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BIOHACKING IN COMPETITIVE SWIMMING

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Apstrakt

Prosperity and progress in competitive swimming can be observed as the results of acquired knowledge about human movement in the water environment. It is based on learning and, regardless of the period of development, with the development of science and technology in a broader sense, a significant causality can be seen. The development of competitive swimming in the new technological and informational environment takes place through the intensification of the swimmer's self-awareness process, whereby the swimmer gains knowledge about personal characteristics and the effects of the training program, in the direction of efficiency in further process of individualization of his practice. Self-awareness is a cognitive process that is at the core of an athlete's progress today. Its essence can also be presented as "hacking your own body and mind" (biohacker). By hacking (self-hacking), the swimmer learns about the reactions of his organic systems, recognizes their reactions and anticipates the course of expected adaptations to various training and competition stimuli. Based on the information acquired on that way, the swimmer has the opportunity to understand the factors of his functional system, as well as to direct them to a higher level of functioning through self-awareness, which will enable him to progress towards a better "version" of himself. Therefore, the subject of this paper is biohacking as a concept - a trend in training and competition practice, during which, with hacks, we intend to encourage the effectiveness and efficiency of organic systems, and the overall productivity of swimmers. The aim of the paper is to „shed light“ on the swimmer's self-hacking as a growing step in the process of learning and self-awareness, during which they acquires, analyzes and learns from direct perception and during which the swimmer's cognitive skills are developed through a technological and digital environment.

Keywords: SELF-HACKING / SWIMMING / SELF-AWARENESS / PERSONAL DEVELOPMENT

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DEFINITION OF THE TERM AND DEVELOPMENT OF BIOHACKING

Biohacking (eng. Biohacking / DIY Biology) is a relatively new idea that, in the last twenty years, has emerged as one of the fastest growing in the field of modern biotechnology. At first glance, it is a new trend, with which an individual strives to progress towards self-knowledge through hacks (trick; in the sense of the subject of this paper: self-experiment, invention, method, instruments...) and to provide qualitative and quantitative information important for the efficient functioning of the body and brain.The essence is that an individual approaches the hacking of his body and mind ("biohacker"), so that in the first step he recognizes, and then clearly specifies, remembers and understands as much information as possible about his organic systems through various training and competition situations, and based on of the thus acquired "new" information translates the factors of the functional system that builds the result, to a level that will enable to an athlete to move towards the best "version" of itself in the chosen area of cognition.

The semantics of the term indicates a close connection (both linguistic and spatial) of human locomotion, human biology and computer science, which, thanks to the acquisition of selected data from the immediate learning of swimmers, strives to verify the causality of the training and competition process. In a broader sense, biohacking represents a system of actions that, through acquisition processes, contribute to self-knowledge in different ways, indirectly leading to an improvement in the quality of life and making everyday life easier. In a word, they represent a powerful tool in achieving the goals of modern human being.

In its rough form, biohacking as a "movement" arose in the 50s and 60s, as a result of a pronounced human tendency towards self-knowledge, as well as to, as much as possible, study and adapt own environment (Asprey, 2019). These statements, as a space of cognition, can be characterized as the first period of development of biohacking, given the fact that in this phase its basic principles, which have been maintained until today, were formed, and they imply that "anyone everywhere can biohack". In the following decades, this caused creation of "home laboratories", in accordance with the goals of the individual, but also with the development of a whole network of biohackers who place their knowledge in „incubators“ and world-famous laboratories of technological progress. The exact moment and origins of biohacking in the form it has today cannot be determined with particular precision, but certainly the first iGEM[1] competition, held in January 2003 at the Massachusetts Institute of Technology (MIT), was an extremely significant step in the formation of the biohacker community. Since we live in an information society, dominated by innovative information and communication technologies, it is a completely natural tendency to exploit technological innovations in the learning process, to which the development of the Internet has contributed today. One of the causes of the speed and expediency of learning is the almost instantaneous transmission of information about activities carried out in real time. We are witnessing the development of direct data transfer from portable devices, which indirectly affects perception, forms attention, and develops cognition that directs future progress through programming, development and improvement of training methods, as well as the organization of free time and sports time. Although at first only used to monitor health, general condition and basic physiological parameters, portable technology has become a new source of perception of physical activity, providing the possibility for individuals to "quantify themselves" in very simple ways (Wolf, 2010), but also to compare themselves with others. Self-hacking is, in fact, the *summa summarum* of all the activities that an individual undertakes every day in order to make the most of his potential. Consequently, and in relation to the subject of this paper, this term (entity, subculture...) includes cognitive skills in the process of improving nutrition, hydration, supplementation, quality of sleep, training, recovery, but

[1] International Genetically Engineered Machine - international competition in genetic engineering; world competition in synthetic biology.

also ways of thinking. They also include activities such as various types of meditation, coordination, perceptual experiments and so on. Clearly, defining this phenomenon makes it much easier to analyze its role and place in the swimming training and learning system.

BIOHACKING IN COMPETITIVE SWIMMING

"Man is a being of the earth, a being that steps, stands, walks and moves on solid earth" (Schmitt, 2002). However, for those who consider swimming as an essential part of their being, water is a source of resistance to movement and for movement. Water is perceived as an *arche*, a primary element, as something that, *per se*, determines the relationship with the world of sports in which they participate. Swimmers spend their sport time in the water. The common denominator of their aspirations is to learn and progress through improvements in the general state of both mind and body. In this way, a person not only exercises, but also "creates new cultural values through training and exercise in the water" (Jevtić, 2011). Intentions about learning and progressing through swimming are deeply imbued with the core ideas of self-hacking. In other words, swimming can be observed as one of the powerful sources of "hacking of human nature", considering that a large number of methods for improving neuro-physiological functions, biomotor adaptations, but also the response of the immune system itself, are based on staying and swimming in cold water (Kox, van Eijk, Zwaag, van den Wildenberg, Sweep, van der Hoeven, Pickkers, 2014). In other words, the causality of the entities swimming and biohacking can be further observed through two consecutive processes, namely:

- hacking as a function of self-knowledge (of swimmer)
- hacking as a mediator (or catalyst) of understanding and further development of swimmer and swimming.

The results of the analysis of information sources, which are included in the subject of this work, singled out several areas of deduction, and they are:

SELF-HACKING OF PSYCHOLOGICAL PREPARATION OF SWIMMERS

Coaches, athletes and sports psychologists who work with them greatly agree on the importance of mental strength, mental fitness and its connection to elite sports achievements. On the determinants of achieving athletic success, until recently there has been a very small number of studies (Mellalieu, Hanton, 2010)(Crust, 2007). If we take into account the data that the average athlete needs at least three to four hours of training on a daily basis, six to seven days a week, in order to achieve somewhat more noticeable results, it is not difficult to conclude how mentally and physically (Ekmekçi, Miçooğulları, 2019) demanding and exhausting the processes are, especially when it comes to the fact that athletes perform demanding mental actions simultaneously during the performance of certain motor tasks, such as maintaining concentration, visualization, directing and focusing attention, etc. In order for the cognitive components that affect sports skills (such as focus, calmness, self-motivation, coping with pressure, cooperation, anxiety...) could be more adequately recognized and then used, it is necessary to approach the methods of training aimed at enabling athletes to improve their mental skills and apply them as well as possible in direct training and competitive activity. Thus, the training practice is filled with the principles of autogenic training which, as a psychologically recognized technique, is used in the fight against stress of psychogenic origin. It is one of the oldest and most famous psychological techniques for achieving deep relaxation, inspired primarily by techniques of meditation, yoga and visualization.

Conscious breathing exercises

Competitive swimming requires effective regulation of breathing mechanisms at flow and air volumes significantly larger than when performing exercises on land. This further implies that the development, efficiency and high coordination of the respiratory musculature is one of the imperatives in this sport. (Wells, Plyley, 2005). From a series of conducted studies on the topic of respiration during swimming, it has been observed that it is determined by air retention, which provokes numerous responses of the cardiovascular system, especially in the area of bradycardia and peripheral vasodilation. Self-induced apnea affects the reduced desaturation of oxygen in the arteries. Despite immediate physiological responses, practice to the challenges of apnea and training its effects uses pranayama yoga, which is based on slow and deep conscious breathing. (Bera et al., 2017). This technique itself has a calming effect and helps the individual in the process of eliminating accumulated stress (Bhattacharya, 2002), which indicates that it could also make a positive contribution to the recovery process of swimmers. Studies have found that this type of meditation affects the improvement of respiratory functions (Shankarappa, 2012), about the fact that pranayama involves breath retention, which conditions increased parasympathetic control of respiratory centers. Today, this method of exercise is also recommended for reconvalescents after a cured COVID-19 virus infection (Pal, 2020). The effects of applying pranayama (or any other form of conscious breathing) to swimmers were almost completely unexplored, until recently a group of authors from India conducted a trial on a sample of 27 internationally ranked swimmers, aged between 13 and 20 with 8.29 ± 2.9 years of competitive swimming experience (Hakked et al., 2017). They were randomly assigned to experimental and control the group; the experimental group practiced "segmented" breathing, stimulating breathing and nasal breathing with voluntary breath holding, for half an hour a day, five days a week for one month. Control measurements were performed on the first and thirtieth days of the process and included 1) a spirometric test 2) an athlete's anxiety scale (SAS-2) and 3) the number of strokes per breath during swimming. The results showed a significant improvement in the experimental group compared to the control group in the domain of maximal voluntary volume (MVV), forced vital capacity (FVC) and the number of strokes during one breath. The results of this research suggest that this practice of breathing helps develop respiratory endurance in young swimmers (Table 1).

Table 1. Comparison of pulmonary functions in a sample of swimmers (Hakked et al., 2017)

Tested parameters	Experimental group		Control group	
	Before	After	Before	After
SVC	3.13±0.52	3.01±0.59	2.59±1.07	2.63±0.71
IRV	1.19±0.43	1.45±0.76	1.01±0.45	1.12±0.46
FVC	2.91±0.42	3.14±1.03	2.52±0.65	2.39±0.75
MVV	106.5±30.61	115.45±31.44	102.98±23.52	97.65±20.37
MV	27.35±11.95	23.04±14.15	24.93±21.03	17.78±9.82
PEF	6.34±1.13	6.84±1.61	5.67±1.47	5.45±1.80

Training of psychological skills

Psychological skills training (PTS training) is one of the basic forms of psychological preparation of athletes, which is based on the alternation of negative thoughts and emotions with positive ones. However, after more detailed research on PTS, clinical psychologists have come to the conclusion that this method can often cause both a negative reaction in an athlete, a decline in his abilities, and even, as a consequence of the above, the absence of results or their regression (Gardner, Moore, 2004). Realizing these shortcomings, Gardner and Moore (Gardner, Moore, 2004) developed an approach of "mindfulness – acceptance – commitment" (MAC), based on transcendental meditation

(TM), and whose essence is that athletes at a given moment "become aware" of their thoughts and emotions, to accept them, but not to analyze them at that moment, but instead to shift the focus to the next task. Twenty years later, not only that this approach has been evaluated by numerous clinical psychologists, but it is also used by many top athletes, including the most prominent swimmers of today (Harung, Travis, 2015). It is also known that meditation affects the amygdaloid complex - a part of the limbic system located in the temporal lobe of the brain, in front of the hippocampus, which is responsible for processing emotions, anxiety and associated physiological reactions, whose proper regulation is of great importance for achieving maximum performance in sports competition, especially swimming (Desbordes, 2012).

Visualization

Visualization is a mental skill that has become almost an indispensable part of the training and recovery process of a huge number of athletes. It is defined as (re)creating experiences within the mind (Weinberg, Butt, Culp, 2011). Surveys conducted on the population of swimmers in the Olympic Village have shown that a large number of members of the group use visualization with a goal to improve performance (Ungerleider, 2005). Recent studies represent different attitudes regarding the impact of this skill on the performance of athletes themselves, compared to different sports. However, in the context of swimming, current research suggests that visualization can be an extremely powerful tool in psychological preparation, and that it can induce numerous positive effects, since, in the leading study of the Post (Post, 2012), which deals with this phenomenon, it was found that as many as 3 out of 4 swimmers respond positively to it. Although there are studies that refute the importance and effectiveness of this technique, it is an indisputable fact that it has a positive effect on swimmers (Casby, Moran, 2012) by reducing stress levels, increasing self-confidence, safety and providing a sense of control and management of the given situation, which irrefutably affects the performance in the competition itself.

Rhythm and music

The use of music in biohacking, both in general training and in the process of swimming training is not a new phenomenon, since the values of elements of music in everyday life, and accordingly in sports, have been recognized a long time ago. When talking about music, rhythm[2], as one of its most basic characteristics, in addition to its basic definition, can be seen as one of the basic elements of different styles, which further abstracts one style from another. However, rhythm can also be viewed through visual presentation, i.e. as a "temporal movement through space", and one of the most obvious examples of this is swimming. Experience from practice has shown that children who approach swimming training that takes place with adequate music and encouragement show a higher degree of motivation for work (Jirousek, 1995), are more relaxed in the water, but also more enjoy the learning process in general. Also, a large number of swimming coaches and instructors believe that music can be an exceptional "tool" for improving both the speed and the essence of the swimming technique (Dillon, 1952).

The benefits of musical rhythm in swimming practice soon became the cause of the increase in the number of studies on this topic. One of the leading ones deals precisely with the benefits of listening to music and the perception of its rhythm by swimmers. Karageorgis and Terry (2001) highlight the following as the main benefits:

- strengthening the positive and suppressing the negative mood
- relaxation or intentional excitation before a competition or training session
- Distraction from unpleasant sensations (such as pain and fatigue)

[2] Rhythm – a series of tones and breaks of different durations in the musical part; the ratio of pronounced and unpronounced parts of the beat.

- Increased efficiency of work resulted from the synchronization of movement and music...

It is known that every movement essentially contains the coordination abilities of rhythm. One of the best examples is swimming – a skill with a pronounced rhythmic component of movement, which requires accuracy, order, symmetrization, pace, movement of body parts derived in horizontal and vertical planes, about all three axes. This fact is further supported by studies examining the influence of the rhythm and tempo of music that swimmers listen just before the start. Listening to appropriate music 5 minutes before swimming affected swimming speed by 1.44% (Smirmaul, Dos Santos, Da Silva Net, 2014). Despite the established benefits, there is still a small number of scientific verifications about the selection and, according to that, listening to music that could be considered appropriate for a given training program. One of them, conducted on a sample of 24 competitive swimmers, showed that listening to music that swimmers chose themselves during the 50m and 800m training sets had a beneficial effect on the measurement results, but also that the music, in this protocol, did not significantly affect the subjective feeling of enjoyment in performed activities (Tate, Gennings et al., 2012). Motivational and neutral music with a tempo of 130 beats per minute (130bpm) have a beneficial effect on the result on the 200m using the front crawl technique. The result was 2% better in repetition with music than in the test without music; however, this study also showed that there was no difference in influence on subjective feeling, arousal and similar feelings (Karageorghis, Hutchinson et al., 2013). In an experiment with the tempo of music in the range of 125-140bpm, which from the musical side can be described as a relatively fast tempo (108-200) on performance, heart rate, perceived effort, during the 6 x 200 m test using the front crawl technique, but at the tempo of swimming determined by the swimmers themselves, swimmers finished swimming faster by listening to music, compared to the test without it (Olson et al., 2015). In other words, an inner sense of the rhythm of movement and tempo of performing movements when swimming, which can be developed by implementing music or using a metronome in the training process, is one of the factors that make the swimming technique more efficient, and therefore the swimmer faster.

SLEEP BIOHACKING FOR SWIMMERS

Sleep, as a reversible physiological state of impaired wakefulness, has its many significant cognitive and biological functions that have exceptional value for top athletes. Recent research shows that not so small number of athletes, especially swimmers (if we take into account the time of realization of the morning and afternoon training), have certain problems with sleep, i.e. with the amount and / or quality of sleep. Chronic sleep deprivation, which can develop over time, could be a significant problem in the competition, and especially in training, since it affects the decrease in the ability to learn, memory, perception of pain, inflammation and fatigue (Halson, 2014), disruption of glucose metabolism, which will further result in changes in carbohydrate metabolism, nutrition disorders, food intake, protein synthesis and so on (Guyton & Hall, 2019).

A large number of studies do not deal withthis issue, within the framework of sports swimming, although the problem with sleep could potentially become a serious problem, if we take into account the training schedule during the day (and week), but also the habits of young swimmers, who very often putt their sleep at the very end of the list of personal priorities. The study, which was conducted on the population of elite swimmers, was concerned with assessing the impact of morning training on the amount of sleep that swimmers achieved during the night. The test was conducted for 14 days, during the period of the most intensive preparations for the Olympic Games in Beijing in 2008. The sample consisted of seven swimmers who trained at the Australian Institute of Sport. During the entire measurement period, they had 2 days of rest and 12 days of training, which will begin with morning swimming training at 06:00h. Swimmers were tasked to write a sleep diary during entire protocol, in which they subjectively evaluated the sleep from the previous night, and which was

also one of the indicators of both quantity and quality of their sleep in general. Another indicator of the quality of sleep were collected from gadgets for monitoring, who monitors the stages and evaluates the quality of sleep. On the nights preceding the day of training, subjects went to sleep at 10:05p.m., getting up at 5:48a.m. On the night before the rest day, they went to sleep at 00:32a.m., got up at 9:47a.m. It was determined by detailed analyses of the data that in the nights preceding training, the time of going to bed and the time of waking up is shifted, the time spent in bed is significantly shorter, and the attributes of sleep are significantly worse than in the days of rest. The study, therefore, showed that trainings that take place in the early morning hours greatly affect the quantity and quality of sleep, which impairs psychological and physiological functions, and to some extent affects the effectiveness of training (Sargent, Halson, Roach, 2014). Just as it is possible to influence the quality of mental skills discussed previously, it is possible to "hack" the quality of sleep with the aim of improving the performance of swimmers, by taking certain actions, i.e. maintaining adequate "sleep hygiene", which is one of the important factors that have an impact on the circadian rhythm. A circadian rhythm is a defined twenty-four-hour cycle during which precisely defined processes take place in the body at a specific time (Sollars, Pickard, 2015). The most important factor for harmonizing the circadian rhythm is light, so the fact that this rhythm during evolution was consistent with the sunrise and sunset is not surprising (Wright et al., 2015). Although all lights can exert an influence on the circadian rhythm, the greatest influence is the "blue light" (Wahl et al., 2019), emitted by electronic devices. It can cause the most serious disturbances of the circadian rhythm, which is why it is important to eliminate it at least 60 minutes before going to bed, or at least reduce its effect by using "f.lux" systems that automatically adjust the emission of light from the screen according to different times of the day.

HACKS FROM THE DIET AND SUPPLEMENTATION SYSTEM

"The potential and giftedness a swimmer acquires by inheritance, and manifests thanks to adequate training. Quality nutrition is an element that can restrain or release that potential." (Maglischo, 1993). Unlike a large number of other sports branches, competitive swimming is a sport in which, depending on the discipline and technique of swimming, the race takes place in a time span of 20 seconds to 15 minutes, which means that the sources for performing are drawn from both aerobic and anaerobic energy systems. Also, what sets swimming apart, when we talk about nutritional needs, is the increased need for food consumption, compared to other sports. This phenomenon is explained by the stress to which the thermoregulatory system is exposed every day (and even several times during a day); due to staying in cold water, there is a dissipation of thermal energy into a cold water environment. Nothing less important factor is the dynamics of glycogen, especially within small muscle groups, which makes the post-training image dependent on carbohydrate intake. A study dealing with running has established the same trend in the space of external temperature influence in this activity also, where when running for 60 minutes, the feeling of hunger increases drastically more when running at 10 degrees than when running at a normal temperature of about 20 degrees (Wasse, 2014). Changes in energy needs of swimmers are mainly created as a consequence of the scope of training, its intensity, training goals, and other life activities of the athlete, which are not directly related to swimming. Accordingly, these elements should be taken into account when creating an individual nutrition program, that should strive for the intake of micronutrients and macronutrients adjusted in accordance with the requirements of the training period, daily life obligations, rest and recovery et cetera. Qualitative and quantitative monitoring of ingested foods and diversity in the selection of nutritionally rich food are things that young swimmers can easily learn, which is at the same time a form of self-hacking, but also a factor that biohacking of the diet in a broader sense can greatly facilitate, given that there are an extremely large number of applications for advising in

choosing and monitoring in the energy and nutritional values of the selected food in a meal, which automatically calculate the percentage of the representation of certain nutrients in meal.

In addition to food and food choices, swimmers pay great attention to supplementation, which is confirmed by the doping control data from the Olympic Games hosted in Sydney in 2000, which indicates that swimming is the sport with the highest prevalence of supplement use (Corrigan & Kazlauskas, 2003) – 99% of top swimmers use supplements as dietary supplements, 94% use some other supplements that are not related to nutrition, and it was also found that one of the tested swimmers used 27 different forms of supplementation (Baylis, Smith, Burke, 2001). However, when we talk about "hacks" that can affect nutrition and supplementation, it is noticeable the identical principles to be guided and to which to pay attention in both cases (Baylis et al., 2001):

- The needs for energy and supplementation vary significantly due to the individual differences of swimmers, but also the training components in a given week, microcycle, macrocycle, and even the sports career itself.
- Nutrition and supplementation during the competition are in the function of faster and better recovery of the athlete. They are very individual and largely dependent on the schedule of races during the competition.
- Manipulation of these components can have both positive and suppressive effects in relation to certain biological and physiological functions and processes, such as sleep, which has already been discussed. In this way, it can adversely affect the sports performance.
- Because of all of the above, it is of great importance that the athlete, before embarking on the biohacking of his diet ("Food BioHacking"), consult with an expert who will provide him with appropriate advice and guidance that he will later be able to adhere to himself.

HACKING IN THE SPACE OF EFFECTS OF SWIMMING EQUIPMENT

Thanks to the circumstances of living and creating in the modern era, we are witnessing constant and incredibly rapid progress in the development of information technologies, which in various ways affects the pushing of boundaries in almost all sports, especially in swimming. Innovative solutions that appear in the way swimmers equipment are made also play a role in self-recognition process... Thus, although swimming goggles were used in 1911. when swimming the English Channel (La Manche), and the caps for swimming in the 1920s, the quality of their production became satisfactory only in the 70s, when these parts of equipment first appeared in official international competitions. This is precisely the first period in which the Olympic records in swimming rapidly shifted. A similar trend has been observed again since 2008, evidenced by the fact that 94% of Olympic champions, as well as 98% of swimmers who became record holders at these Games, swam in today's banned "LZR Racer" costumes. Therefore, the choice of equipment used in training and competition indisputably contributes to the performance of the athlete himself, to a greater or lesser extent - for example, the mentioned LZR Racer costumes contributed to the speed of swimming by 1.9 - 2.2% (Moria, 2010) and etc.

Swimming costumes

The first ideas about the potential effects of swimsuits on swimming speed can also be considered as the beginning of the application of biohacking in modern swimming, before it as a term began to exist at all. These ideas were brought with the development of technology; large companies, which were engaged in the production of swimming equipment, began to develop and produce new models of swimsuits, which were soon approved by the World Swimming Organization (FINA), and which soon brought with them a lot of new records, on the Olympic Games in Sydney, Athens and Beijing, as well as World championships held from 2001 to 2009. What distinguished this type of

costume from the previous ones is primarily the tendency to cover as large a surface of the body as possible so that the flow of fluid around the extremities and trunk of the swimmer becomes as laminar as possible. However, in addition, effects on the shape of the body itself, shifting the center of gravity, more efficient redistribution and blood flow to the heart were observed (Jevtić, 2021)... In this period, the focus was mainly on the selection of materials from which the costumes will be made. Before the Beijing Olympics, Mectex, AIS and NASA worked together on a new model called "LZR Racer" – the first costume ever made from a combination of previously known materials - elastin and nylon (50%), and new material, polyurethane (50%). These costumes enabled a better flow of oxygen through the working muscles, but also easier and better maintenance of the hydrodynamic position of the body, which positively influenced the swimming speed by 2-4%. Based on this model, many other companies produced costumes from pure polyurethane shortly thereafter (Thurow, Rhoads, 2008). The popularity of this model is perhaps best illustrated by the fact that a number of the world's leading companies, including allowed to their wimmers to wear this costume, although it was produced at first by "Speedo" and later by "Arena", "TYR", "Jaked" and other leading companies. The most records in the history of Olympic swimming were broken at the mentioned games. However, almost all of them were moved again the next year, at the World Championships in Rome in 2009. Realizing that if technology continues to develop and in certain ways influences the development of sport swimming (and aware that this will inevitably happen), this will do more harm than good for swimming in general, primarily by making it impossible to set a record and set unattainable goals in the future, the World Swimming Federation decided that, from January 1st in 2010, the use of costumes of this type will be banned. In this way, at least for a while, the eventual discrediting of the efforts of swimmers and their coaches, by putting the characteristics of the equipment at the forefront, ahead of their efforts, dedication and achievements.was prevented.

Portable technology used in training ("gadgets")

The term "gadget" (first used in English in 1886), includes all "small mechanical or electronic devices or devices that have their specific purpose" (Cambridge Dictionary, 1995). Accordingly, under this term will be classified technological devices that can be used in the training of a swimmer with the aim of biohacking his body, mind and environment. Some of the first were complex devices with the help of which a man recorded swimming underwater for the first time, recorded and biomechanically analyzed the parameters of his swimming, etc. One of the devices that is extremely popular and exploited by a huge number of athletes and recreative athletes is the "smart watch". This type of gadget is an integral part of the lives of many of us. A lot of modern models are well equipped with several different types of sensors with which they monitor everyday life activities, collect and analyze predefined data and almost directly provide feedback. The appearance of waterproof smartwatches has had a positive impact on open water swimmers, offering them a solution that allows accurate monitoring of swimming parameters in a broad sense, length of the section, pace, heart rate, zone of intensity of swimming, but also the efficiency of stroke, etc. This type of gadget can also be a very useful tool for beginner open water and marathon swimmers, recreational swimmers or triathletes, due to the fact that, thanks to these characteristics, it can be a kind of guide through the exercise process, whereby the athlete guided by the interface of the device learns to "listen to his body" and implement physical exercise in a way that is the most convenient for him. On the other hand, the future of smartwatches in pool swimming is not the dominant direction, given that they will never be able to replace quality and experienced swimming coach, the quality of his feedback and the capacity of his observations. However, if we also have in mind swimming in the Physical activity and sport classes curriculum, as well as swimming training, it is not difficult to conclude that the aforementioned devices can contribute to teaching, especially in introducing students to the functions of their own body, changes concerning physiological functions when the body is in immersion, i.e. those changes

that occur during swimming (or performing some other physical activity), and from which certain conclusions can be drawn that are in accordance with the goals of the PE and health curriculum.

As has been pointed out many times, swimming is the dominant technical sport in which it is necessary to constantly master the aquatic environment, which is up to 800 times denser than the air in order for effective and efficient movement by swimming. In order for these intentions to be achieved, the swimmer must strive to demonstrate the highest possible quality skills within the predefined swimming techniques, in order to reduce the resistance of the environment that surrounds it and increase the thrust, i.e. generating propulsion, and thus moved well through the water. Of all the pieces of equipment used in the swimming training, the swimming paddles contribute the most to the aforementioned goal; they are very practical and easy to use, and they increase the contact surface with which the swimmer acts on the fluid, and thus the resistance to its movement. If he wants to be more efficient in the water, the swimmer must act with variable kinematics and kinetics of strokes that have an effect on the course of cognitive, biological and temporal adaptations of swimming. mentioned mechanism gives the swimmer a sense of movement forward, but also a kinesthetic feeling of "hanging and pulling on fluid" during stroke. Thanks to the development of science and technology, this part of swimming equipment has also received its more modern variants, so as the result we now have paddles that are predetermined for certain techniques, those for working on general technique, strength, which contributes to the quality of the training process, and shows itself as a very useful tool in certain phases in the swimming learning process. Among modern models, we must especially emphasize “Smart Paddle” that represent the upgrade of the basic model by installing an advanced portable underwater sensor. During swimming, the sensor records the applied force and characteristics of the resulting movement, such as the path, speed and orientation of the hand during the catch, but also in other phases of the arm movement. The device can be controlled with the help of software that directly gives feedback in the form of information on the duration of movement , number of strokes on a particular section, lengt of strokes, degree of efficiency of each phase of swimming, time spent in each of phases, but also more complex data such as force profile, speed, three-dimensional model of pull etc. By using them in the training process of top swimmers, the feedback becomes significantly better, which results in the intensification of the process of self-knowledge, and therefore the creation of a higher quality and more complex training system.

"SONR" device

In addition to the tendencies to adapt the training process to swimmers as much as possible, there is also a clear intention of the coach to do their part of the job as economically and efficiently as possible. Thanks to the existence of such a need, a "SONR" device has been developed - the first underwater wireless communicator for swimmers and coaches. The device is unique in that it is not based on headphone technology, therefore no cables, which very often cause interference in transmission or signal interruptions, but the entire compact device, weighing only about 15 grams, is inserted under the swim cap or placed anywhere on the head, attaching to swimming goggles and working on a wireless principle. Thanks to the anatomy of the human skull and the resonant property of its bones, the swimmer is able to listen to the information that the coach gives through the transmitter during swimming. Another benefit of this device is the ability to network the team, i.e. the option for the coach to communicate with a single transmitter at the same time with, for now, a maximum of eight swimmers wearing receivers, but perhaps its greatest value is reflected in the fact that it can greatly facilitate the training process of swimmers with different types and degrees of visual impairment.

"NOME" System

In recent years, a lot of attention in the world of swimming has been attracted by the "NOME" system, made up of a device that is placed next to the starting block and an LED strip on which there are lights, and which is enveloped in a PVC envelope. Using software installed on the Android or iOS platform, the coach is able to control both the speed and intensity of the lights on the strip stretched along the track in which the swimmer is, and thus conducts the pace of swimming. The purpose of this system is to give feedback to the swimmer in real time, without need to stop with swimming in order to get information about swimming pace – as long as he is above the lit lights (or those illuminated by a predefined color), the pace of swimming is appropriate. The use of this system makes training more interesting, increases the level of motivation in swimmers, allows them to better focus on the efficiency of swimming and develop a sense of speed of movement, without dissipation of attention and time on monitoring the clock during swimming. Some of the options offered by the system are changing the length of the section, automatic stroke counter per lenght (which can also be an indicator of the effectiveness of swimming), indicator for starting the turn, indicator for finishing underwater after the turn, factory integrated "library" that has a programmed pace of different swimming records against which an athlete can simulate races in training, etc.

FEEDBACK TECHNOLOGY

Tracking systems are an extremely important tool in the training process, since they provide an instant feedback, both to athletes and their coaches. For this purpose, a large number of commercial feedback systems was created. They can now be divided into systems that provide direct and those that provide indirect feedback (Di Palma, 2018). The use of both systems is a widespread phenomenon in almost all sports. However, due to the environment in which the swimmer is located, this is not often in swimming. In other words, it is not always possible to use both of these monitoring systems. The currently most exploited form of tracking of the movement of athlete are sensors. Inertial sensors are technological devices intended for measuring certain kinematic variables of body movement (or body segments) on which they are attached. Currently available sensors on the market can be divided into two basic groups: accelerometers and gyroscopes (Callaway et al., 2009). Depending on the subject of observation, they can be used separately, in combination with each other, but also within larger "networks" (a number of sensors set up to cover a specific space and the swimmer in it).

Not infrequently, the self-perception of a swimmer's performed movement can be out of sync with reality. Therefore, video technology is an extremely useful tool in the training and training of swimmers, since the athlete is all the time in a horizontal position in the water environment, which makes it difficult to create an accurate image (which is developed through many years of training that causes the acquisition of a feeling for the water, its properties and its own movement in it). Currently, there are several leading video-based systems on the market, such as SwimPro, SimiAnalysis, and AngelEye. All of these systems consist of high-resolution wireless cameras that capture swimmers movements and send the footage to the base ("IQ2"), from where coaches can further review, analyze or import them into other software (e.g. Kinovea, DartFish, etc.) which can give them some more detailed biomechanical analysis of movement. The data is transmitted in real time, which means that the cameras can be networked with a mobile phone, tablet or monitor and analysis can be done *in situ*. Thanks to the development of the Internet network and technology in a broad sense, these recordings can be saved to external storage or uploaded to an internet platform intended for storing only this type of data ("SwimmingCloud"), with unlimited access. In this way, it is much easier to share the knowledge and experience gained in practice among swimming coaches around the world.

CONCLUSION

Using his knowledge and skills, man rejects almost all animal characteristics that he had and thus destined to became *Homo faber*. On this evolutionary path, he developed consecutive science and technology, and realized that, thanks to their causality, they are the main driving force, not only of the personal but also of the integral social and also the development of civilization.

The aspiration to achieve positive changes in all life activities describes human development. In this regard, each individual, in his own way, undertakes certain activities with the intention of improving the quality of his life in a broader sense, which is significantly helped by self-perception and technology. Consciously or not, all people biohack.

The priority goal of a swimmer is to constantly improve the abilities and skills that lead to the maximum. Considering that, both the training process and the organization of swimming competitions, is increasingly relying on encouraging the process of biohacking in breaking personal records. Therefore, it is not surprising that training and competitive development as well as technological devices are increasingly involved in swimming every day. Participation in sports, whether in the role of an athlete, coach, manager or some other actor, implies continuous education and training of "hard & soft " skills in the use of modern technologies and information systems.

Theoretical analysis, description, precise definition of the term "biohacking" and the terms hacking and self-haking, but also the invention of causality between the aforementioned term and sports swimming, we notice the steps of training methodology and technology that lead to more expedient (self)knowledge of swimmers and recognition of self-hacking as a mediator (or catalyst) of understanding and further personal development. Therefore, the existing as well as the coming theories and facts related to modern knowledge about the influence of various factors on the training and competitive process in sports swimming, are shaped through the conclusions of cognitive processes of neuroscience, anatomy, physiology, psychology, sociology, management, sports and education, to computer sciences.

The use of technological innovations cannot replace the swimming coach, the quality of his information, the capacity of his observation, his influence on the integral development of swimmers... These entities (coach and technology), throughout the training process, are in a causal relationship and constant connection.

The process of self-hacking can be observed as a trend that combines the overall activity of swimmers and coaches in all these cognitive spaces, with the aim of improving personal efficiency, both mental and physical, in the function of the swimmer's personal and athletic development. Intentions in this direction also define a clear framework, place and role of the process of biohacking and self-hacking in the process of learning and training swimming.

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