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## NUTRITIONAL INTERVENTION IN FRAILTY SYNDROME IN ELDERLY

#### **Martyna Andreew**

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#### Abstract:

From one year to another numer of older people all over the world has been growing. Senility is characterised by polypragmasy, range of disorders is wide and one of them is frailty syndrome. This syndrome refers to many areas of human life. There are multiple causes leading to frailty, but significant resultant, which drives it up, is poor nutritional status. The aim of this article is to present ways of nutritional intervention which may prevent an occurrence of frailty syndrome among older adults or mitigate conditions related to it.

#### **Keywords:**

frailty syndrome, nutritional support, elderly

## Introduction

As World Health Organization estimates, the fraction of the world's population over 60 years will grow from 12% to 22%, what will take place until 2050. Moreover, next year (2020) people aged 60 years and older will outnumber children below 5 years. It needs to be highlighted that the pace of population ageing is much faster than in the past.

Older age can be described as a time of occurrence of many complex health conditions, such as: 'frailty, urinary incontinence, falls, delirium and pressure ulcers'. They are not discrete disease categories. They are called as geriatric syndromes and causes underlying them are plenty. Such health syndromes predict in a higher extent death than the presence or number of diseases [1, 2].

Balanced diet, regular physical activity and refraining from tobacco, also in older ages, can minimalize the risk of non-communicable diseases and, what is more, to improve physical and mental capacity. Maintaining muscle mass and good nitritional status can help in reverting frailty and also in retaining good cognitive function or keeping independence for long time [1].

There is a cycle for development of frailty, presenting its components. It can be listed that there is some nutritional assistance for counteracting of frailty, which includes, among others, Mediterranean diet, specific macronutrients (protein), vitamins (vitamin D) or fatty acids (omega-3) [3].

The aim of this article is to present ways of nutritional intervention which may prevent an occurrence of frailty syndrome among older adults or mitigate conditions related to it.



## **Frailty syndrome**

Functioning domains of frail older people, afflicted by this syndrome, embrace: 'gait, mobility, balance, muscle strength, motor processing, cognition, endurance, physical activity and nutrition'. Due to highly cost-intensive health care of frail elderly, in front of health care system is quite a challenge. That is so important to prevent an occurrence of such geriatric syndrome, in the way of decreasing a numer of people who are afflicted or attenuating its results [4].

According to Veninšek et al., frequency of frailty is 9.9% and 13.6% and of pre-frailty 44.2% and 34.5%. Age and female sex increase the risk of frailty's occurence, respectively appears in 39.1% of men aged 85 years or older and in 45.1% of women [5]. Fig. 1. shows main components of frailty syndrome [3, 6].



Fig. 1. Cycle of frailty syndrome Source: adaptated from Morante et al. [3]

There is the frailty phenotype, which is distinguished by few specific features (in case of recognition of frailty syndrome patient should has three or more physical criteria: 'weight loss, exhaustion, physical activity, walking time, and grip strength').

Three categories describe patients in the context of frailty syndrome. This division is presented on the Fig. 2.





Fig. 2. Categories of patients in the context of frailty syndrome Source: adaptated from Lorenzo-López at al. [2]

There are many risk factors of frailty syndrome, but the main are low physical activity and primarily poorer nutritional status. An inappropriate nutrition may lead to multiple negative causes, such as:

- an accelerated risk of chronic diseases;
- an oxidative stress;
- weakened immune system;
- higher risk of osteoporotic fractures;
- peripheral arterial disease;
- a frailty.

Proper, balanced and nutrition with good nutritional value is key not only for the prevention and treatment of diseases, but also for ensuring healthy aging and therefore for an independence of elderly and better quality of their lifes, making them independent from caregivers [2].

## Dietary support in order to prevent or mitigate frailty

The major issue in preventing the development of frailty syndrome is nutritional status. There are few theories about factors leading to development of the frailty, but the most likely are inappropriate intake of calorie, protein, vitamin D and calcium.

Taking into account Mediterranean diet, it can be considered as a protective factor against frailty. Although there are not clinical researches, which would assess the adequacy of this diet, there is interesting relationship between olive oil, inflammation, and frailty. It is suggested that TNF-alpha and II-6, produced by olive oil, may diminish the risk of frailty.

Another nutrient is protein, one of the key in the dietary treatment in such syndrome. Maintenance the muscle mass remains probably as the most important factor in fight against frailty. There are two ways to gain this goal – building new muscle mass or prevention from a loss of muscle mass, what is the most significant for frail elderly population.



Some of researchers, like Kim and Lee, suggested that protein–energy supplementation based on liquid formula, which delivers 400kcal of energy,25g of protein, 9.4g of essential amino acids, and 400 mL of water, applied for 12 weeks, can drive down the risk of frailty syndrome.

Different report pay attention to supplementation which improves physical activity performance - whey protein and L-creatine co-supplementation or whey protein supplementation. This was a 3-month investigation.

Niccoli et al. were conducted clinical trial on hospitalised elderly populations. There were two group – control (with any supplements) and group which was supplementing whey protein. The last group had higher grip strength and knee extensor force. Due to that, procedure like that can be consider in meliorating protein nutritional status and effects of rehabilitation.

Satisfactory result was gained by Dirks et al. In this trial also there were two groups, in first resistance-type exercise training was associated with milk protein (15g *bis in die*) and in second with placebo. In group which was supplementing milk protein there was noticeable improvement in muscle cross-sectional area [3, 7].

It is key to join appropriate intake of dairy products/supplementation of calcium with vitamin D supplementation. That was done in Latham et al. 10-week study. Another group of researchers, Boxer et al., also were using connection of calcium and vitamin D in dose of 50,000 IU per week. Unfortunately, as in previous study, this research did not ameliorate physical performance.

The last, but not least, there was conducting multicentre randomised work, in the course of which one of the examinated group was getting supplementation based on vitamin D and leucinerich protein, where the other group was using an isocaloric supplementation. This kind of proceeding may help frailty elderly, who can not exercise [3, 8].

On the other hand, omega-3 fatty acids intake might result in minor risk of frailty. In a 2-year large cohort study of León-Muñoz et al., it has benn proved.

After Hutchins-Wiese et al., daily 2.4g dose of eicosapentaenoic acid and docosahexaenoic acid with association of antioxidants (selenium and vitamin C) can improve physical performance.

Partial participation in betterment of mobility in frail females had also omega-3 supplementation (docosahexaenoic acid, eicosapentaenoic acid) together with phosphatidylserine, d- $\alpha$  tocopherol, folic acid, and vitamin B<sub>12</sub>, but it is not clear to what extent [3, 9].

#### Summary

Nutritional assessment plays considerable role in prevent frailty syndrome, including loss of mass and function of muscle. This geriatric syndrome demands highly cost-intensive treatment and has multiple side effects, what, taking into account, makes disability among elderly and leads to dependence from caregivers. Further ivestigations are needed, especially in the field of stopping muscle mass decline, not only build new muscle mass in elderly.

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# **NoSAS QUESTIONNAIRE – INNOVATIVE DIAGNOSTIC TOOL IN SCREENING TEST OF SLEEP DISORDER?**

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#### Abstract:

Nowadays, overweight and obesity are ones of the most frequent chronic, non-comunicable diseases, which carry the threat of descrease in respiratory efficiency, causing respiratory diseases and sleep deprivation so on. The most frequent sleep disorder, coexisting with excessive body weight, is obstructive sleep apnoea According to World Health Organization, obstructive sleep apnoea syndrome is mainly characterised by frequent breakes in breathing, which occur while person is sleeping and loud snoring is typical. It causes burdensome and also dangerous clinical implications, which may even result in threat to life and health, such as: daytime sleepiness, difficulty in concentrating or headaches. There are some screening tests entrusted with the task of early detection of these disturbances. The newest and probably the simplest and showing up high sensitiveness, is NoSAS questionnaire. The aim of this article is to discuss NoSAS questionnaire in the context of early detecting of sleep deprivation.

#### **Keywords:**

NoSAS, obstructive sleep apnea, screening

#### Introduction

Obesity and overweight tipled since 1975, what is more, in 2016 over than 1.9 billion adults (39% of world population – of which there are 39% of men and 40% of women) had overweight and over 650 million of these (13% of world population – of which there are 11% of men and 15% of women) had obesity [1]. These are key risk factor of obstructive sleep apnea [2].

With reference to ICD-11 for Mortality and Morbidity Statistics, obstructive sleep apnea can be classified to sleep-wake disorders and then to sleep-related breathing disorders. It is descibred as '[...] repetitive episodes of complete (apnoea) or partial (hypopnoea) upper airway obstruction occurring during sleep. These events often result in reductions in blood oxygen saturation and are usually terminated by brief arousals from sleep.' [3].

For diagnosis of sleep-related breathing disorders it is necessary to do polygraphy or polysomnography, or screening tests. Availability of such overnight recordings is low and costs of them are high. Due to that, more efficient solution may be screening tools, such as NoSAS [4].



The aim of this article is to discuss NoSAS questionnaire in the context of early detecting of sleep deprivation.

## Sleep apnea

There are three kinds of sleep apnea: obstructive sleep apnea, central sleep apnea and complex/mixed sleep apnea. The most common is obstructive sleep apnea. It can be classfied as sleep-related breathing disorders, in which breathing is interrupted. A breathing pause, called 'apnea' may last at least ten seconds. In this type of sleep apnea breath is impossible, despite efforts. The muscles in the back of the throat preclude an air flow by airways.

Obstructive sleep apnea is very dangerous – pauses sleep and causes low oxygen concentration in the blood - causing serious clinical implications, among others, there are:

- hypertension;
- heart disease;
- mood problems;
- memory problems;
- excessive sleepiness;
- headaches;
- impaired concentration.

Central sleep apnea is characterized by an impaired work of the respiratory center, due to what it is impossible to control breathing.

There are no data about epidemiology of sleep apnea for Poland, but there are some informations about it for american population. Obstructive sleep apnea touches people of all ages and sexes. It is estimated that over 18 million adults in United States of America have sleep apnea.

There are many reasons of sleep apnea. The most important are listed below in Tab. 1.

Tab.	1.	Risk	factors	for	sleep	apnea
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Source: adapted from National Sleep Foundation [2]

Some symptoms may indicate occurrence of sleep apnea. Among which can be mentioned are:

• chronic snoring;



- sleeplessness;
- difficulty concentrating;
- depression;
- irritability;
- sexual dysfunction;
- learning and memory difficulties;
- excessive sleepiness during the day falling asleep while at work, on the phone, or driving;
- disturbed sleep;
- high blood pressure;
- heart attack;
- congestive heart failure;
- cardiac arrhythmia;
- stroke.

To diagnose sleep apnea are used screening tests in early diagnostic process and then polygraphy or polysomnography, called 'sleep study'. During such study, patient is staying at a sleep center and is confirmed sleep apnea and its severity. Different components are estimated, for example:

- sleep state;
- eye movement;
- muscle activity;
- heart rate;
- respiratory effort;
- airflow;
- blood oxygen levels.

Methods of treatment of sleep apnea are few. First of all, the most common is CPAP's mask. This method provides keeping airways open at night, thanks to blowing the air into them (mask is fitting on the nose and/or mouth). There are also invasive methods, for example surgical procedures on the lower jaw and tongue or on hypoglossal nerve, which is connected with implantation of sensor.

Prevention of sleep apnea is very important. Some changes in a lifestyle is necessary – they are showed on Fig. 1. [1, 2].







## Structure of the NoSAS questionnaire

The NoSAS score has ranges from 0 to 17. It contains 5 questions about:

- a neck circumference of more than 40 cm (4 points);
- a body mass index (BMI) of 25 kg/m2 to less than 30 kg/m<sup>2</sup> (3 points) or a body mass index of 30 kg/m<sup>2</sup> or more (5 points);
- snoring (2 points);
- being older than 55 years of age (4 points);
- being male (2 points).

When patient gains 8 points, sleep-related breathing is suspected [5].

## NoSAS - where was it used for the first time and who did use it?

NoSAS questionnaire is relatively new diagnostic tool and there is very little scientific reports about it. Other scales which are used in screening obstructive sleep apnea, are: the Epworth Sleepiness Scale, the Berlin questionnaire and the STOP-Bang questionnaire. These scales concentrate on assess patient's daytime sleepiness [5].

This tool was used used for the first time by Marti-Soler et al. between Sept 1, 2009 and June 30, 2013. Examinated came from the population-based HypnoLaus cohort in Lausanne, Switzerland. Participants was clinically evaluated and had polysomnography at home. In that cohort study 2121 people likely to have sleep-related breathing disorders, including obstructive sleep apnea. It was validated in EPISONO study.

In this research, the NoSAS was compared with screening scores, such as: the STOP-Bang and Berlin scores. Risk of clinically significant sleep-disordered breathing was identified when participant gained 8 points or more and with an area under the curve (AUC) of 0.74 (95% CI 0.72-0.76). The NoSAS demonstrated an even higher performance in the EPISONO cohort, with an AUC of 0.81 (0.77-0.85). This new diagnostic tool showed meaningful better than the STOP-Bang (AUC 0.67 [95% CI 0.65-0.69]; p<0.0001) and the Berlin (0.63 [0.61-0.66]; p<0.0001) [4].



## Researches in the course of which NoSAS questionnaire was used

NoSAS questionnaire, apart from pioneer research which was conducted from 2009 to 2013, has been used in an independent cohort EPISONO, in population-based cohort CoLaus (Lausanne, Switzerland), in the First Affiliated Hospital of Guangzhou Medical University in China, in the Qing SM et al. study (comparing five existing questionnaires: the NoSAS score, ESS, STOP, SBQ and Berlin questionnaire), in Tan A et al. study (comparing the NoSAS and the Berlin questionnaire), in study of patients with resistant hypertension of Giampá SQC et al. and also in study in which NoSAS was associated with arterial stiff ness in a large cohort of healthy individuals (Arrigo F G Cicero, Martina Rosticci, Martino F Pengo, Nicolas Hart, Claudio Borghi) so far [4, 6, 7, 8, 9, 10].

## Summary

An obstructive sleep apnea is more and more often sleep-related breathing disorders, which causes severe clinical implications. Screening tests can help in early diagnosis. The NoSAS is a more useful in a clinical settings than other questionnaires. It is simple, efficient and relatively easy tool for detecting sleep deprivation and connected with them breathing-related problems. It may be use for screening of moderate to even severe form of sleep-related breathing disorders. This tool can speed up early diagnosis and help to point out people for further polygraphy or polysomnography.

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# E-PUBLICATIONS AND OPEN ACCESS NEW TRENDS IN SCIENCE?

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#### Abstract:

The article presents the problem of changing the approach of publishing papers by scholars. This is about the transition from the traditional approach of printing paper texts in the form of volumes (monographs, magazines) to publishing works in electronic form available on the Internet for wider audience. The popularity of electronic publications, the distinction between the use of licenses protecting publishing and published rights, and the distinction between access (open vs. restricted) is considered in the paper.

#### **Keywords:**

E-publication, Open Access, software licences, science

## Introduction

Among the daily duties of academic staff, writing activity is of particular importance. From the historical perspective, the scholars in their lifetime prepared a number of articles, scientific monographs, books edited, which were subsequently submitted, printed and placed in libraries and academic bookstores. Then the scholars, so that they could use their content, had to go to a specific city and university or buy their own copy. It has been so far. Currently, next to printed works, still available in the classic model, electronic items are available "on the spot" regardless of the time of day and place of ordering. Drastic reduction of waiting time for a paper promotes the development of science and its internationalization.

It seems, therefore, that we are currently witnessing an interesting paradigmatic change in the area of publishing scientific works.

#### **Popularity statistics**

Readership statistics vary from country to country. According to the Statista.com portal, on average, residents of European countries spend between 2 and 13 minutes daily reading [1]. The least read by the French (2 mins), followed by Romanians, Italians, Austrians (5 mins each), English, Dutch, Spanish, Belgians (6 mins each), Luxembourg and Germany (7 mins each), Greeks (9 mins), Hungarians (10 mins), Poles and Finns (12 mins each), and the most Estonians (even 13 mins) [2]. Other research results for 2015 show that from the perspective of the week the most, as



much as 10:42 hours on reading spend Indians, further 9:24 hours Thai, 8 hours Chinese, 7:30 hours Egyptians, 6:30 hours Poles, 5:42 hours Americans, 5:30 hours Mexicans, 5 hours Taiwanese [3]. In turn, the Polish report "The state of reading in Poland in 2017" conducted by the National Library shows that in Poland the number of people reading books is systematically dropping. When it comes to statistics of Poles who have read a minimum of one book during the year, this number decreases from 54% (2000) to 38 (2017). In turn, the number of people reading 7 books per year also drops from 24% (2000) to 9% (2017). In 2017, as many as 62.2% of Poles did not read any books [4].

Nevertheless, the sales of books in the world are rising year by year. In 2018 in comparison to 2017 classic printed books publishers revenue increased: hardback +11,8% (from \$688,5 to \$769,6 million) and paperback & mass market +1,4% (from \$759,1 to \$789,8). On the contrary, in the case of e-books, the trend was negative and the loss was -3,8% (from \$373 to \$358,7) [5]. E-book revenue continues to decline down -4,9% in January 2019 when comparing the same period in 2018 [6]. The statistics shows that traditional books have been systematically increasing their sales for several years and are rather digging in and strengthening their position rather than expansively gaining new markets and new numbers of supporters. Users themselves pay attention to the weak points of e-books. Readers pay attention to the smell of a printed book, ability to be easily scribbled in and marked up, easily sharing or be given or even extended durability [7]. Despite of bad condition and quite negative PR currently the e-book market share is about rather closer to 20% [8] but Statista.com counting of e-publishing revenue from 2013 to 2017 looks promising [9].

However, in the area of scientific writing, it is clearly visible that electronic publications are systematically and gradually becoming more common in the academic context. The most vivid example are scientific journals, which until recently were issued only in the form of printed volumes, and are now largely also made available on the websites of a given scientific journal. In polish context we can list at least "Studies in the History of Philosophy" [10] or "Ethics" [11]. The same applies to scientific publishers at universities, like University of Lodz, which offers both printed and electronic books [12].

Of course, there are more such cases and one could risk the statement that almost all bookstores allow the user to choose the form in which the same content was packaged. Perhaps the motivation from the business point of view is the desire to reach the widest possible audience and sell a maximum number of copies. From the scientific point of view, an essential goal coincident with the above mentioned will be the willingness to share the results of scientific research and interaction of scholars with other scholars from the country and the world. It is still necessary to decide in what form these papers should be shared.

#### Possible licenses and access methods

Controlling access to content limits opening and modifying content of electronic data. The fact is that in the computer space [13] it seems to be naturally implemented, but also printed books are subject to license protection on the basis of which they are distributed.

The Creative Commons Licenses Matrix - shows the structure of the access dependency in a transparent manner [14].



Creative Commons			COPY & PUBLISH	ATTRIBUTION	COMMERCIAL	MODEY & ADAPT	CHANGE
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Fig. 1. Creative Commons Licenses explained

CC licenses operate in a way - all exceptions are explicitly included, and if they are not present, then the use is permitted. The "copyright" license is a closed license that allows the use of the work with the consent of the author based on the "permissions agreement". Partners agree to give permission to use someone else's work (literary work, academic work, film, etc.), usually for a fee. The contract is written one time and each time adapted to the specific conditions of use [15]. Recognizing an item as belonging to the public domain allows unrestricted access, copying, modification and even changing the license. What differs from CC BY is the question of author recognition. The CC BY-SA license enables free access to work, both commercial and non-commercial, including changes, provided that the author is acknowledged and indicated. However, it is not possible to change the distribution license. The license CC BA-ND lets others reuse the work for any purpose but it cannot be shared with others in adapted form, and credit must be provided. The CC BY-NC license excludes commercial use, as does the CC BY-NC-SA license, which still forces use under the same conditions as the source. The last CC BY-NC-ND license is the most restrictive because it does not allow for modification and commercial use [16].

A scientific answer to the need to release the results of research was the Open Access philosophy. Open Access Movement has been developing since the 1990s as a scientific movement



and has worked to build a new open model of scientific communication. The main communication channels through which knowledge is distributed in this model are open journals and repositories. There are also science blogs, e-laboratories that become new forms of communication [17]. The graph below presents the basic advantages of Open Access [18].



Fig. 2. Benefits of Open Access

However, it is worth checking how the Open Access position looks in numbers. In WorldCat [19], there is even a separate filter rule to search for Open Access publications. The results are shown broken down into printed texts and electronic publications. The results of an example query for texts where the keyword regarding the subject "university" presents the screen below.





Fig. 3. WorldCat search results

Interestingly, among all the found texts (6616) up to 6424 were articles, of which 1201 are electronic texts available for download. Among the book publications (184), 164 were e-books [20].

## Self-publishing as an option for thrifty

Although the share of the papers published by the author's own effort is rather a margin of mass production of books, it can be an interesting alternative for at least two reasons. The first is a significant acceleration of the publication process due to the inclusion of private financing sources. It also means full control for the author over the publishing process at every stage of cooperation with the publishing house. The second reason is the cost reduction, because self-publishing is simply cheaper. From the perseverance of the author depends on whether he is able to make a book himself, make a preliminary correction, find a cheap printing house. However, what is certainly an important cost on the part of an independent publisher is the issue of promoting your own book, reaching potential reader [21]. There is also the risk of recognizing a self-published book as too weak, for any of publishing houses to publish. Of course, this is not always true, nevertheless the author can sometimes meet such opinions [22].



## The advantage of e-publications over a traditional books

In the scientific context, the biggest advantage of electronic publications is a significant increase in the scope of impact and its immediate nature. This publication is available immediately after placing it in the network and for all readers. Of course, depending on the conditions of the selected license, access to the text may be open or more limited. E-publications shorten the distance between the author and the reader to an absolute minimum, as well as between the author and the publisher. The fact is that other researchers, no matter where they connect, may have access to shared research results. The condition is only having Internet access and basic skills in its use. This is undoubtedly the biggest advantage that is conducive to building interdisciplinary research teams composed of specialists working at various universities. It may also be conducive to raise the scientific level of research and analyses.

Secondly, the advantage of electronic publications is increased mobility and what can be described as "packaging availability". Depending on the storage capacity of a given device, it can be stored from several to several thousand or more publications (books, articles). The volumes can be even more if the device (reader, tablet) will use resources in the cloud or available directly from the server [23]. The researcher can always have the necessary materials on hand, which weigh as much as the carrier itself. Using this comparison to traditional books, it is difficult to imagine the situation of carrying a dozen or so books in a briefcase or backpack. However, what often interferes with researchers is the limited ability to take notes and cross out fragments, which they easily do in a printed book. Partially solved the problem is proposed by cloud service providers and computer software - a good example is the combined DropBox service and Adobe Reader, where in the cloud the notes and deletions are stored in an electronic book [24].



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Dropbox (Personal) Add an Account	V Kor	Adobe Cloud Services PDF	Today, 4:25 PM	307 KB	Adobe Cloud Services
SHARED	POF	Adobe Sign White Paper PDF	Today, 4:25 PM	417 KB	PDF • Modified Today, 4:25 PM
For Viewing For Review	J FOR	ADW1501 PDF	Today. 4:25 PM 56 KB	🖹 Send For Review	
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Fig. 4. DropBox and Adobe Reader synchronisation

It is also worth paying attention to hardware solutions such as improved tablets and a smartphone with drawings and dedicated software for taking notes in documents. Modern tablets, such as the Samsung Galaxy Tab 3 or the Galaxy Note series (see fig below) have special software that allows you to program additional functions in the stylus (i.e. a shortcut for quick notes) and write the document by hand like a traditional book. By combining this technology with the aforementioned synchronization, we gain a safe and worthy way to store your notes in an electronic form that is in no way inferior to traditional methods [25].





Fig. 5. Galaxy Note pen dedicated application

In a sense, the associated advantage is the ability to index electronic content, and thus easy search for specific phrases and words across the entire publication. This is what distinguishes electronic publications on the background of printed ones, in which to search a given phrase, you have to fan the entire book. This makes it easier to navigate the text and transfer the user from one to the next of the phrases found. This can be a particularly valuable feature for scholars in technical sciences, where, for example, programming textbooks are often over 1500+ pages long. An additional element can also be an interactive table of contents, which instantly transfers the reader to the desired place and all other improvements that are difficult to imagine today, which over time will be developed and implemented by programmers.

An additional advantage of electronic publications is also their price, which is usually lower than traditional books. However, this is not always the case.

#### Summary. Is this a change for a long time?

The history of books dates back to the Middle Ages, when copyists in convents handwritten books and embellished them with ornaments. At that time, few could afford to buy books, and it was not until the Gutenberg invention that printed books became more accessible to the ordinary bread-eaters. So the history of a printed book has a much longer history than electronic editions, but now you can wonder whether it will stand the test of time. Never before in history has there been



any similar threat to paper books. The fact is that other media and other forms of entertainment compete with the book for many years, but this dispute concerns a completely different field. It is difficult to say today about fate of traditional books, especially in the face of a systematic decline in the level of readership and the list of restrictions on traditional books and the advantages of e-books. The fact is, however, whether traditional books still have and probably will continue to have their supporters attached to the specific smell of printing ink or rustling pages. They will never change to new electronic releases. The question, however, is that over time they will not find themselves in a niche or even in the margins of reading. Analysing the transformations of modern society, one can come to the conclusion that service provider must adopt towards the client or end user perspective. In a globalized world, it is important that access to information is as fast and easy as possible, and the distance between the service provider and the customer as short as possible. Such optics also begin to be found within the walls of the university conducting research. Hence, one can presume the future success of electronic publishing and paradigmatic change, which may already be taking place before our very eyes.

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# DYNAMICS OF CHANGES IN PHYSICAL FITNESS OF I-LEAGUE HANDBALL PLAYERS SPR OLKUSZ IN THE ANNUAL TRAINING CYCLE

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#### Abstract:

The aim of the study was to assess the level of targeted physical fitness of handball players of the first-league SPR Olkusz team in particular periods of the training cycle in the 2011/2012 season. The material structure of the training sessions of the studied team in the preparatory and starting periods was also analyzed. Physical fitness tests (Noszczak test and Cooper test) were conducted in three periods of the training cycle: at the beginning of the preparatory period, at the end of the preparatory period and at the end of the start period. The following parameters of the tested handball players were analyzed: age, playing position, body weight and height, as well as motor skills (speed, oxygen and speed endurance, explosive force and dynamic force), evaluated with the help of 6 tests (Cooper's test, 30 m run, five jumps, medical ball throw, handball throw, swing gear at 300 m).

#### **Keywords:**

handball, physical fitness, women.

## Introduction

Sport creates opportunities for people to improve their personalities and specific mental and physical characteristics, enabling them to compete nobly for perfection. The term 'sport' is derived from the Latin word 'Se desportare', which means having fun, playing or enjoying leisure time free from family and professional responsibilities. Nowadays, the element of sport as entertainment, pleasure and fulfilment of free time falls within the scope of physical recreation, while professional sport is a very elite area, because it concerns a small group of people who, through their corporeality, want and can gain the recognition of the public [1].

Team games are the most popular among many sports disciplines. For this reason, they are an integral form of exercise in school physical education and recreation. Through participation in the game we discover and shape all health and educational values, develop motor skills, independence and competition. One of the most popular team sports games in our country is handball [14]. It can be classified as one of the sports disciplines having a significant impact on the comprehensive human development. The game is conducted in conditions of significant nervous system stimulation



with appropriate vegetative reactions conducive to the development of various motor characteristics. An important feature of handball is teamwork. The cooperation of the whole team convinces the players that the achieved results are not only the merit of one player, but also an indicator of the effort of the whole team [4].

## **Material and Methods**

The main objective of the study was to assess the level of targeted physical fitness of handball players of the I-league SPR Olkusz team in particular periods of the training cycle in the season 2011/2012. Moreover, the material structure of training of the studied team in the preparatory and starting period was analyzed, which allowed to assess the effectiveness of the training work. The aim of the study, so specified, was reduced to answering three basic research questions:

1) What was the level of special physical fitness of the examined handball players in particular training periods?

2) How did the level of motor abilities of the tested handball players change in the analyzed period?

3) What was the number and type of training of the SPR Olkusz team in particular training periods?

This paper presents the results of the research of 14 handball players who represented SPR Olkusz in the 2011/2012 season in the first league games. The Olkusz Handball Association was established on May 20<sup>th</sup>, 2009, although it acquired legal personality only on July 20<sup>th</sup> 2009 and then the handball section from the club LKS Kłos.

## Scope of the tests

The study analyzed the results of physical fitness tests:

1. Targeted fitness test for handball players - Noszczak test [7], which includes:

a) 30 m sprint;

We determined a distance of 30 m with the start and finish lines marked [15].

b) Medical ball throw (2 kg) - forwards and backwards;

c) Five jumps;

d) Throwing a handball at a distance;

e) Swinging gear at 300 m;

Determine a distance of 30 m and limit it with stands [12].

2. Cooper test - assessment of aerobic strength. The test consists of a 12-minute continuous run [7].

## Material preparation methods

The following methods were used to evaluate the results of the studies:

1. Evaluation of the level of development of individual parameters on the basis of arithmetic mean values and standard deviations.



2. Evaluation of the rate of development or regression of all parameters taken into account in the work on the basis of the WTR III index according to the Wolanski formula (1975):

$$WTR III = \frac{2(X_p - X_{p-1})}{t(X_p + X_{p-1})} \times 100\%$$
(1)

Where:

 $X_p$  - size of the tested characteristic during the survey p;  $X_{p-1}$  - size of the tested characteristic in the age class preceding the survey p; t - time in years dividing the successive surveys.

## Results

Physical fitness level of the handball players was tested in each training period. Additionally, the arithmetic mean values are presented graphically in Fig. 1-7. The first study was performed at the beginning of the preparatory period after ten-day individual trainings shaping strength. The second study was conducted after the preparatory period, and the third study was conducted after the end of the initial period.





As can be seen from the analysis of Fig. 1 in the third study, the competitors achieved the best result in a run over a distance of 30 m. The lowest level of speed was characteristic for the tested athletes at the beginning of the preparatory period.





Fig. 2. Average results of a medical ball throw attempt Source: own research

The analysis of Fig. 2 shows that the highest level of strength of upper limbs was achieved by the athletes during the second study. There is a small difference in the average results in this sample between the first and the second study. On the other hand, the lowest level of strength occurred at the end of the third study.



Fig. 3. Average result of the five jumps test Source: own research

In Fig. 3 it can be seen that the average results of the five jumps test are slightly different from each other. The best result was during the second study, then slightly smaller after the third study, followed by the result from the first study.





Fig. 4. Average results of a handball throwing attempt Source: own research

The analysis of Fig. 4 shows that the players showed the highest handball throwing power in the third study with a slight difference (i.e. 0.2 m) from the second study. The first study shows the lowest measured handball throwing force.



Fig. 5. Average swing test results per 300 m Source: own research

The analysis of the results of the running test (Fig. 5) shows that the best time the athletes won in the second test. On the other hand, the average results from this race are comparable in the first and third tests.





Fig. 6. Average results of Cooper's attempt Source: own research

The analysis of Fig. 6 shows that the average results of the aerobic strength test are the highest at the end of the study. In the first study the average of this test is much lower than in the second. This means that the strength level has increased significantly during the preparation period.

Based on the comparison of the results of special fitness tests and the Cooper test conducted periodically, it is possible to assess the dynamics of the development of motor skills of SPR Olkusz handball players. This assessment was calculated on the basis of the WTR III index according to the Wolanski formula.



Fig. 7. Percentage rates of development of motor test results indicators Source: own research

As can be seen from the analysis of Fig. 7, between the first and the second study, the results in all the tests of motor skills progressed significantly in the case of the handball players.

In the whole analyzed period (from the beginning of the preparatory period to the end of the start period) the handball players improved in four attempts, and in two of them there was a slight regression of the results obtained. The greatest decrease in the level of motor skills occurred between tests II and III, because the regression of results occurred in as many as three attempts. In the 30 m race, the highest development rate was achieved by the examined athletes after the

preparatory period, and the lowest result was recorded after the starting period and it differed from the best results by 6,6%. When analyzing the medical ball throw (2 kg), it can be observed that there was a significant progression in strength between test I and test II. However, in other test relations this force decreased three times. In the five jumps test the athletes again achieved an increase in motor skills development after the preparatory period. The jumping rate improved by 16,3%, and test II in relation to III showed a regression in the power of lower limbs. In handball throwing and in the Cooper test, WTR III again showed the progression of motor skills development during the relation between tests I and II. The most outstanding indicator is the aerobic strength test of 33,5%. It also shows a pendulum gear of 300 m, which shows a regression of motor efficiency between tests I-III and II-III. During this test, an increase in the dynamics of efficiency development by 6% after the preparatory period is also noticeable.

On the basis of the analysis carried out in the study, the following conclusions can be drawn:

1. The players of SPR Olkusz were very well prepared for the competition. This is confirmed by the high level of special physical fitness at the end of the preparatory period.

2. In the starting period, the tested athletes experienced a significant decrease in the level of power and speed strength. Due to the importance of these elements of motor skills in handball, when planning training in the next start period, more emphasis should be placed on maintaining their high levels.

3. The total number of trainings of the SPR Olkusz team proves that the training work is well prepared and planned. However, the observed changes in the motor skills of handball players - especially in the starting period - imply the need to change the proportions of the applied training means and methods in the starting microcycle.

## Discussion

In modern handball, individual technique, motor skills and tactical preparation of players are of great importance, because the factor determining the skill level of teams is the speed of action. Over the past few years, the way in which handball technical and tactical tasks are carried out has changed significantly. First of all, the dynamics of the game has increased through a quick start from the middle of the pitch after a lost goal, often encountered player activities such as: throws and passes the ball with rotation and the freedom to operate the ball in contact with the opponent. Therefore, attention should be paid to the balance of training in terms of all motor skills in the preparation of players [8]. One could say that the recipe for a good sport result is to combine excellent technical skills with maximum speed and adequate power of the players. When assessing the skills of the best playing teams in the sport, these fundamental elements are not sufficient, remember to prepare the tactical team, i.e. cooperation in attack as well as in defense. This paper is devoted to the analysis of the dynamics of changes in the physical fitness of I-league handball players of the SPR Olkusz team in the annual training cycle. The research showed that the SPR players reached the highest level of speed and oxygen strength only after the end of the start period. On the other hand, the highest dynamic force and anaerobic strength were shown already at the end of the preparatory period, and high results of explosive force of upper and lower limbs were maintained throughout the whole season [2]. The aim of the study was also to evaluate the



dynamics of changes in the level of motor abilities during the training macro cycle. The assumption of each trainer is to prepare a team in terms of fitness and technical skills, so that it can be based on this throughout the season and improve only some technical and tactical elements. It should be recognized that the results obtained confirm the accuracy of the sports training, because the motor skills of the athletes changed in direct proportion to the work done during the training. In general, the studied handball players were characterized by the highest level of special physical fitness at the end of the preparatory period [4].

After all the tests of motor skills were performed, there was a progression of the results in each competitor. During the preparatory period, muscle strength and endurance increased markedly, and it is known how important these motor skills are in handball. However, during the start season, a regression in the results obtained by the tested athletes in the attempts to assess the dynamic strength (medical ball throw, five jumps) and speed endurance (pendulum run 300 m) was observed. On the other hand, there was a slight progress in speed (30 m run) and endurance (Cooper test). It seems that during the training sessions of the start period more emphasis should be placed on maintaining high power level and speed endurance.

Handball belongs to group of sports disciplines in which aerobic and anaerobic transformations alternately, depending on the pace of play, dominate. Most often during matches, technical and tactical games are performed with high intensity. They use of anaerobic energy potential of the player manifesting itself as the strength and speed of his actions. However, the game time, i.e. 60 minutes, requires the player to deplete all of the body's oxygen energy resources [5]. The preparation and start period were also analyzed in terms of the material structure of the training sessions of the team. In the preparatory period, the largest number of technical and tactical training sessions were held, followed by slightly fewer strength, speed and endurance elements. On the other hand, the number of jumping trainings was the lowest, although the athletes carried out spinning training. However, there were only five of them. Moreover, the studied handball players played 15 friendly games, which allowed them to improve their individual technique and team tactics. In the preparatory period, a total of 75 training session were held. During the start period, most of the training was of a technical nature, due to the fact that it appeared three times in each macrocycle. In a smaller number there was tactical and speed character of the training, then there was much less strength, strength and jumping elements. In this period 156 training practices, 5 sparring and 22 league matches were held. Due to the very variable nature of the long-term effort, oxygen and anaerobic endurance is needed for this specific type of sport, but a strong connection with these elements plays muscle strength [9].

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# DIFFERENT WAYS OF SPENDING FREE TIME AMONG CHILDREN IN ERLY SCHOOL AGE

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#### Abstract:

This article focuses on the problem of the idea of free time; after the school, duties and chores; among children in early school age. The free time children's life matters specially as the it can be spend in different ways, which are only sometimes related to children's interests. Many habits are created in the early school age. Because of that it is important to prepare children to use and spend free time rationally. The amount of free time, what influences the free time and where or how the free time is spent are the three factors which are important in upbringing. If children acquire right habits of spending free time during their childhood, it will be easier for them to arrange their free time when they are older. The aim of this article is to present the results of the research on free time among third – formers. From this results one can learn if the structure of children's free time is correct and if social media and technology are the main factor which influences children's free time.

#### **Keywords:**

early-school age, free time, ways of spending free time

## The terminology of free time

The concept of free time was the subject of interest of many remarkable people from ages. According to Aristotle if we work we are not happy because we have not got free time and we do not manage ourselves. He thought that free time is not connected with leisure or the end of work. Our free time should be spent on studying philosophy, art and science. Denis Diderot thought that the history of free time is the most important part of our life [1].

In June 1957 UNESCO recognised the idea of free time and made it popular. French sociologist Joffre Dumazediera defined the free time as all the activities which we want to do if we desire from such reasons as: entertainment, achievement of some new skills, education of ourselves, interesting social life and any different activities which are not social, domestic or occupational [1]. The thought was first considered in Poland by Aleksander Kamiński who in his work on 1965 instead of "free time" used "holidays" which was defined as time " ... free form primary work, including students and pupils from school, overtime work or second work. According to students and pupils

from homework, commuting (to work or work), satisfying basic needs (sleep, hygiene or eating), duties and responsibilities as well as schooling of working people" [2].

In the literature three terms describing free time are usually used: "leisure", "leisure time" and "free time". The term "leisure" means personal fulfilment and self – enrichment which are achieved by spending free time in a way which is relaxing and allows to unwind. However, this is not the only feature of free time. The term "free time" means time spent in a way a person chooses according their own wishes. There is not any biological and economical coercion. The term "leisure time" is a part of "free time". The person can dedicate their selves to free time values [3].

As there is a variety of factors influencing the concept of free time, it is difficult to create a detailed definition of free time. According to A. Czajka the factors which influence the definition of free time are:

- social economic conditions,
- environmental conditions which are the differences created by urban or rural conditions, occupational differences, material level of life, and the like,
- cultural traditions, intellectual and cultural level of the society and is individuals and all the consequences [4].

The definitions of free time will be different depending on examined aspect. It can be defined compendiously as it is done in Słownik Pedagogoczny ("pedagogical dictionary"): the time at one's disposal after their obligatory duties are finished. The obligatory duties are: job, school and homework, household chores [5]. Zbigniew Drozdowski thinks that the aim of fee time is to neutralise fatigue and this can be achieved as a result of physical and psychological regeneration. It is important to take care of the personality, which can develop thanks to developing interests and passions. It is considered to be an important factor of mental hygiene and balance [6]. According to Władysław Gawrocki free time is time which is ours after the job. It is time for resting, relaxing, developing our interest and for recreation or entertainment. The main objective of free time is satisfaction from both activity and inactivity. In order to enjoy free time one should achieve proper state of mind [7]. Krzysztof Przecławski believes that time which is left after satisfaction of biological and hygienic needs can be treated as free time. It can be freely spent [8]. Anna Zawadzka defines free time as: time for non - obligatory activities which are undertaken voluntarily to rest, relax, develop and take part in social life [9]. According to Ryszard Wroczyński free time is time left after completion of family, job and social duties and it is used to rest, relax, entertain and to develop one's interests [10].

Children's free time may be understood as:

- time dedicated to rest between learning,
- time in the end of the week Saturday and Sunday of different school free days,
- time after school,
- holidays [11].

Different possibilities of free time, as special social sphere, is connected with great potential which may be used to educate, develop creativity, develop cognition or to leisure and recreation. The conducted research focused on children's activities in their free time after school, excluding weekends and holidays.


Free time, sensibly spent, can have positive influence on personal development as well as on development of society's culture. Activities in which we participate during our free time have enormous influence on our personal development and on development of society's culture. Lack of free time can have negative influence on our health. It can also cause lack of self satisfaction and satisfaction with the world. What is more, it can lead to negative influence on attitude towards people and personal achievements [12].

Nowadays, free time is a determinant of society wealth and is very precious. It is a value which is inseparably connected with: household wealth, lifestyle, life satisfaction. People can decide on their own how they want to spent their free time. It is the law as well as one's own political or religious orientation. Having free time is ensured by the low.

## Free time of early-school children

All definition of free time underline freedom of undertaken activities. Every activity should give joy and happiness. Free time aims at causing same changes in child's personality and at shaping it. But first of all free time is needed to regenerate. R. Worczyński divided ways of spending free time by children and teenagers:

- sport,
- tourism,
- participating in art events or amateur art,
- the mass media (reading, radio, film, television),
- different forms of intellectual activity (self education),
- social activity (for example peer group),
- different form of activities (collecting or hobbies) [10].

M. Ćwiakowski names three functions of free time: economical, educational and hygienic. The economic function allows to regenerate the strength which was lost during work, learning or other efforts. Personality is also created and developed. During free time our productivity is rebuilt. First of all we thing of skills development and perfection. To sum up this function's tasks are:

- "skills development and culture development,
- resting which means rebuilding of productivity,
- rational and inventing act,
- developing of productive skills of society" [13].

Educational function means " that in different social processes which takes place fully or partly during free time personality is formed and developed" [13]. These elements influences universal personal development: mental development, aesthetic, socio – moral and physical. Harmonious development of elements leads to universal development. What is more, we must remember about mutual relationships and dependences. Each personality develops by upbringing, self – learning and unprompted social development. The educational function consists of unprompted social development. People sometimes does not realize when they are learning and gaining knowledge and skills. For example, when we read a book or watch a film as a form of leisure, we do not realize that we acquire new some information. The last element described by Ćwiakowski is hygienic function. " it is devoting time to rest, sport, entertainment and it influences health maintenance and

growth"[13]. Free time used in rational way aids health maintenance and prolongs human life. Nowadays it is very important. People are so busy that they forget about their health. People demand more and more form themselves and from others all the time. Also, children want to be the best so they attend extra classes. Human relations may also have negative influence on body [13].

Dąbrowski names four functions of free time: rest, entertainment, interests and talents development, looking for own's place in society [12]. First three (est, entertainment, interests and talents development) are connected with one's needs. People rest in order to regain mental and physical strength, People looks for entertainment in order to feel pleasure, satisfaction and to feel some change. What is more people attend extra classes: special interests groups or art classes in order to upskill and gain knowledge. The effects of the last function are not immediately seen and are not directly felt. Winiarski gives yet another classification. He names following functions:

- 1. Creative satisfaction of needs, interest development, discovering abilities and talents, developing creativity which is essential in one's development.
- Protective creating conditions essential to satisfaction of children and teenagers needs. They must be consistent with safety and they must nor cause danger of life. It is important to even development deficits and to show the right educational direction. It is a result of social changes.
- 3. Recreation organization of leisure and entertainment.
- 4. Development developing attitudes towards education, developing interest in education and the newest achievements.
- 5. Integration integrating people who live and raise the same area, creating bonds between them.
- 6. Environmental developing social culture, motivating to engaging in educational care as well as in cultural and educational activities, initiating cooperation of different facilities and institutions engaged in satisfying of local needs [14].

Recently, free time and its aspects are gaining more and more importance. Parents have less and less time for their children because they work and have many duties and responsibilities. Because of that there is not enough time for children. Family wields influence on development of children's social personality. The atmosphere at home and life style decide how the children use their experience, how they create ideals and feelings. Family is basic environment which wields the most influence on children's personality. Parents are role models for their children. Thanks to family children establish their first contact with people , they get to know and learn different role models. Parents take care of their children during free time. There are some indications: "1. Children's free time may by spontaneous but it should be directed depending on psychological development and needs. 2. Free time should be organized in different ways 3. It is important to provide appropriate amount of free time, according to standards and age 4. Children's free time depends on parent's free time [15].

#### Free time after school among third – formers

The research was conducted among parents of early-school children. The research was diagnostic survey. The technique was questionnaire and the research tool was the inquire form. The



questions were both open and closed. The main question was : How do the parents organize their children's free time? Eighty people were questioned (70% women and 30% men). The responders were in 30 - 35 years old (40%) and 35 - 40 years old (50%). Only 10% of responders younger than 30 years old. Responders often had two children (60%) or one child (25%). The place of residence plays very important role as it greatly influences children's future. The results shows that the majority of responders live in the city (75%) and only 25 % live in the villages. Responders who live in the city have more opportunities to provide access to different cultural instructions. Proximity and availability of cultural and entertainment institutions influences the way free time is organized. 75% of the responders make use of different organizations and institutions. However it is influenced by financial situation. The financial situation greatly influences the way free time is organized. 85% of responders take into consideration their financial situation when organizing free time. The responders described their income as middle. The income is 500- 600 zloty per person (55%). The main causes which limit free time organization are availability of institutions (54%) and low family income (46%). Only 34% of responders provides extra classes for their children. The extra classes are additional expense. They have got one child. The rest explains that they have not got enough money. Each member of family has got their own favourite interests and hobbies on which they spend their free time. Children spending time with parents can follow parents' interests. Also parents can implant their children the same ways of spending free time. The responders prefer reading books or watching films in their free time. Only few prefer sport and team games. Their children spend their free time outside (33%), in front of computer (23%), in front of TV (26%) and films (18%). 65 % of the responders said that their children prefer similar interests and hobbies as them.



Fig. 1. The most popular (similar interest and bobbies as parents) form of free time Source: own source

According to the responders the most popular form of free time are: reading books (31%), watching TV (28%), using the computer (13%), sport (11%) listening to music (7%), drawing (7%), do-it-yourself (3%).

Reading books (31%) was preferred ways of spending free time. The first contact with a book children have in their family. The family introduces to a child he word of cultural values and



implants bookishness. The high cultural level of spending free time guarantees harmonious development. In their own time children should do what they like and what suits them. That is why the family should create conditions which favour harmonious development [14]. 82% of the responders said that they are trying to provide their children with ways of spending free time which that encourage cultural and harmonious development. The fact if the parents spend their free time with their children is also important. The amount of free time spend with a child and the ways of spending free time decide on relations within a family. The better the relations are the more influence the parents have on their children's ways of spending free time. The parents know their children's interests so they can guide their children's development and create conditions to choose a way of spending free time. 58% of the responders indicated good relationship with mother and 31% indicated good relationship with father. The amount of free time spent together influences relationship. In the opinion of 53% of the responders it is about 1-2 hours per day. 27% said it is 3-4 hours per day. 7% said it is more than 4 hours and 13% said it is less than 1 hours. The most popular form of spending free time together is watching TV (58%). In all households there is a TV. The parents treat television as the only source of knowledge and entertainment. The TV programs watched together are: nature film/programme, music programme, science programme, cartoons, films. The family has the biggest influence on children's extent of experience with watching TV. The parents usually decide how much time the child spends watching TV, on which programmes the child watches and when the child watches. The choice of TV programme should depend on a child's age, experience, interests and maturity. Among other ways of spending free time the responders name: reading magazines (12%), visiting relatives and friends (9%), walks (11%), garden plot (10%). Only good relationship with children and awareness of their needs and abilities allow the patents to satisfy children's needs and encourage interests development. The responders undertake a wide range of different activities in order to care for their children development. The amount of free time and its use mostly depends on every day planning of family life. So it is important to skilfully plan and organize free time. The rational use and organization of free time develops children's tastes and habits. The research confirm that 87% of responders can skilfully organize free time. To the elite ways of spending free time belong: playing an instrument, ballet and learning foreign languages. The research confirms that parents' education and interests influence ways of spending free time. Those parents offered more interesting activities and they encouraged to undertake those activities (55%). Also number of children in the family influences ways of spending free time. The parents with one or two children are more interested in their children's free time (58%). The question whether the parent's age influences ways of spending free time is also interesting. The research does not confirm that. 73% of the responders said that the age of parents does not influence ways of spending free time. 83% of the responders said that number of children in the family can influence ways of spending free time. Based on the results of the research it can be said that children happily and willingly spend their free time with parents (76%). However, this can be easily seen among younger children (4-6 years old). The older the children are the more happily and willingly they spend free time with their peers. That was the answer of 42% of the responders. Does the parents know with whom their children spend free time? The research showed that 93% of responders know with whom their children spend free time and with whom the children are friends.



The parents also know the ways their children mostly spend free time with peers. There are: playing computer games (61%), playing together (19%) going out together (20%).

## Summary

The way children spend free time after school is very important for their development. There are many possibilities for children to acquire new skills and knowledge in their free time. Nowadays, children receive many information form mass media. The press, the radio, the television, the Internet, photos, films, fairy tales, tales, books are the basis of communication in mass culture and they define its character. They satisfy the needs of free time when it comes to entertainment, rest and self development

The data shows the importance of the role of the parents in shaping and creating their children's interests development. On the base of the conduced research it can be said that: the family greatly influences different ways of spending free time, the place of residence is important when it comes to free time management. The access to the institutions and organizations as well as distance from them give more possibilities, the financial situation greatly influences the way free time is organized, the parents' education and interests influence ways of spending free time, the television became the main way of spending free time, the parents know abilities and interest of their children, the parents spends their free time with their children.

The role of the family in free time management and interests development advantages universal child's personality development and introduces a child into world of culture. As M. Grochociński said the lever of culture in the family is one of the most important factors which decide on children's free time management. As the free time influences our lives, it is important to show children ways of spending free time which will develop and enrich their personality as soon as possible. Only good free time management and family interest in spending free time prevent demoralisation among children and teenagers. Human's behaviour during their free time, connected with the greatest freedom of choice, show their real pursuits, their attitudes and their values. Via creating and developing motives to the most desirable way of spending free time one may directly influence creating and developing attitudes and values among children and teenagers. Spending time together should be the most important and indissoluble part of family life.

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## **PROBLEMS IN HYDROGEN STORAGE METHODS**

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#### Abstract:

It is being argued that hydrogen will become one of the main energy carriers, however, in order for this to happen, it is necessary to develop and build a whole hydrogen infrastructure that consists of production, transport and storage. Hydrogen storage methods and the development of appropriate technology for this purpose, are playing the most important role in the entire so-called hydrogen economy. The aim of the article is to review the main ways of hydrogen storage. Basic disadvantages and advantages of each of the methods are presented.

#### **Keywords:**

hydrogen storage, hydrogen energy, Hydrogen economy

## Introduction

The fuel evolution is related to the direction of increasing the hydrogen content, starting its history from the coal through petroleum to natural gas to the destination of pure hydrogen [1].

Hydrogen is seen as a promising alternative to other energy carriers. During the combustion reaction with oxygen, the side effect is only water, so hydrogen is a non-emission energy carrier, it does not emit unwanted greenhouse gases [2].

Despite the fact that hydrogen is an power-intensive and ecologically pure carrier of energy, the main problem associated with the entire hydrogen ecology is the way it is stored, due to its extremely low normal density of 0.09 g/l (at 288 K and 1 bar) [3-4], so under normal condition (at ambient temperature and atmospheric pressure) takes a volume of 11 cubic meters.

Therefore, it can be stored as compressed gas under high pressure, in liquid form at a suitably low temperature and in a solid form [5].

#### Hydrogen storage in the gaseous state

One of the most common methods of gas fuel storage is the compression of gas to a small volume under high pressure. An important difference between the storage of gaseous fuels such as natural gas, and hydrogen is its lower specific weight, which requires much more energy to be



compressed [6]. Fig. 1 shows the relationship between volumetric density of n-H2 (normal hydrogen) as a function of pressure for three different temperature [7].



Analyzing the above-mentioned Fig. 1 it can be concluded that the presented relationship between volumetric density and pressure is non-linear. Hydrogen at a pressure of 300 bar reaches a density of 20 kg/m<sup>3</sup>, at pressures from 700 to 2000 bar we can adjust the volume density from about 40 kg/m<sup>3</sup> to even 70 kg/m<sup>3</sup>. However, pressures of the order of 2000 bar are not used due to technical problems with their execution [8]. In laboratory use or in industrial applications, hydrogen is usually compressed to pressures of about 15-50 MPa (150-200 bar). However, in vehicles using fuel cells, pressures from 37-70 MPa are used. While, the stations use tanks that store hydrogen at a pressure of about 100 MPa.

There are still a number of problems associated with the storage of hydrogen in the gas phase using high-pressure tanks. The main problems is primarily the large amount of energy needed to compress gas, stresses occurring in the reservoir material, which are caused by repeated cycles of refueling and discharging (from low to high pressure), or safety issues which always occurring when using high pressures. Other important problem is the penetration of hydrogen, which causes brittleness and therefore the problem may be the selection of appropriate materials for the construction of tanks [4].

#### Hydrogen storage in the liquid state

Another way of storing hydrogen is to store it in the liquid phase. In order to store hydrogen in this form, it is necessary to liquefy it, then crogenous tanks with a temperature of -253°C, at ambient pressure, are used. An advantage of this method compared to storage in gaseous state is the higher energy content per unit of volume [7].

In this storage method, first of all, consideration should be given to the energy used to liquefaction hydrogen, it is about 64% higher than the energy required to compress it. Another



problem, apart from the need for more energy, is the evaporation of liquid hydrogen, which is the result of absorbing heat from the environment through a tank. It was found that the evaporation takes place in about 3 days from the tank's charge and it is ranges from 0.1% to 3% [6]. The rate of hydrogen evaporation from the vessel is a function of its size, shape and thermal insulation. Since the losses due to evaporation are proportional to the surface to volume ratio, the evaporation velocity decreases as the size of the tank increases. For example, in the case of two-layer, vacuum-insulated spherical dews with a capacity of 50 m<sup>3</sup>, the loss resulting from evaporation is 0.4% a day and for tanks with a capacity of 100 m<sup>3</sup> it is 0.2% and 0.06%, for tanks with a capacity of 20 000 m<sup>3</sup>. Due to the evaporation problem and the high energy required for liquefaction, this method of storage works well in applications where hydrogen is consumed within a short time [9].

## Hydrogen storage in solid state

The storage of hydrogen in solid state has become quite attractive direction primarily because this method allows to achieve a greater volumetric hydrogen density compared to the previously described methods of storage in the gas phase or in tanks with liquid hydrogen [10]. There are a number of solid-state materials such as: metal organic frameworks, carbon based materials, metal organic frameworks, hol-low glass microspheres, capillary arrays, metal nitrides amides, clathrate hydrates, doped polymer and zeolites, capillary arrays and metal hydrides [11]. Thus there are many groups of materials that just use their hydrogen activity, however, metal hydrides and their alloys are typically used for this purpose [12].

The host materials in the intermetallic compounds are ordered stoichiometric compounds, which are usually made of two metallic components A and B. As it was shown in Fig. 2, these compounds are made of metals that easily form stable hydrides - component A and another element that does not form stable hydrides - component B. The intermetallic compounds so formed can be grouped according to their stoichiometry, shown in Tab. 1. Part of the groups will be described below [8].



A: Hydride forming element; B: Non-hydride forming element

Fig. 2. Periodic system of elements with selected elements hydride and non-hydride forming Source: [8]

Composition	А	В	Compounds	
AB <sub>5</sub>	Ca, La, rare earth	Ni, Cu, Co, Pt, Fe	CaNi5, LANi5, CeNi5,	
			LaCu5, LaPt5, LaFe5	
$AB_2$	Zr, Ti, Y, La	V, Cr, Mn, Fe, Ni	LaNi <sub>2</sub> , YNi <sub>2</sub> , YMn <sub>2</sub> , ZrCr <sub>2</sub> ,	
			ZrMn <sub>2</sub> , ZrV <sub>2</sub> , TiMn <sub>2</sub>	
$AB_3$	La, Y, Mg	Ni, Co	LaCo <sub>3</sub> , YNi <sub>3</sub> , LaMg <sub>2</sub> Ni <sub>9</sub>	
$A_3B_7$	Y, Th	Ni, Fe	Y <sub>2</sub> Ni <sub>7</sub> , Th <sub>2</sub> Fe <sub>7</sub>	
$A_6B_{23}$	Y	Fe	Y <sub>6</sub> Fe <sub>23</sub>	
AB	Ti, Zr	Ni, Fe	TiNi, TiFe, ZrNi	
$A_2B$	Mg, Zr	Ni, Fe, Co	Mg <sub>2</sub> Ni, Mg <sub>2</sub> Co, Zr <sub>2</sub> Fe	

Tab. 1. Examples of groups of intermetallic hydrides

Source: [8]

One of these, is the AB<sub>5</sub> group represented by the LaNi<sub>5</sub> alloy, their advantage is the ability to absorb hydrogen already in the room temperature, however, the stored content is only 1.4% by weight. Another group are AB and AB<sub>2</sub> type materials, an example of which can be FeTi, which has the capacity of 1.8 wt. % . The materials in this group have good thermodynamic properties, but the problem here is the activation of the process itself, it is complicated, the materials have to be subjected to initial cycles of absorption and decomposition in high temperatures and under high vacuum [12-13]. The next generation are A<sub>2</sub>B type alloys, eg. Mg<sub>2</sub>Ni, which have disadvantages such as high temperature of the absorption and desorption process and slow reaction kinetics, however, they have good hydrogen storage capacities of about 3.6% by mass, have relatively low weight and are not expensive [13]. The publications also include materials that can store hydrogen up to several percent of the mass. However, the problem here is to hydrogenate them under the same conditions [14]. This group also includes borohydrides, such as LiBH<sub>4</sub>, whose has a gravimetric hydrogen density of 18.5 mass% and a volumetric hydrogen density of 121 kg H<sub>2</sub> m<sup>-3</sup>, due to the decomposition of LiH and B, but the rehydrogenation process requires very regime



conditions, i.e.  $600^{\circ}$ C at 15 MPa hydrogen pressure, due to the chemical inertia of the boron element, it is also important that the release of hydrogen takes place in two stages, starting at 400 ° C and can not be terminated below 600°C, due to the decomposition of thermally stable lithium hydrogen. Another example of a material belonging to this group is LiAlH<sub>4</sub> with a theoretical capacity of 10.5% by weight. however, the reaction of this hydride is almost irreversible due to the extremely high equilibrium pressure at relatively low temperatures [14-17]. Another example of the materials with a problem of reversibility of the process is AlH<sub>3</sub>, NaH and LiH, which also have a high hydrogen capacity [18-20].

Thus, metal hydrides are interesting and widely studied solution as solid hydrogen storage, however, as of today, no comprehensive solution was found and a number of tests are still being carried out.

## **Summary**

Despite the fact that hydrogen is still perceived as a prospective, ecological energy carrier, there is a problem with its effective and payable storage method. By explaining all the available hydrogen storage methods discussed above, we can conclude that each of them is characterized, in addition to its advantages, by a number of disadvantages, problems that need to be addressed, and the problem is the accumulation of large quantities in a small volume. Limitations on the use of known methods include, among others, the use of high pressures in magazines in the gas phase, or the use of very low temperatures and the need for good insulation in liquid storage storage. It seems that the most prospective is the storage in solid-phase such as metal hydrides, but this requires further research and look for new solutions.

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## HYDROGEN ENERGY FOR MOBILE USE

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#### Abstract:

Mobility - the people and goods transport - is a socioeconomic reality that will confidently increase in the nearest future. Therefore, this transport should be safe, economical and most importantly as green as possible. One of the solutions that meets the above criteria is the use of hydrogen as a fuel. Hydrogen is lightweight, highly abundant (120 MJ/kg) and its oxidation product (pure H<sub>2</sub>O) is environmentally friendly [1-3]. In addition H<sub>2</sub> is the most common element in the Universe, so its resources seem inexhaustible. Unfortunately, the problem occurs with hydrogen storage. Therefore, it is very important to search for and develop the most effective ways of storing hydrogen and obtaining energy from it necessary to move cars. In the automotive industry, hydrogen is used as an energy source in two ways: in internal combustion engines and using fuel cells. Consequently this paper describes the energy properties of hydrogen and the use of hydrogen in the automotive industry.

#### **Keywords:**

hydrogen storage, mobile tank, hydrogen fuel cell car, alternative energy sources

## Introduction

The rapid industrial and civilization development observed at the turn of the last few decades contributes to the degradation of the Earth's ecosystem as well as to the slow but steadily growing scarcity of natural resources, mainly of energy resources. Gas and oil reserves are drastically decreasing, and the energy demand of the world is constantly growing [1-6]. All these phenomena have a direct impact on the search and effective possibilities of using alternative energy sources. The solution of this searching is hydrogen. During burning in oxygen, hydrogen releases large amounts of energy, which is why it can be an ideal source of energy in domestic and industrial applications, but also in transport or mobile systems. The calorific (heating) value of hydrogen is high and amounts to 120 MJ/kg - for coal it is value of 25 MJ/kg, and for gasoline - 47 MJ/kg [1, 6, 7]. Hydrogen, unfortunately, is characterized by a small degree of energy packing - about 9 MJ/l so in order to obtain energy from hydrogen it is very often necessary to compress it or liquefy it under high pressure (from about 15 to even 80 MPa) [2-5]. The interest in energy from hydrogen at the turn of the last years is still very high and is constantly growing [7, 8]. This is because this source is associated with a real prospect of replacing oil and gas in the future [5-9]. The implementation of hydrogen energy still faces major difficulties and problems, especially with developing techniques



for cheap hydrogen acquisition, finding materials and methods for inexpensive and safe hydrogen transport and storage as well as the development of a fuel cell, engine or battery with the highest efficiency [3, 5, 7-9].

Mobile hydrogen storage tanks can be used in boats and ships, trains and trams as well as buses, passenger cars, bicycle, mowers, etc. In mobile applications, one of the limiting criteria is the weight and size of hydrogen storage tanks. Therefore, the size and type of the tank depends primarily on the vehicle in which it is to be used. This work focuses on describing mobile tanks used in passenger cars. In cars hydrogen can be use in fuel cells and internal combustion engines. Using hydrogen in both cases always requires safe and cheap technology for its storing and refueling. Due to its physicochemical properties, hydrogen requires special storage systems. Three methods of storage are tested: in gas form in high-pressure tanks, in liquefied form in cryogenic tanks and in solid bodies in which hydrogen is chemically bound [7-10].

## **Energy properties of hydrogen**

Hydrogen is the element opening the periodic table - the hydrogen atom consists of a single electron and proton, which is why it is the lightest chemical element. It is an element whose atomic number is 1 and atomic mass is 1,00794 u [11]. Hydrogen density, in all physical states, is also the smallest with respect to other substances. Hydrogen gas (0.082 kg/m<sup>3</sup> - 273 K, 1013 hPa) liquid hydrogen (70.8 kg/m<sup>3</sup>) and crystalline hydrogen (88 kg/m<sup>3</sup>) [5, 9, 13]. The melting point of hydrogen is -259.2 °C, and boiling - 252.8 °C [7, 9-12]. Hydrogen in free form occurs in very small amounts (about 3.10-6 wt.%) in volcanic gases and in the upper atmospheric layers, sometimes also in natural gas, granite and other rocks. On the Earth, this element is very widespread, but it can be found almost always in bonded form, e.g. in the form of hydrocarbons (oil, natural gas), water or other organic chemical compounds of living organisms [2-5, 14]. Pure hydrogen can be obtained through the process of electrolysis of water, coal gasification, steam reforming of natural gas or oxidation of biomass or other hydrocarbon products [1, 2, 15].

However, in mobile applications more important are a hydrogen energy properties such as: octane number, calorific value, energy of ignition, burning velocity (fuel propagation speed) and auto-ignition temperature. Hydrogen has the highest calorific value and heat of combustion (in relation to mass). Due to the very low density, hydrogen looks unfavorably compared to other fuels if these values are referred to volume. For this reason, hydrogen works well as fuel for vehicles where mass plays a greater role than volume (eg rockets or spacecraft). Hydrogen has a very high diffusion coefficient in nitrogen (which is the main component of the air) which results in a high flame velocity. The limits of flammability and hydrogen explosion are shifted strongly towards the ends of the scale, which results in a very wide range of flammability and explosiveness of the mixture of hydrogen and air [15, 16].

The octane number determines the resistance of the fuel-air mixture to auto-ignition and detonation combustion during compression, as well as during the combustion process already started in the engine cylinder. The higher the octane number, the higher the fuel value. The octane number is also intended to determine the fuel quality for spark-ignition or turbine-ignition engines. The octane number of hydrogen 130 - this value is also much higher than for typically used fuel



substances. for comparison, octane number of gasoline is 87-98, diesel: 30 and methane: 125 [1, 5, 9, 12].

Calorific value determines the amount of energy emitted on the way of heat when burning a unit of mass or volume of fuel. During the experiment it is assumed that the combustion is complete and complete, and the water vapor contained in the exhaust does not condense (despite the fact that the exhaust gas reaches the initial temperature of the fuel). The calorific value of hydrogen, as previously mentioned, amounts to as much as 120 MJ/kg. This parameter is much higher than for typical fuels used in today's economy. In addition, it is important that due to low molecular weight and high heat of combustion, hydrogen has the highest energy-to-mass ratio compared to other energy carriers such as methane, methanol or octane (which is the main component of gasoline) [3, 7, 12, 15].

Energy of ignition it is the smallest value of the spark discharge energy, which under given conditions can cause ignition or explosion of the fuel mixture. For hydrogen, this parameter is 0.02 MJ - this value is as much as an order of magnitude lower than for other conventional fuels [1, 6, 7]. In order to determine whether the value of this parameter is suitable for "good" fuel quality, it is also necessary to mention such properties as: burning velocity (fuel propagation speed) and auto-ignition temperature of the fuel substance. Hydrogen combustion speed is 3 m/s - for gasoline only 0.4 m/s, in turn the auto-ignition temperature for hydrogen is 585 °C and this is the highest value in relation to other fuel substances [5-7].

Tab. 1 presents the most important properties of various types of commercially used fuels.

Parameter	Hydrogen	Gasoline	Propane	Methane
Heat of evaporation [kJ/kg]	444	302	388	577
Calorific value [MJ/kg]	120.0	47,0	46.4	50.0
Heat of combustion [MJ/kg]	141.9	44.4	48.9	55.5
Auto-ignition temperature [°C]	585	222	466	534
Ignition energy [mJ]	0.02	0.25	0.25	0.30
Flame speed [cm/s]	270	30	38	34
Coefficient of diffusion in the air [cm <sup>2</sup> /s]	0.63	0.08	0.10	0.20
Lower limit of flammability [vol. %]	4	1	2	5
Upper limit of flammability [vol. %]	75	6	10	15

Tab. 1. Comparison of properties of conventionally used fuels

Source: [16]

## Hydrogen in transport application

Hydrogen was used as fuel for the first time in 1806, when Francois Isaac de Rivaz patented the first combustion engine on hydrogen and oxygen with electric ignition. A year later, de Rivaz constructed the first prototype of a hydrogen powered vehicle (Fig. 1). The central engine element was a cylinder with a combustion chamber in which the piston moved. A mixture of hydrogen and oxygen exploding in the chamber set the piston in motion [17].





Fig. 1. The first hydrogen and oxygen combustion engine vehicle with electric ignition Source: [17]

In 1838, the Swiss chemist Christian Friedrich Schönbein discovered the principle of the fuel cell. Based on this work, the Welsh scientist Sir William Grove created the first working fuel cell (1840). He concluded that if electrolytic separation of water into oxygen and hydrogen requires a large amount of energy, in the reverse process it can be produced. Thanks to these works, already in 1849, the first fuel cell powered boat was constructed [10, 17].

Hydrogen was condensed for the first time in 1898 - it was done by Scotsman Sir James Dewar. As a result of this phenomenon it became possible to store a larger amount of hydrogen in a smaller volume. Thanks to that, in the 1960s, work on a Space Shuttle Main Engine (SSME) was started, which was used for the first time in 1981. Liquid hydrogen and oxygen were used for power supply. The second half of the twentieth century was the time of the development of hydrogen technologies. The first attempts at "modern" hydrogen-powered cars were made in 1966 (GM Electrovan) [10, 17, 18]. In 1978, Mercedes Benz constructed a hydrogen powered bus. The huge hydrogen fuel tank surpassed the driver and the vehicle was able to reach a top speed of 90 km/h. Since 1996, in Erlangen and since 1999 in Munich, buses with hydrogen fuel cells. In 2014, Hyundai, as the first manufacturer in the world, began mass production of its ix35 Fuell Cell model equipped with hydrogen fuel cells – Fig. 2. [10, 17, 18]. The range of the car is 600 km with one refueling, which lasts only 3 minutes. The tank allows the storage of 5.64 kg of hydrogen at 700 bar [17].





Fig. 2. Hyundai ix35 FC, and the way of fixing the hydrogen storage tank Source: [10, 17]

Since 2016, the Toyota Mirai FCV is the first passenger car produced in series – Fig. 3. The driving gear in this case is a combination of fuel cell technology with electrical technology [18].



Fig. 3. Toyota Mirai FCV, and it's the fuel cell Source: [18]

Today, after more than two hundred years from the idea of Rivaz, all the necessary equipment for hydrogen power supply is located in passenger cars, and the efficiency of the drive has increased by more than 70 percent [10, 16, 17].

## Hydrogen energy in passenger cars

Hydrogen as a source of energy in passenger cars can be used in two ways: in internal combustion engines, where internal hydrogen combustion takes place, or in electric motors powered with hydrogen fuel cells. Regardless of the type of engine, the hydrogen on the car must be properly and efficiently stored. The basic parameters describing the "usefulness" of hydrogen storage systems are: gravimetric density and volumetric density. The ability to store hydrogen in sufficiently large quantities, technological simplicity, safe use of methods and low storage price are the basic conditions that must be met in order to be able to use hydrogen in a wide range and with high competitiveness. These conditions apply to both large hydrogen storage installations for



energy purposes, as well as smaller ones used in cars and quite small for powering mobile devices. Currently, the following methods are most often used for hydrogen storage [1-5, 10, 13]:

- in compressed form,
- in liquid form,
- in a form bound in hydrides,
- in a form bound in carbon nanotubes,
- in a form of chemical connections with a high hydrogen content.

Storage of hydrogen in compressed and liquid form requires the use of tanks with a very robust construction in terms of temperature and pressure. When using metal hydrides, the absorption takes place directly to the metal. When using simple crystalline metal hydrides, hydrogen is absorbed by combining it with the crystallographic lattice of the metal. When using carbon nanotubes, hydrogen is stored on the basis of physical and chemical adsorption, which are based on energetic adsorption mechanisms. Storage of hydrogen in the form of compressed, liquid, metal hydrides or in bound form in sorbents is a reversible process. The storage of hydrogen in a chemically bonded form differs from those previously presented. Because it is not possible to regenerate overworked material in the vehicle from which the stored hydrogen has been exhausted. Therefore, regeneration takes place outside the vehicle in technically suitable installations [1-5, 10].

Currently, well-established technical and commercialized storage methods are compression or hydrogen condensation. The first one is dominant technology, especially in vehicles. Currently, this technique allows the storage of hydrogen in completely composite tanks designated as compressed hydrogen under nominal working pressure equal to 700 bar [10, 13, 18].

#### Internal combustion engine (ICE)

In hydrogen internal combustion engines, electricity generated as a result of the reaction of burning hydrogen with oxygen or air is transformed into mechanical energy directly driving the car. In such engines, hydrogen is injected into a chamber filled with oxygen or air, where the fuel mixture burns directly, of which the product is naturally water vapor [19].

The hydrogen internal combustion engine is simply a modified version of the traditional gasoline-powered internal combustion engine. Typically hydrogen engines are designed to use about twice as much air as theoretically required for complete combustion. Examples of cars with hydrogen ICE are: Mazda MX-5 Miata, Ford E-450 H2ICE Shuttle Bus, BMW Hydrogen series 7 or Premacy Hydrogen RE Hybrid [19].

Currently, cars with hydrogen ICE are not widely and serially produced. The solution with the use of an internal combustion engine is not as popular as electric motors with fuel cells. Therefore, more attention was paid in this work to the use of hydrogen in fuel cells.

#### **Electric engine**

An electric motor powered by hydrogen fuel cells transforms the chemical energy coming from hydrogen into electricity that sets the car in motion. In this type of cars, electricity is generated without burning fuel and oxidant, which allows to avoid emissions of harmful compounds such as sulfur oxides or nitrogen, hydrocarbons and carbon oxides. In cars of this type, hydrogen (fuel) and oxygen (oxidizer) are supplied from the outside to the fuel cell, where electricity is generated.



Directly from the cell the current is transported to the batteries and to the engine [1, 2, 21]. To better understand the principle of operation of this type of car, the principle of operation of hydrogen fuel cells should be clarified - as described below.

## **Fuel cells**

Very low efficiency of internal combustion engines, pollution of the environment and the threat of exhaustion of oil resources caused increased work on fuel cells. No emission of toxic and harmful substances, usually quiet operation, and independence from the power grid ensured fuel cells practically an infinite number of applications. Fuel cells, unlike internal combustion engines, convert chemical energy of fuel and oxidant directly into electricity [5-10, 20, 21]. The elimination of fossil fuels combustion process in conventional engines allows to avoid emission of harmful compounds burdening the environment and ensures high efficiency of energy conversion. An example of a hydrogen fuel cell is shown in Fig. 4. A cell of this type is always made of an anode, a cathode and an electrolyte or electrolytic membrane, which are located between two electrodes. The electrolyte is designed to allow the flow of hydrogen cations and block the flow of hydrogen electrons [1-5, 20, 21]. The operation of such cell consists in the fact that hydrogen is supplied to the anode from the tank in a gaseous form, where it is broken down into cations and electrons. The hydrogen cations through the electrolyte are transported to the cathode, to which oxygen (in pure form or contained in the air) is additionally supplied from the outside. Oxidizer (O<sub>2</sub>) then reacts with fuel (H<sub>2</sub>) to form water, which in the form of steam leaves the cell. At the same time, electrons from the breakdown of hydrogen flow to the cathode by means of an external circuit, causing the generation of an electric current. As a result of this type of electrochemical reaction in the fuel cell, electricity and water are generated. The following are the reactions that occur both on the anode and cathode [1-5, 20, 21].

The reaction taking place on the anode [2, 21]:

$$H_2 \to 2H^+ + 2e^- \tag{1}$$

The reaction occurring at the cathode [2, 21]:

$$\frac{1}{2}O_2 + 2H^+ + 2e^- \to H_2O \tag{2}$$

In mobile applications, fuel cells produce energy directly for the drive, in contrast to internal combustion engines where mechanical energy is converted by mechanical gears into drive energy. The efficiency of fuel cells in the generation of electricity reaches even 50%. In the process of cogeneration, production of electricity and heat, fuel cells achieve efficiency of up to 85% [21, 22].

There are many types of fuel cells, for example: SOFC (Solid Oxide Fuel Cell), DMFC (Direct Methanol Fuel Cell), PEM (Polymer Electrolyte Membrane), AFC (Alkaline Fuel Cell), PAFC (Phosphoric Acid Fuel Cell), MCFC (Molten Carbonate Fuel Cell) and others. The lifetime of some of the latest generation cells reaches up to 40000 operating hours, while maintaining operating parameters [21, 22]. List of features of selected fuel cells is presented in Tab. 2 [22].





Fig. 4. The scheme of the hydrogen fuel cell operation Source: [20]

Fuel cell		Working	Efficiency		
tuno	Electrolyte	temperature	(electricity	Application	
type		[°C]	generation)		
PEM Pol	Polymer in solid state	75	35 - 60%	- UPS devices	
				- portable batteries	
				- low power plants and energy and heat generators	
				- automotive industry, mobile applications	
DMFC Polymer in solid state	Dolumor in	75	35-40 %	- portable devices	
	solid state			- batteries	
				- automotive industry, mobile applications	
AEC	КОН	<80	50 - 70%	- military	
ALC	solution	<00		- cosmonautics	
PAEC	Phosphoric	210	35 - 50%	stationary generators	
TAIC	acid	210		- stationary generators	
	Molten			Large power plants and generators	
MCFC	carbonate	650	40 - 50%	CHD (Combined Heat & Dower) devices	
	Li/K			- CHF (Combined Heat & Fower) devices	
SOFC	Oxide	650 1000	45 60%	- Large power plants and generators	
	ceramics	050-1000	45 - 0070	- CHP (Combined Heat & Power) devices	

Tab. 2. List of features of selected hydrogen fuel cells

#### Source: [22]

At present, almost every major automotive company in the market carries out advanced tests of a vehicle powered by fuel cells. At present, the FCV (Fuel Cell Vehicle) cost-effectiveness equals contemporary hybridists. With the advances in fuel cell technology, FCVs will certainly become very popular. The advantages of fuel cells as a means of transport are: high efficiency (65% for a fuel cell compared to 35% for an internal combustion engine), no vibrations and noise



accompanying energy production, energy production directly driving electric motors, no fuel burning during stoppage, stability of torque and many others [21, 22].

Each car fueled by fuel cells is equipped with an energy recovery system during braking. This system charges batteries in older solutions, or super-capacitors, in newer ones, which then provide energy at peak load, e.g. during acceleration. Currently, most vehicles are powered by PEM cells. It is a very efficient and trouble-free cell, but it has a significant disadvantage, like the DMFC cell. It is a high content of water in the cell, in particular in the electrolyte. This causes problems at temperatures below 0 °C. Admittedly, supplying a small amount of fuel to the cell during a stoppage would allow for self-heating of the cell, but this solution could prove to be uneconomical. In addition, a working temperature not exceeding 80 °C may be too low to heat the cabin during the winter, and the use of electric heaters would significantly reduce the power allocated to the propulsion system. The problem also occurs at high temperatures and is related to the need for electrolyte humidification [21, 22].

# Comparison of the energy efficiency of an internal combustion engine and fuel cells

The efficiency of fuel cells, unlike internal combustion engines and thermal circuits, is not subject to the restrictions of Carnot's circulation. The internal combustion engine is characterized by a narrow range of operation at maximum power, while fuel cells are characterized by high efficiency in a wide range of power and temperatures. Therefore, internal combustion engines are suitable for operation at constant loads and fuel cells with variable loads [23-28].

The efficiency of converting energy from fuel through cells is also subject to limitations related to thermodynamic principles - but these are completely different limitations than for thermal engines. In the case of thermal circulation, the efficiency depends, according to the Carnot equation, on the upper temperature ( $T_1$ ) and the lower heat source ( $T_2$ ) [26].

$$\eta_c = 1 - \frac{T_1}{T_2} \tag{3}$$

Despite the use of new technologies in internal combustion engines, it is still not possible to achieve a significant increase in energy efficiency, which is closely related to fuel consumption, the combustion of which causes pollutant emissions such as nitrogen and carbon oxides, hydrocarbons and solid particles [23, 26].

The theoretical efficiency value for fuel cells is described as follows [27]:

$$\eta_{th} = \frac{\Delta G}{\Delta H} = 1 - T \frac{\Delta S}{\Delta H} \tag{4}$$

Where:

 $\Delta G$  – change of free enthalpy (normal energy of Gibbs exchange) reaction [kJ/mol],

 $\Delta H$  – heat of reaction of the chemical process (change of enthalpy) [kJ/mol],



 $\Delta S$  – change in entropy as a result of a chemical reaction [kJ/K\*mol],

T – reaction temperature [K].

Where water is a reaction gas product,  $\Delta H$  energetically corresponds to the hydrogen heating value. However, if water is a liquid product,  $\Delta H$  corresponds energetically to the heat of combustion. Therefore, the theoretical efficiency of the fuel cell (calculated from the formula 3), in the liquid state is 83%, and in the gaseous state up to 95% [25, 27, 28].

Fuel cells are more efficient under part load operation than the ICE. These are not limited by the Carnot efficiency. At full power output, the internal resistance and concentration polarization losses increase resulting in the loss of fuel-cell efficiency and it drops close to that of the ICE. Efficiency of fuel cell compared with that of gasoline and diesel engines is presented in Fig. 5 [29].



Fig. 5. Comparison of efficiency of fuel cell with conventional internal combustion engines Source: [29]

## Conclusion

Currently, hydrogen as a fuel in the automotive industry is used in two previously described ways: in internal combustion engines and in electric motors with fuel cells. The second solution is much more frequently used - there are real prospects for replacing traditional cars with electric cars powered by hydrogen fuel cells. The development of hydrogen technology is progressing at a considerable pace. However, to be able to talk about the full commercial success of this technology, solutions are needed to reduce the costs of hydrogen acquisition and storage. A realistic picture of technological and economic opportunities pushes the vision of a global hydrogen-based energy system to use hydrogen as a co-existing energy carrier to ensure energy stability and the development of a sustainable energy system. It is also very important to constantly improve fuel cells, which will increase the lifetime, electrical efficiency and improve the proper work temperature.

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# THE REPUBLIC OF FINLAND – SECURITY POLICY AND DEVELOPMENT PROSPECTS

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#### Abstract:

Taking into account the dynamism and multi-faceted nature of contemporary threats, states create their own security concepts, adequate to the current situation. The security concept pursued by the Republic of Finland is based on a policy of non-alignment, i.e. remaining outside the structures of military alliances. The accepted research problem is to answer the question: how does the Republic of Finland create its own security in the 21st century? Consequently, the research area will be concerned with the concept of national security of the Republic of Finland after 1991 in the Northern Europe region. Adequate to the accepted research problem and research area, the following hypothesis has been put forward: historical experience suggests that the maintenance of the policy of non-alignment by the Republic of Finland will be an effective solution against contemporary threats to the modern world. Therefore, in order to meet the requirements of the assumptions of scientific, the characteristics of Finland were initially presented. In this text, reference is also made to the neighbourhood policy of the Republic of Finland. The next part is made up of challenges, opportunities and threats of the Republic of Finland.

#### **Keywords:**

Republic of Finland, security policy, policy of non-alignment

## Introduction

The ever-changing world is creating new, unpredictable threats. Ensuring safety of population is always placed in the overriding objectives and interests of both individuals and states. In the past, state security was influenced mainly by determinants such as politics (power), economics (economy), strategy or military power [1]. In the 21st century, their value has not changed, but the development of civilisation has also brought a negative impact. Today, science and technology, together with well conducted policies, efficient economies and well-developed strategies, are able to face new threats. They also make it possible to take advantage of opportunities for the development of one's own society. It is a fact that military force is still a factor influencing the position of a country in the international system, but in order to think about external security, it is important to guarantee the nation's internal security. Synergies between them are therefore necessary.



## The security environment of the Republic of Finland

Starting with security environment analysis, Finland (Finnish Suomi) is located in the northeastern part of Europe and is one of the Nordic countries. Finland is a lowland country, heavily forested and rich in lakes. The western and southern borders of Finland are natural and are delimited by the Gulf of Bothnia and the Gulf of Finland. It is worth noting that between the two bays there are also moraine hills, which are used as defensive elements. In addition, Finland neighbours Russia (1313 km), Sweden (586 km) and Norway (729 km) [2]. Finland is a parliamentary republic in which the President (elected by universal suffrage) holds the office of Head of State. The legislative authority, on the other hand, is the responsibility of the government and the unicameral parliament, which consists of 200 members also elected by universal suffrage [3]. Finland stands out from other countries with a relatively high level of satisfaction and trust in politicians and public institutions [4].

On the other hand, the climate is characterised by a fairly cold winter and a sunny summer [5], which results in a shorter vegetation period of plants and thus in a reduced agricultural productivity. The area of the Republic of Finland covers about 338,000 km<sup>2</sup> and the population is about 5.427 million [6]. As a result, Finland is a sparsely and unevenly populated country. The dominant majority of the Suomi population is made up of native Finns (92%), followed by Swedes (6%) [7]. In Finland, nickel ore, copper, zinc, iron, chromium, gold and silver are mined. However, there is a lack of energy resources, which is a big problem in view of the increasing level of energy demand. As a result, imports of energy raw materials are in the first place. Due to the large forestation of the territory, the basic branch of industry is the processing of wood, e.g. for the production of paper. Finland also has an extensive armaments industry, which provides virtually all the weapons and equipment needed for its own army. Other major industrial sectors include: mechanical engineering, iron and steel industry and independent metals. Fishing and reindeer husbandry are traditional and well-developed sectors of the economy [8].





Source: M. Cywińska, Polacy w Finlandii na straży polskiej kultury, tradycji, języka oraz więzi międzypokoleniowej, https://prawy.pl/65489-polacy-w-finlandii-na-stazy-polskiej-kultury-tradycji-jezyka-i-wiezi-miedzypokoleniowej/, 10.05.2019.



Finland is a state focused on the innovativeness of the economy, on which it spends almost 4% of its GDP. It ranks fourth in terms of an environment conducive to innovation [9]. It is worth noting that large financial outlays of the state attract entrepreneurs to develop new services, technologies or products. The innovation of the economy is expressed by the fact that Finns themselves produce electronic components for the army (Elektrobit, Elesco), starting from weapon systems to training equipment (Noptel). Human capital is an important element influencing the success of innovation in the Finnish economy. Finland has been investing in the level of education of its own citizens for years. Around 6.8% of GDP is devoted to this. Targeting the population at acquiring knowledge tailored to the specificity of the state economy allowed to obtain graduates responding to the needs of the market. Finland is a state that encourages students to start their own business already during their studies (the famous Start-up Companies project) [10].

Due to its small internal market, the Republic of Finland has to be export-oriented. As a result, its products or services must be competitive in the global marketplace. The focus on the development of technological/economic innovation and the level of education has made Finland an attractive market for foreign investors.

The next stage of the analysis of the state as a security subject is its national identity. It is expressed in a sense of cohesion and unity of society, as well as in a sense of distinctiveness from other nations in terms of tradition, culture, history. One of the Finnish nation attributes is their socalled "civic religion", namely nationalism. Its roots date back to the civil war in Finland (1918). It was then that two parties with different views took one and the same position regarding independence. During World War II, Finland was under the influence of the Soviet Union. As a result, this young state was deprived of the freedom to choose its own policy. Under the Soviet-Finnish treaty (1948), Finland's lack of involvement in the disputes between the powers was emphasised [11]. Only the collapse of the Soviet Union led to the partial abandonment of the idea of neutrality and non-aligned policy. The historical experience is reflected in the provisions of the contemporary strategic document - "Government Report on Finnish Foreign and Security Policy" [12]. This act indicates that Finland's main strategic interest is to strengthen its international position in order to ensure its independence and territorial integrity. Finland considers its own defence capabilities to be a key element in ensuring its security. The Finnish army model is based on the principle of the universal duty of defence. Finnish experiences from wars in the past (e.g. the Winter War of 1940) exemplify how important are the involvement and faith of citizens for the defence of one's own country. Therefore, there are also regional troops in Finland - consisting of citizens with military training, who know their own territory well - distinct from the professional army [13]. In addition, they are supported by local forces, most often associating reservists and volunteers in small branches. The professional army combined with the regional army and the local forces form the defence pillar of Finland. On the other hand, the impressive speed of military mobilisation and well organised territorial defence deter potential Finnish opponents. "The Finnish Armed Forces have the potential (15 000 soldiers in time P with the possibility of rapid development to 34 700 in the operational component and a high mobilisation capacity of 350 000 in time W) and are considered a real guarantor of state security" [14].



## Neighbourhood policy of the Republic of Finland

Finland's relations with the surrounding countries play an essential role in safeguarding its interests and fulfilling Finland's objectives. Finland has been cooperating with other countries in the region in the military sphere for years. Their relations are reflected in the establishment of cooperation within NORDEFCO (Nordic Defence Cooperation). This agreement provides for joint military training and exercises to improve the defence readiness of its members. Sweden is the special partner of Finland. Both countries are linked by similar historical experience, self-confidence and function outside of the North Atlantic Treaty Organisation (NATO). Finland, Sweden and Norway jointly participate in the United Nations (UN). It is worth to refer to the Article 51 of the United Nations Charter, which states that "does not prejudice the natural right of any member of the United Nations against whom an armed assault has been carried out to defend himself individually or collectively" [15]. As a result, the three countries complement each other when it comes to protecting their own region.

Finland's accession to the European Union (EU) was an important step for Finland's security. The provision of Article 17 in the "Treaty on the Functioning of the European Union" concerning the idea of common defence turned out to be particularly controversial for the EU strictly neutral states. At the initiative of Ireland, a provision has been added stating that EU policy will not disrupt: "the specific nature of the security and defence policies of certain Member States" [16]. As a result, Finland joined the EU without disrupting its own policy of non-alignment, while at the same time increasing its own security. The adopted solution also led to the expansion of the Finnish sphere of influence in the international environment. EU member states (e.g. Germany) have become main receivers of Finnish goods.

With the decision to join the European Union, the Finns decided to join the Common Foreign and Security Policy (CFSP). One of the characteristic activities undertaken by Finland under the CFSP was the creation of the "Northern Dimension of the European Union" [17], which has become a platform for closer cooperation between the EU and Russia. Following the entry into force of the Lisbon Treaty and the introduction of the European Security and Defence Policy (ESDP), Finland has started to be more active than before. This is reflected by its participation in the EU civilian and military operations and in its efforts to management crises. An important element of ESDP cooperation is the so-called Nordic Battle Group.

The Russian Federation is the most unpredictable and at the same time crucial for Finland's interests. In the past, Russia's aggressive policy has struck Finland's independence. However, the Republic of Finland is trying to maintain stable relations with Russia – mainly in terms of trade. In response to the growing aspirations of the Russian Federation to expand its sphere of influence (Russian-Georgian war), Finland is strengthening its cooperation with the United States and NATO [18]. The idea of fully joining the North Atlantic Treaty Organisation remains controversial among Finns. From a NATO perspective, the accession of Finland and Sweden could prolong the north-eastern flank of the alliance. The Republic of Finland would enter under the so-called NATO 'protective umbrella', which would send a signal to Russia that attempts to exploit the Finnish zone would involve an American reaction. It is clear that Finland's accession to NATO would result in



the loss of the non-aligned policy that Finland is very keen on (especially for historical reasons). As a consequence, Finland is now engaged in carrying out exercises under American (Baltops) and NATO (BRTE) command [19]. This solution develops the capabilities of the Finnish army while maintaining independence in the event of an attack on another NATO member.

## Challenges, opportunities and threats of the Republic of Finland

As a result of the described characteristics of the state as a security entity, the next step in the Finnish security analysis is the challenges, opportunities and threats that Finland is facing.

One of the key challenges for the Republic of Finland will be increase in its energy demand, which will result in increasing dependence on imports of energy raw materials. In 2008, the Finnish government adopted the Climate and Energy Strategy for 2020, which highlights increase in energy consumption. This document forsee ending import of energy raw materials and, at the same time, increasing share of renewable sources. The fulfilment of assumptions contained in the Strategy (including the expansion of nuclear power plants) is an opportunity for Finland to become an energy-independent country. Otherwise, the threat will be its total dependence on Russia, the leading exporter of energy resources, which may use raw materials as a "bargaining chip" to force actions in line with its interests. Due to Finland's neighbouring country and the Russian Federation aggressive policy Moscow may become a source of potential threats. It is worth mentioning the strategic role of the autonomous region of Finland - the Åland Islands, located between Finland and Sweden. Their occupation by the army of a potential aggressor would not only complicate the defence of Finnish territory, but also limit the possibility of obtaining assistance from Sweden, while blocking – airspace and maritime communication routes. Literature on the topic suggests that due to the strategic position of the Åland Islands, Russia is trying to block the Finns and Swedes from joining NATO [20].

The challenge for Finland will be increasing number of immigrants from the Middle East, Africa and Asia. Due to its high level of social benefits, Finland is an attractive country for immigrants. However there may be fighters from the so-called Islamic States, whose presence increases the risk of terrorist activities, hiding among people fleeing from the war [21]. In addition, the threat will be the growing nationalist movements among the Finns, which is manifested by the activity of anti-immigration patrols, a special group called "Odin Soldiers" [22]. These developments will create tensions between Finnish citizens and immigrants in terms of e.g. the value system, religion or culture.

The growing risk of hybrid threats is key test for the Republic of Finland. Their flexible character connected with possibility of combining conventional and unconventional forces may effectively lead to destabilization of the state. The paralysis of electric power stations or water installations would have direct impact on citizens and may result in the dismantling of society. Hybrid attacks may be initiated not only by states (e.g. Russia), but also by terrorist organisations. Consequently, the challenge for Finland will be to establish a comprehensive system of protection against hybrid threats and, if they occur – to minimise their impact on the country.

The next challenge for Finns is demographic change. The progressive ageing of the population, internal migration, depopulation of certain areas and, consequently, the decline in the natural

growth rate will lead to a partial inhibition of economic development. Therefore, the economic pillar of the country will be threatened, which will lead to a decline in GDP and a lack of interest of foreign investors.

The next step in the security concept is to present a potential scenario for the Republic of Finland's activities in the security area by 2040. The policy of non-alignment, both in history and today, is of great importance to the Finns. As a result, the country will not decide to join the North Atlantic Treaty Organisation. Such a solution does not preclude further development of cooperation with NATO or the United States. However, if there is a risk of a military conflict involving both the Russian Federation and the United States, the Finns' position on NATO membership may change.

Looking ahead, Finland will continue to develop its own defence capabilities. This is mainly due to reasons relating to the so-called 'turn to Asia', i.e. a shift in the United States' focus from Europe and simultnous reduction in expenditure on the defence of European countries. Technologically developed and well-trained Finnish army and territorial forces will be a pillar of security, acting as a deterrent to opponents.

In addition, Finland, by establishing cooperation with other countries in the region, including NORDEFCO, will seek to jointly strengthen common security. Maintaining good relations with Russia will theoretically prevent direct military aggression. Moreover, achieving energy self-sufficiency will not only strengthen Finns in the international arena, but will also free them from potential pressure from the Russian Federation.

Active participation in the European Union will make it possible for Finland to pursue one's own economic interests. Technological innovation and the level of education of citizens will continue to be among Finland's priorities. The increase in funds for both objectives will make it possible to secure the state in this respect. Export of technologically advanced products will effectively increase Finland's production capacity, improve the country's competitiveness on the global market and allow for the enrichment of the society.

In view of the influx of migrants, the use of temporary stay, the change of migration policy and the introduction of the necessity of minor social works will effectively reduce the number of people arriving. In the context of the radicalisation of Islam and the use of terrorist methods, it will be necessary to establish international intelligence cooperation. As regards hybrid threats, Finland will work with the EU and NATO to develop specific safeguards or reduce the effects of their occurrence.

#### Summary

In conclusion, Finland is an active state in the international environment for its own security. Finns are aware that nowadays no state can defend itself, especially against hybrid threats. As a result, they are engaged in partnership with their neighbours and in the ideas of common security of the region, while at the same time constantly improving their defence capabilities and following the policy of non-alignment, which is manifested by the lack of membership in NATO. The words of the military strategist André Beaufre are relevant to the Finnish strategy, stating that 'the strategy is the only applicable perspective because it does not try to guess the future, but to build it methodically from its own intentions and possibilities' [23]. Finns consistently use their own

capabilities in the face of a changing future by, among other things, striving for energy independence. The involvement of the whole of society in the defence of its own country is part of the concept of deterring opponents. Conscious choice of innovations and raising the level of social capital effectively contributes to the economic growth of the country. Additionally, when analysing history and contemporary international relations, it should be stated that Finland, due to its geographical location, is a small state participating in the game of the superpowers. As a result, the establishment of a strategic partnership with the West and the East is a way to overcome potential threats.

This piece of analysis thereore confirms the hypothesis presented at the beginning, namely that Finland's policy of non-alignment is adequate to the challenges, opportunities and threats the state faces and will be able to cope with the threats of the modern world.

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# LETTERS OF LOVE. JOANNA BOBROWA IN THE CORRESPONDENCE OF ZYGMUNT KRASIŃSKI

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#### Abstract:

Love in the life of Zygmunt Krasiński occupied a special role. Two women deserve attention here: Joanna Bobrowa and Delfina Potocka. They radically changed Krasiński's way of thinking about love, especially Bobrowa. She was the first woman thanks to whom the poet could see what sensual and carnal love is. The affair that lasted few years was perfectly in line with the romantic idea, subordinated to the poet's entire life. The relationship with Bobrowa was a perfect example of romantic love, governing its own rights, not subjected to any conventions. And though the love did not survive, as Krasiński - due to his father's order - ended his relationship with Bobrowa, there is no doubt to say how enormous role it played in his life, which we can see reading a large correspondence of the poet, whose value can not be overestimated, and which perfectly shows us the life of romantic heroes.

#### **Keywords:**

romanticism, love, letters

#### Introduction

It can be said a lot about romantic love, but there is no way to define it, especially since romantics rejected all the norms and patterns. Love enabled to be free of accepted standards, gave a sense of infinity and limitless, thereby transmitted a lover to "a sphere reserved for selected ones, masters, saints, heroes and artists" [1]. Which one of the romantics would not want to experience such a state? Krasiński would definitely be one of them. He wanted not only to love but "to go mad about love" thus everything was subordinated to the affair with Bobrowa. Not only he changed his travel plans, but he also stopped writing because: "First, you need to live to be a good writer. I give up writing for some time and I am starting to live: I will knock back few cups of weddings, few cups of pain, start to love humanly, suffer humanly and then sit and write down all of these – and that will be good. Matter is not such a mean thing as I thought so far, as for all eternity, we will be in material bodies. There is no spirit without matter, as much as there is no thought without a word and no body without form. There are delights and there is material poetry. This one shall be harmoniously blended with the spirit poetry, and then a newly poeticized man would rebirth, thus



everyone will recognize him and worship him. Otherwise no one would feel sympathy for him, otherwise it would be an inorganic creation on earth [...]. So I have modified and I have come down from the clouds and until now the clouds for us have stood as the baldachin over a head, not as the stay or the flat.

From the letter to Gaszyński, it appears that Krasiński undergoes a large metamorphosis under the influence of his feelings for Bobrowa. He understood that it is difficult to write about love if you do not know its taste. Until now, love was only known for him from reading, stories or observations, and the feeling he had previously had for Henrietta Willan was only a substitute for what he could get from Bobrowa. This time, Zygmunt wanted to experience something new, both as a man and as a writer. He wanted to see if "there is a passion in a big way, love beyond the limits set for a man" [1], and romance with Bobrowa was the best opportunity for that. Krasiński no longer rebelled against matter, which he had noticed as a necessary evil not so long ago. He understood that it is an indispensable ingredient of love, which: "[...] is subject to the life interests of the species and the natural laws of lust and social rights of morals, and therefore has to reckon with something such as erotica, time, marriage and family. Romantic theory of love, which tried to distinguish the feeling of all this, fell into naivety" [1]. And this Krasiński wanted to avoid this time. As he said, it is time to "step down from the clouds" and start living for real. In a short time, the poet became convinced that the love adventure that had happened to him was an extraordinary event, both in positive and negative terms.

## Zygmunt Krasiński and Joanna Bobrowa

Zygmunt and Joanna met in the spring of 1834 in the house of the Bóbr-Piotrowicki family in Rome. Even during the first meeting, Bobrowa aroused Krasiński's interest. The beauty of her has played a significant role here. Joanna Bobrowa was considered one of the most beautiful women, which can be stated on the basis of the description of Ferdynand Hoesick: "Tall, slender, shapely and dignified in movements, auburn-haired, in a crown of extremely luxuriant, reddish hair, with marvellous sapphire eyes [...] with a pale, dull complexion, extraordinarily delicate, with features that are not regular and classic, but rather composed of an unspeakably charming and grateful whole, characterized above all by the physical glamour in a woman, and this charm largely affected men to be very much interested in her [...]" [3], including Krasiński. It is difficult to say unequivocally what impression Zygmunt had on her, but everything indicated that he had charmed her as well. He was a perfect candidate for a romantic lover. Thanks to him, Joanna - "a true daughter of her time" [3] - could feel like the heroine of de Stäel's novel, or Countess Idalla from Słowacki's "New Dejanira".

Bobrowa wanted new emotions, sensations, passions, and the marriage with Teodor was not enough for her. She considered them the most prosaic form of love, even though her husband loved her very much and made sure that she would not lack anything. For her, however, it was not enough. So when Zygmunt appeared, Bobrowa's dreams began to take on real shape. The atmosphere of Rome was still conducive to the development of feelings. A joint sightseeing of the city, evenings spent in the theatre and opera or friends, brought Zygmunt closer to Joanna: "time went down in conversation or listening to Danielewicz's music, and a wonderful game of it,



especially when he played Beethoven or Mozart, if it could fall its listeners into a reverie, surely, they will include Ms. Joanna and Zygmunt to an even greater extent than others present" [3].

Krasiński quickly became convinced that Bobrowa was an excellent woman for a mistress. However, he did not realize at the time what consequences this romance would bring. For now, Joanna was an ideal for him. Zygmunt imagined that she was his Beatrice, which the poet must save from her husband "tyrant". He believed that she was not happy with Teodor, who did not appreciate her, did not respect her, and most of all he did not love her. According to Krasinski, Bobrowa was a being who "never, never had happiness" [4] as he wrote in a letter to Słowacki. However, this was not true, but it was not about the truth. Romantic love was governed by different laws: "Its goal was to disprove the sense of reality in the sphere of will and imagination [...]" [1]. Often, those in love fell into exaggeration, deliberately embellished, coloured, dramatized to emphasize the role of love or justify their behaviour. After all, if Bobrowa were a happy married woman, what purpose would she look for a lover? On this basis, Krasiński said that under the angelic smile of a beloved one must be hidden deep sadness and despair, and hence, she needs someone to free her from the hands of the "hangman". Naturally, Zygmunt was supposed to be the one. At that time, Krasinski did not take into account that Joanna was only bored with the monotony of her marriage and needed a change, and even if he realized it, he would not accept it. It was too prosaic, therefore, when Joanna after more than a year of acquaintance admitted that she did not respect her husband, Krasiński considered it his triumph: "[...] Probably she did not like her husband and she had something to dislike, however, with what delicacy she always has been saying about him [...] how she defended him against me, long before she finally admitted, but only to me, that she did not estimate him. The highest one, the last one was my victory to forced it on her! " [5]. To persuade the mistress to utter a negative opinion about her husband was the best proof to see how great influence Krasiński had on Bobrowa.

Zygmunt was able to manipulate people perfectly, he knew what to say and how to behave to convince his reasons. So, how much was Krasiński in love with Bobrowa, and how far was it from his side? In the end, it turned out that the romance with Bobrowa was for Krasinski only an adventure thanks to which the poet could fully feel what romantic love is. Krasiński did not intend to bound with his wife, although for a long time nothing indicated it.

The beginning of the romance, as it usually happens, was only rich in pleasure. Nothing interfered with the happiness of lovers. First, a joint tour to Rome, then a trip to Florence, Venice, Munich and Cologne. These places, selected not accidentally, fostered the development of feelings between Joanna and Zygmunt. A pair of lovers did not even bother the presence of Teodor. The fact that they had to hide their feelings from Bobrowa's husband, and then even before Zygmunt's father, on the one hand complicated the already difficult situation, and on the other fuelled the feelings. Joanna and Zygmunt were aware of the necessity of keeping up the pretense, mainly because of the possibility of a scandal. Initially, both Krasiński and Bobrowa did not pay attention to rumours circulating about their affair. As befits romantic lovers, they were not interested in the outside world at all. They rejected accepted norms and conventions. As a result, they were exposed to the lack of acceptance and rejection, which in the near future would negatively affect their relationship.



Bobrowa, initially convinced of the uniqueness of the feeling connecting her with Zygmunt, ready to fight the whole world in defence of her love, with time, began to feel remorse, both in relation to Teodor and daughters left in Podole. She understood that her place was with the family. In addition, she realized that love for Zygmunt has no right to exist in real life. Every great love, according to the intention of the romantics, had to be filled with pain and suffering, with no chance of a happy ending. That's what Bobrowa thought. She left Krasiński at the end of September, hoping to keep a letter contact and have a possible meeting next year. Tears and attacks of hysteria took place at the farewell. Despair, caused by parting with Zygmunt, was accompanying the pair of lovers just a few weeks before Bobrowa's departure to Ukraine, which is why the poet received her departure with great relief, to which he confided to his father in one of the letters: "You were still fatal humour yourself ..., spasms, tears and long silence. It's all very heartbroken, because I truly love her, with no crazy imagination, but honestly, truly with my heart. I was even relieved when she was gone. I miss her, but somehow I feel more free" [4]. Krasiński's behaviour was a big surprise for Danielewicz. He could not understand the poet's way of thinking: "Sad he is sad, whether under the watchful eye of a lover or away from her. If only Mrs. B. thought about it, she would see that instead of amusing her, he adds her boredom. Such love I do not comprehend, I do not understand, and sooner I will lose my mind than I will" [6].

After the departure of Bobrowa, Zygmunt left Frankfurt and, together with Danielewicz and Sauvan, went to a winter stay in Rome, where he could finally rest and improve his health. He also intended to return to reading and writing, but the melancholy and apathy in which he fell, broke all his plans. Zygmunt still was taking his holidays with Bobrowa emotionally, he recalled the time spent with his beloved. He was afraid that he would never have such intense experiences again. He was afraid that from then on his life would be filled with boredom and monotony. The only cure for his distress was correspondence with his beloved, which allowed him to experience the past moments in his imagination. In one of his letters, he referred to the "Parisian", the opera of Dionizetti they saw together. A few months later, he went there again to recreate the image of his Joanna in his head. Florentine music was to help him, and they listened to it there: "May my imagination be blessed, if she caused me torment, she also gave me pleasure. It has the power that resurrects, gives life that makes fun of time and tears away its victims. I was happy yesterday evening and today the memory of the shadows that moved before my eyes, caused by Florentine music is as strong as reality" [4]. Returning to the past, especially through letters, did not give the poet as much happiness as it might seem, because "Mrs. Bobrowa looked critically enough at the wild imagination of the poet. Creativity and distance, she could keep from the lover's over-dramatic correspondence, undoubtedly lost their love. Joanna was not a grateful partner or correspondent in a romantic sense" [6].

Despite his sadness and melancholy, Krasiński did not want to free himself from the memories associated with Bobrowa. As proof of this, one of the protagonists of the then-written drama "Irydion" resembled Joanna, he gave her character traits belonging to her beloved. What's more, Krasiński intended to meet with Bobrowa again. He was just waiting for the right moment. Until then, however, he left Rome and set off for two months to Naples. He visited the famous Trenta Tre Monastery. The nuns who lived there were to foretell the future. It is not difficult to guess with


which question Krasiński went to them. He was interested in the fate of his beloved Joanna. The prophets from Trenta Tre did not leave Zygmunt with any illusions. They foretold Bobrowa's imminent death, which does not change the fact that she outlived Krasinski by thirty years. She died as an eighty-year-old woman. However, Krasiński could not know it then. After hearing the prophecy, he wanted to meet Bobrowa as soon as possible, meanwhile he had no news from her for a long time. All information that came to him did from people who were friends with the Bóbr-Piotrowicki family or poet's acquaintances. In one of his letters to the Soltan, he wrote: "I do not have anything from Dresden. I heard from the side that lord and master is trying to get the office of the governor in the country, because he was only a district marshal until now, and that's why he will not go to his wife; and therefore she would go to a health resort herself, which would be a great treat, but the Jesuits, the Jesuits! Oh! Rascals will take her away from me" [5]. The lack of news from my beloved increasingly worried Krasiński. The meeting in Kissingen was questionable, the more so because the poet was aware of the presence of spies, i.e. Jesuits. He knew that the rumours could harm Joanna, her reputation, and yet he decided to go to the health resort as soon as he received a letter from his beloved.

Bobrowa's view put Krasinski in an indescribable joy. One of his greatest desires came true. He again had a beloved woman by his side. The happiness was all the greater when Zygmunt noticed that Bobrowa like him, was eagerly awaiting the meeting. Krasiński shared his observation with Soltan: "I found her in the most bizarre state of mind, being in love with me twice as much as before, after 9 months of not seeing each other, and therefore you admit that it is like winning the lottery that does not happen to everyone" [5]. Krasiński felt himself the chosen one. He even stated that: "I will not experience such happy days any more. An unbelievable soul, noble above all. [...] Adam, maybe you will be glad to know for a moment that the one who loves you, has got to paradise and is writing to you from there" [5]. The paradise, that the poet wrote to the Soltan, quickly turned into a hell. The romance of Joanna and Zygmunt became a loud episode among the patients. Teodor was so close to finding out about the betrayal of his wife. In order to avoid this, the lovers limited their meetings. From then on, they could only see each other in the evenings, which after a while became burdensome and exhausting for both of them. Bobrowa, contrary to appearances, was not indifferent to the public opinion. The gossips which got to her ears, were clearly disturbing her. Nor did she have enough strength and courage to defy them: "There is no scandal, no mockery, no anger that would drink my poor fill [...]. The days there made my life hell, only in the evenings did I just rest with her, when everyone had fallen asleep, in this living room memorable forever, among the hydrangea shrubs, by the light of lamps, by the glare of her tearful eyes. There her whole soul, good and noble, melted in tears before me. There, tormented because of her love, I loved her even more than before, but I felt an enormous obligation, a stern necessity of leaving, so as not to harm her reputation" [5]. Krasiński kept his word and left. Previously, however, it was not without dramatic scenes. This time, Zygmunt appeared in the main role. He believed that the only way out of this hopeless situation was suicide. In this way, he tried to manifest his suffering caused by the inability to be with his loved one. Krasinski tried to kill himself with a dagger, but "her hair saved him." Once again, Zygmunt attempted to take his life two months

later during his stay in Venice. Waiting for Bobrowa the poet struck himself with a dagger. This time, Danielewicz was the one who saved him.

Never again, Krasiński did not try to commit suicide. It did not mean, however, that the love problems were over. It was just the opposite. You could say that they grew by day. The wave of the rumours against Zygmunt and Joanna turned out to be the smallest obstacle on the way to happiness. This year's holiday showed that there is more that divides Kraiński and Bobrowa than bounds them, ranging from characters to marriage. As it turned out, each of the lovers had completely different point of view or different expectations.

For Krasinski, from the very beginning, the romance with Bobrowa was just a love adventure that would end sooner or later. There was no question of marriage, which can be deduced from the letter to Sołtan: "She took all my past, but she couldn't my future. I knew it from the start" [5]. Zygmunt could not marry Joanna for obvious reasons. First of all, she already had a husband and two children. Second of all, Zygmunt did not want to marry. Apart from the reluctance to the institution of marriage, he could not imagine Joanna as his life partner. His father shared similar view, who was already looking for a suitable candidate for a wife. Hence, in May 1837, the idea of marrying a son with Julia Potocka had born, especially because: "She was admired by the poet because of her beauty, pose, mind, musical talent, and from a dowry amounting to two and a half million Polish zlotys" <<i n Galicia, not under Russian government », which gave more political independence. Parents of the maiden were very willing to the marriage [...]" [6]. Therefore, nothing prevented Krasiński and Potocka from getting married. At the last moment, Zygmunt, however, changed his mind. In a letter to Soltan, he wrote: "After all, I will not get married. Mathematical reasoning would do nothing against this deep affection, destroying calm of a woman unknown to me I shall not give her the last blow. Humanly speaking, a huge mistake am I making. Not am I a fool, to not know I am fool. I am letting go of the only marriage, that could provide me certain independence and for few years, some illusion of happiness that beautiful is. One day I will probably get married, but with some mediocrity, with some obscenity, with something not as perfect as Julia. But can I behave differently?" [5]. Everything indicated that Zygmunt deliberately released the only chance for happiness at the time. Although the relationship with Bobrowa was far from ideal, Krasiński did not want to deprive his beloved of peace, he did not want to "kill" her, as he said. He was also afraid that they would call him a "deceitful man", and Krasiński, contrary to appearances, wanted a good opinion. Therefore, not only Bobrowa was struggling with these kinds of problems.

After rejecting the marriage proposal, Zygmunt left Vienna and then went to Kissingen, where his father waited for him with another matrimonial offer. The general realized that convincing his son to marry Eliza Branicka would not be an easy task. In the first place, he demanded from Zygmunt returning to the country and breaking all ties connecting him with Bobrowa. While Zygmunt did agree to come back to his homeland, he did not want to bring an end to his acquaintance with Joanna. No rational arguments reached him, especially because Bobrowa was constantly fighting for Zygmunt's love. She had no intentions of giving up so easily. She used a variety of methods to achieve the goal. However, it is to be admitted that she did it rather ineptly. With her behaviour, she was pushing away her beloved increasingly - for instance, she repeated

several times how much she would like to be married to Zygmunt. She was ready to divorce her husband only so that Krasiński would stay by her side. Her behaviour clearly differed from romantic morality. Bobrowa was nothing like the lover from Krasiński's reading, "she was not a real artist of romantic love. She was completely emotionally involved, in a human way, however, her experiencing the love with Zygmunt was too monotonous, maintained in the tone of hysterics, crying, sometimes even fury tiring of her monotony, tedious and hard to bear for a lover, shaping every erotic adventure in his rich imagination. The hysteria of the two resulted in a tense atmosphere, to unprecedented proportions, their exaltation reached the limits of madness" [6].

Bobrowa's behaviour was not favourable to the romance. Their relationship was not far from falling apart, the more so because the poet was already aware of the kind of woman Joanna was: "... such a misled mind belongs to this woman, so tangled, so unstable in undertakings, timid at every step, passing from the fiercest passion to icy cold, being afraid of the things she demands the most, and demanding what she's the most afraid of, in a way that I no longer think to serve my soul as a reflection of each of her changes of mind. I have been her mirror for such a long time. Now let her find out what it is not to be yourself, but someone else" [5].

The fragment of the letter to Soltan above, could indicate that the relationship between Zygmunt and Joanna had definitely ended. Meanwhile, it was not like that at all. Krasiński was still living in a world of memories, still waiting for letters from his beloved. What is more, he wrote to her letters himself, he sent her gifts, for example, binoculars with a short poem beginning with words: "I want you to look at people through my glasses". Another time he sent a silver cross, which was to symbolize the end of a love adventure. In Krasinski's case, however, words and intentions did not go hand in hand with deeds. The poet contradicted himself. In spite of harsh criticism of Joanna's behaviour, he still agreed to meet her. He could not refuse her.

The lack of consistency in Zygmunt's actions prompted the general to proceed. He knew that as long as Bobrowa did not disappear from Zygmunt's life, all plans of his son marrying Eliza Branicka, would come to an end. The general went to Zahajec in Ukraine to talk with Bobrowa. He made her promise in written that she would never meet Zygmunt again or correspond with him. Bobrowa had to accept the conditions of Wincent Krasinski, but she did not resign from Zygmunt. In order to keep her word, she sent a letter through her friend. She counted on a success in regaining her beloved. She did not know, however, that Krasiński was meeting another woman, Delfina Potocka, the second great love of the poet.

And although the affair with Bobrowa was in the past, there is no doubt that it was forever carved in Krasinski's memory. It was an experience that fully reflected the character of romantic love. However, to what extent were they true feelings, and to what extent were they not? It is difficult to determine today, especially if we are aware that Krasiński complied his whole life with the romantic idea. His existence resembled a theatre play in which he wasn't only acting, but most of all directing. He chose the actors with great care, who, like romantic heroes, played the roles assigned to them, thus realizing the vision of the poet. Joanna Bobrowa undoubtedly played one of the leading role in the emotional life of Zygmunt Krasiński.



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