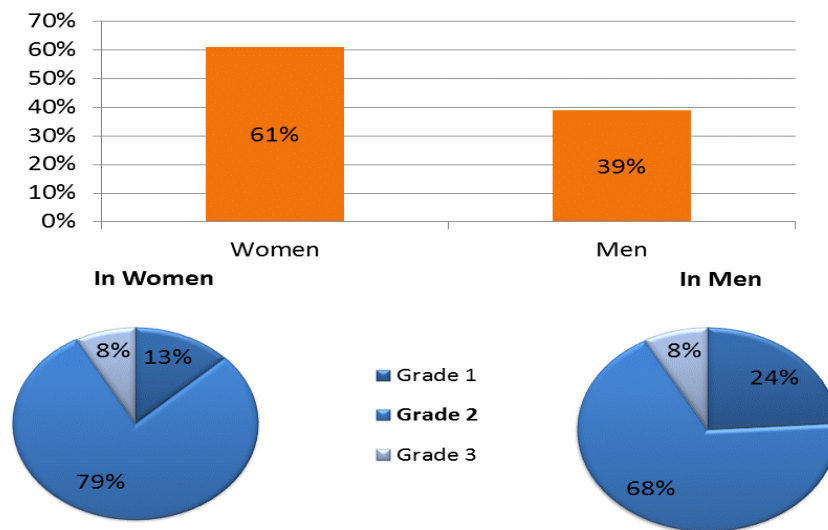
Chronic heart failure occurs in 64% (80) of women and in 58% (37) of men (Figure 3). More often for women it is functional Class II – in 50% (40), but for men – Class III by NYHA in 46% (17). Frequency of functional Class I is 12% (10) in women and 13% (5) in men, Class II in men is 38% (14), Class III in women is 33% (26), but Class IV – 5% (4) and 3% (1), respectively (Figure 3).

Figure 3. *Frequency of chronic heart failure*
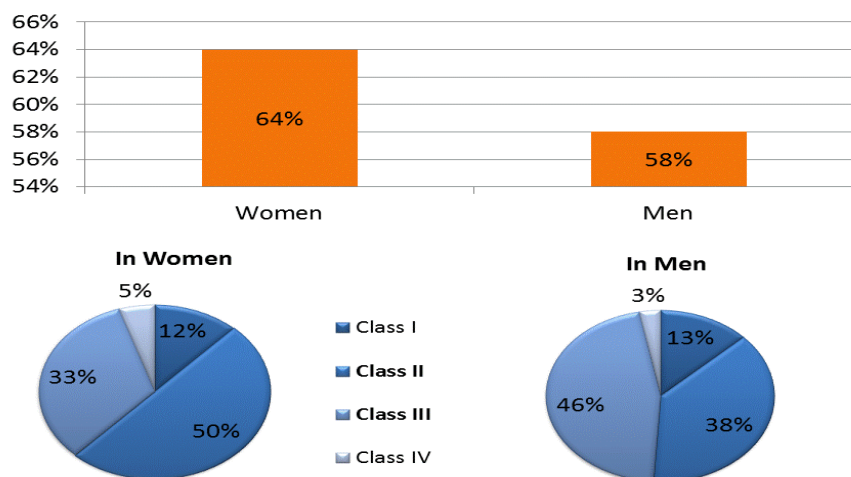
Atrial fibrillation occurs in 28% (35) of women and 33% (21) of men. More frequently it is permanent form – 74% (26) and 95% (20), but paroxysmal form – 26% (9) and 5% (1), respectively. Old myocardial infarction appears in 15% (19) of women and 28% (18) of men. Myocardial infarction without previous percutaneous coronary intervention (PCI) occurs in 58% (11) and 28% (5), but with PCI and implanted stents – 42% (8) and 72% (13), respectively. Type 2 diabetes mellitus appears in 18% (23) and 14% (9).

Other risk factors – lower limb fractures (hip, femur, tibia), orthopedic and other surgeries, obesity, varicose vein, superficial vein thrombosis, oral contraceptives, hormone replacement therapy, tumor, stroke with paralysis – occur rarely ≤10% (Figure 4).

Figure 4. *Frequency of other risk factors*
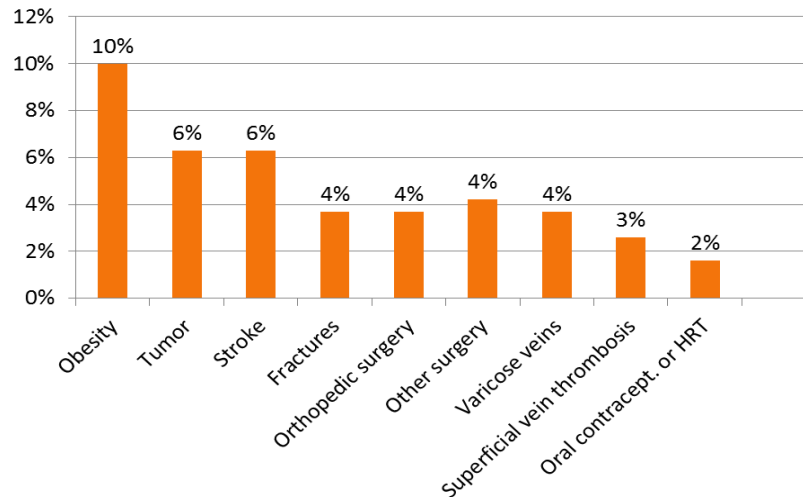
In all patients were determined blood biochemical parameters, more precisely, lipids - total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and triglycerides (TG). For both genders total cholesterol in average is normal (if the reference interval is TC <5 mmol/L) – 4.4 (±1.1) in women and 4.1 (±1.1) mmol/L in men (Figure 5). But for patients with high cardiovascular risk this reference interval should be reduced to TC <3 mmol/L. In this case for both genders total cholesterol levels are elevated. If the normal reference interval is accepted as LDL-C <3 mmol/L, then for both genders LDL-C is normal in average – in women 2.7 (±0.9) and in men 2.6 (±0.9) mmol/L (Figure 5). But if the reference interval is reduced to LDL-C <2.5 or <1.8 mmol/L (in patients with high cardiovascular risk) then these averages are above the norm. HDL-C is decreased for both genders – in women 1.02 (0.87;1.34) and in men 0.95 (0.76;1.19) mmol/L with a statistically significant difference (p=0.045) between them (normal reference interval is HDL-C ≥1.2 mmol/L) (Figure 5). Triglycerides for both genders are in normal levels – in women 1.2 (1.0;1.6) and in men 1.0 (0.8;1.5) mmol/L (normal reference interval is TG <1.7 mmol/L).

Figure 5. *Blood biochemical parameters – total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C)*
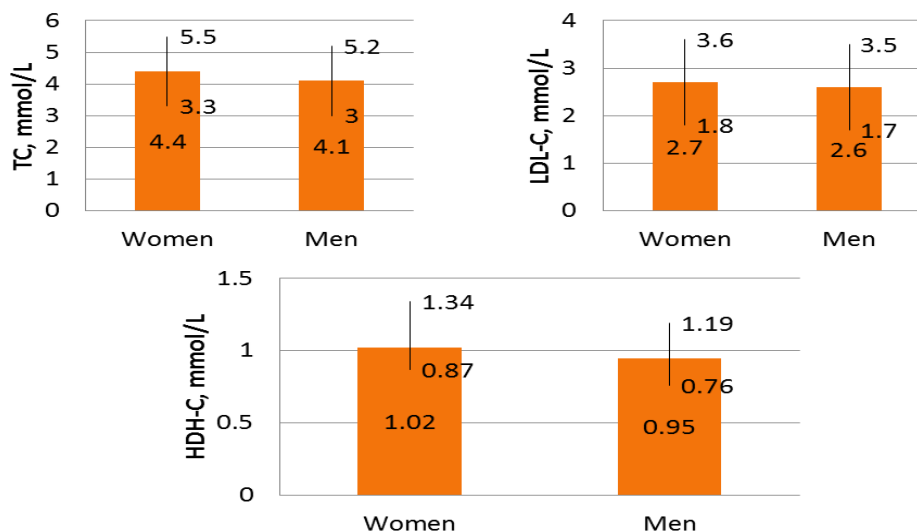
Discussion

As it is retrospective research there are some restrictions. For example, in case histories it is not obligatory for doctors to write down whether the patient smokes or drinks alcohol regularly, so it is impossible to get the information about these risk factors.

In this study the average age of patients with pulmonary embolism (PE) is 74 years for women and 64 years for men, and PE is more common in women than men (2: 1). The average age is stated similar in other studies (61-79 years), but there is a difference in PE frequency between genders – in several studies it is described that PE occurs with equal frequency in both women and men (Stamm et al. 2014; Stryjewski et al. 2011). This could be explained by the fact that in Latvia women are in a higher proportion (1.7 times more) in this age group, when PE is more frequent (data from the year of 2013 – in the age group 60-79 years women are 256'964, but men - 152'013) (LR CSP: 77).

Although it is stated that left common iliac vein passes under the right common iliac artery during its normal course leading to VTE more often on the left side limb (Patel et al. 2014), in this research deep vein thrombosis most frequently occurs on the right side limb. It shows that this anatomical variant is not so determinative and this compression by artery is not so significant.

In this study atrial fibrillation is in 30% of patients while in other research it was detected in 24% of patients with PE (Kukla et al. 2015). It means that in average atrial fibrillation occurs in every fourth patient with PE.

The results show that there is no significant difference between treatment technique used in old myocardial infarction – with or without previous percutaneous coronary intervention (PCI) and implanted stents. In both cases old myocardial infarction can be as a risk factor for PE.

The normal reference interval for total cholesterol (TC) and low-density lipoprotein cholestorol (LDL-C) is dependent from the patient's cardiovascular risk – the higher is risk the lower is reference interval. This cardiovascular risk includes SCORE risk charts, previous cardiovascular disease, myocardial infarction, acute coronary syndrome, stroke, hypertension, diabetes mellitus with target organ damage, severe chronic kidney disease, dyslipidemia, smoking, obesity, unfavorable heredity (Ērglis u.c. 2007). Essential hypertension occurs in 61% of women and 39% of men, old myocardial infarction – 15% and 28%, diabetes mellitus 18% and 14%, respectively. There are also other risk factors and that means that for these patients with PE in this research should use reduced reference intervals for lipids. With such statement in this study patients with PE in average have increased TC and LDL-C and decreased HDL-C (high-density lipoprotein cholesterol) which results in dyslipidemia (also one of the factors for increased cardiovascular risk).

Conclusions

- Non-modifiable risk factors in pulmonary embolism are age ≥ 64 years and female gender (two times more occur in women).

- Modifiable risk factors are deep vein thrombosis (most frequently in the right lower leg), essential hypertension (more often Grade 2), chronic heart failure (more often functional Class II in women and Class III in men by NYHA), atrial fibrillation (more frequently permanent form), old myocardial infarction and diabetes mellitus, type 2.

- In less than 10% of patients occur other risk factors: obesity, lower limb fractures (hip, femur, tibia), orthopedic or other surgeries, varicose veins, superficial vein thrombosis, tumor, stroke, oral contraceptives or hormone replacement therapy.

- From all these risk factors mentioned above in men more frequently appear deep vein thrombosis, atrial fibrillation and old myocardial infarction, but in women – essential hypertension and chronic heart failure.

- In this study patients with PE in average have increased total cholesterol and low-density lipoprotein cholesterol and decreased high-density lipoprotein cholesterol which results in dyslipidemia.

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