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”BABEŞ-BOLYAI” UNIVERSITY CLUJ-NAPOCA

FACULTY OF PHYSICAL EDUCATION AND SPORT
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DOCTORAL THESIS

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Title

OPTIMIZATION OF STRENGTH AND POWER, PERFORMANCE PREDICTORS IN SWIMMING

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Keywords

Sports performance, swimming, training, strength, power, speed, technique

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List of published original papers

1. **A. Suciu,** C. Popovici, C.A. Popovici *Anxiety and swimming performance*. 2012, Revista Studia UBB Educatio Artis Gymnasticae, vol 4: 113-121.
2. **A. Suciu,** C. Popovici *Effects of vertical water training on knee extensors strength in swimmers.* Elsevier, Procedia-Social and Behavioral Sciences, Al treilea Congres Internaţional de educaţie Fizică şi Sport şi Kinetoterapie (ISPEK 2013), 2014; vol 117:420-426.
3. Popovici C., **A. Suciu** *Dry land training and swimming performance in children aged 11-12 years.* Palestrica Mileniului III, Civilizaţie şi Sport, 2013, vol.14(3):219-222.

The importance and argumentation of the theme

Obtaining valuable results in sports can no longer be conceived without a rationalization of the whole training process, in accordance with the well-established requirements for each training level. Obtaining performance can take different shapes, depending on the nature of the means and methods used, as well as on the human resources involved in the performance activity, the necessary material and financial resources, the degree to which the studied theme is known. Enhanced efficiency and a minimum risk in obtaining sports performance has led to a fast development of scientific research in the area of sports, as well as to a knowledge transfer from and to other areas.

The quality of the training act must be ensured at an optimum level which allows for reaching the potential of the athletes with maximum results.

In the context of the evolution of the current society we believe that certain modifications are necessary in the manner of approaching the instruction programs focused on objectives which concern the education of the motrical capacity taking into consideration individual particularities of age and gender specific to ages 11-14.

From this perspective the present paper intends to bring some improvements to the training of sprint swimmers (butterfly stroke) in our country, taking into consideration the latest international developments at the same time.

The argumentation for approaching the present theme has been supported by the following:

- the lack of recent studies on the development of strength and power,
- the introduction of new training programs which aim both to educate the motricity capacities speficic to the chronological age, as well as to observe possible posture problems or physical deficiencies which might stop or determine the forming of these capacities. We start from the premise that speed will improve gradually in short swimming competitions if we improve strength and power, obtaining thus better sports performance. On the one hand motivation is ensured by the importance that must be shown to physical training, in all its aspects and on the other hand by the necessity to make use of informational and technological means in the training with the purpose to objectify the development of strength and power.

The purpose of the paper resides in the rethinking and restructuring of some strategies that already exist by introducing helping materials and equipment with the purpose to develop strength and power on short distances. At the same time we want to identify in the traditional method and means the principles which lie at the basis of the development of these qualities (strength-power), and we will apply them afterwards in real work conditions. The present study intends to contribute to the development of better training methods with low use of physical and emotional effort so that performance can be attained faster and more efficiently.

Actuality of the theme

Electronic materials were an important source of information in the realization of our study, materials which, by their content, contributed to the scientific foundation of the theme. The specialty literature from abroad proved to be a real support for deepening ourselves into the elements and methods characteristic to the present study as it was one of the main documentary sources. The specialty literature from our country offered a large variety of treaties in the form of monographs, books, articles which represented a valuable informational source, many of these can be found quoted in the content of the paper and in the bibliography list.

A large number of studies has shown the importance of developing strength and power in order to increase sports performance.

Research done on swimmers between 13 and 14 shows the importance of applying the plyometric training which, together with training specific to swimming, can have a positive effect on the start in swimming. (Bishop et al., 2009)

The positive effects of the plyometric training were underlined by Potdevin et al. (2011) who mention the importance and relevance of this type of training for a successful start and turn.

The use of added resistance in strength training (parachute training) is recommended in specific training with the condition that this be done close to maximum speed. (Schnitzler et al., 2011)

Power is an essential motricity quality which can offer an objective analysis of sprint in swimming. (Sharp R.L. et al., 1982)

Strength training on dry land combined with programs of electrical stimulation have as a result the improvement of speed and implicitly of performance in sprint swimmers and they are more efficient than the usual swimming training. (Girold et al., 2012)

The start (defined as the time needed to complete the first 15 m) is a key element in sprinters (50m), together with the strength of their arms and the power of their detachment. (West et.alt., 2011)

New and original elements

The new element resides in the elaboration of an exercise program for the development of strength and power in swimmers by using the Biometer Isokinetic Trainer. Strength and power training is very important and necessary, this is conceived depending on the needs, particularities and the level of the swimmer. The purpose of this program is to improve and optimize the swimmers' performance during trainings and competitions in order to obtain best results.

The originality of the present paper resides mainly in the in-depth approach to the methodology of the development of driving skills strength and power, as well as of the butterfly stroke. By improving strength and power, speed grows and thus one can obtain better times in swimming competitions. Making use of the Biometer Isokinetic Trainer is also something new in the training of swimmers. I would like to mention here that a similar equipment can be found only at the National Institute for Sport Research in Bucharest.

THE CONTENT OF THE PAPER

The thesis is structured in three parts: part I – The theoretical and scientifical foundation of the paper; part II-a – Research methodology; part III – Personal research contributions.

Part one contains five chapters, the second one two chapters and the last part has four chapters.

In Chapter 1 – Definitions of the fundamental concepts, it highlights the driving skills strength and power, with definitions, classification criteria (according to different authors), development methods (variants proposed by different authors), the phases of strength, the role of strength in swimming, strength training in swimming, power training in swimming.

A. Demeter (1981) defines **strength** in the paper ”Physiological and biochemical basis of physical qualities” as being ”the capacity of the neuromuscular system to defeat resistance through muscle contraction”.

”The strength of the human body (and not the one which represents a mechanical characteristic of the moving of any body) consists of the capacity to perform efforts of winning, maintaining or giving in in relation with the external or internal resistance through the contraction of one or more groups of muscles” . (A. Dragnea, 1996)

V. Tudor (2002) defines the strength of the human body as being ”the capacity to defeat an internal or external resistance through muscle contraction.”

Power is defined as being the ”rate at which muscles can produce strength” (Enoka, 2002). Power can also be defined as the degree of strength production; strength production times speed (P=SxS) (Cronin and Sleivert, 2005); or the amount of work performed per time unit. This is necessary to any sportsman in order to be agile and fast.

Power is a function of maximum strength (Bompa, 2001), thus a high level of strength can determine the rise in power, resulting in an increased level of speed, swiftness and agility.

Maximum power can be defined as the critical threshold of interaction between strength and speed (Cronin and Sleivert, 2005).

In Chapter 2 – The current situation of swimming research; I reviewed a number of articles published on swimming, recent studies from the specialty literature.

In Chapter 3 – The components of the complete training, we present in detail the 6 components: physical, technical, tactical, psychological, theoretical training and restoration.

The technical component

By ”technique” we understand ”a system of motricity structures specific to each sport branch performed rationally and economically in order to obtain a maximum of efficiency in competitions” (I. Şiclovan, 1984). The term ”technique” ”unites the set of methods, procedures and rules, combined with a certain personal skillfulness and which is applied in the execution of operations or work or, in general, in the application of a profession” (Mic dicţionar enciclopedic, 1978).

”The technique of a sport branch includes all the motricity activities performed ideally from the point of view of their efficiency” (Dragnea et al., 2002).

When it comes to the component of technique we refer to the techique basis of butterfly.

The *motion of the legs (dolphin kick)*

The legs execute simultaneous motions in a vertical plane. In comparison with the crawl stroke, their amplitude and efficiency is enhanced because here are also involved the muscles responsible for the flexion and extension of the hips. During the motion we distinguish two phases: the ascending and the descending phase.

The ascending phase: is realized with the legs in extension. The leg must be relaxed and passive, the pressure of the water downwards will keep it in extension, acting on the foot and bringing it in a neutral position between plantar and dorsal flexion. It is a preparatory passive phase.

The descending phase: represents the active motion which propels slightly forward. During the ascending motion the hips come down. At this phase the pressure of the water upwards will push the leg and it will effect the flexion of the knee, the plantar flexion of the foot and its inversion. When the leg is at the surface, the foot will perform a strong extension, going all the way down to the alignment of the leg articulations. An important role in the propelling efficiency of the descending motion is represented by the mobility of the ankle (the capacity to make the plantar flexion – Borthels and Adrian, 1971, quoted by E. Mureşan, 1996).

The motion of the arms: has two major phases: the aquatic and the aerial phase.

a. The aquatic phase of the arm motions has three moments, that is: catching the water (catch phase), pulling, exit (release phase).

1. The entry of the arms in the water is done in line with or slightly out of the line of the shoulders. The arms are in an internal rotation, while the palms are in pronation, slightly facing towards the outside, their entry in the water causes small turbulences. After entering the water the hands go down and move forwards for a short period of time before they start making a circular motion outwards and backwards. During the circular

motion outwards the elbow flexes progressively in order to allow the hand to descend under the arm, palm oriented backwards at the moment of catching the water. The catch is done with aligned hand and forearm. This phase ensures the arrangement of the arms in the optimal position for the first propulsive phase – traction.

2. Traction is the first propulsive part of the arm motion specific to butterfly, it performs an ample circular motion of the arms from a wide position of the arms at the catch moment and bringing them close under the swimmer's body. This is realized through the additional flexion (50º-60º) of the elbow and it reaches up to 90º-100º when the hands come together. Some swimmers bring the hands very close together at the end of the traction while others prefer bringing the hands together only slightly.

3. The push begins simultaneously with bringing the hands together under the swimmer's body. This is done up to the level of the hips and it ends at the level of the thighs backwards, outwards and upwards towards the surface. At this point the hands change direction and they perform a circular motion outwards-backwards and upwards towards the water surface. The hands rotate outwards and they must be kept that way and backwards during the push. The medial part of the forearm must remain oriented backwards during the underwater motion.

b. The aerial phase of the arm motion

The clearance of the arms from the water is initiated before the hands reach the water surface or the elbow extends completely. The palms stop applying pressure on the water after they pass by the hips and they return inwards (supination) so that the hands come out of the water with a minimum of effort and low turbulances. After clearance the elbow extends and the arms perform an ascending traject laterally over the water. The arms stay in inwards rotation during recovery, thus initially the palms are oriented inwards on clearing the water and when entering the water they are oriented outwards. When the arms pass the shoulder line, the swimmer breathes by tilting the head forward while, at the same time, he raises his hips, thighs and legs.

Coordination between arms and legs

For each arm cycle there will be performed two leg motions. The first descending leg motion must be performed during entering and catching the water while the second descending motion will be performed simultaneously with the moment of pushing the water.

The descending motion of the first leg motion must start before the arms enter the water, it must be synchronized with the downwards and sideways motion of the legs. The finalization of the descending leg motion is done before catching the water. The efficiency of the first motion will diminish the turbulences caused by changing the direction of the arms from forwards to downwards and sideways against the water or it will propel the swimmer forwards until the arms will perform the catch.

The ascending motion of the legs which follows the previous descending one takes place at the same time with the traction. The motion contributes to the alignment of the body during the propulsion ensured by traction by bringing the legs above the body, in position for the next descending motion and lowering the hips in alignment with the trunk. The second descending motion is performed at the same time with the push and it ensures gliding forwards and its role is to keep the hips raised during the upwards and backwards motion of the arms in the second part of the push. The last ascending leg motion takes place during the aerial motion of the arms and its role is to bring the arms close to the water surface, aligning the body at this stage of rowing when the traverse speed registers a diminution, at the same time it positions the legs for a new descending motion.

The position of the body

One cannot describe a constant position due to the continuous motion of the body at each rowing phase, yet we do have three intermediary positions specific to a certain phase of an arm cycle. A position in which the body segments are aligned and which is specific to propulsive moment, ensured by the underwater rowing of the arms – traction and pushing; this is obtained through the ascending motion of the legs during traction or through the limitation of the descending leg motion during pushing. A second specific position is ensured by moving the hips upwards and forwards, close to the water surface, during the first descending leg motion. The third position is ensured by the second descending leg motion which will push the hips towards the water surface and it will align the body with the trunk.

Breathing

The head must rise above the water surface in order for breathing in to be possible. The respiratory sequence begins at the same time with bringing the arms forwards, downwards and outwards to catch the water. The coming of the head out of the water is preceded by catching and traction and the breathing in is done during pushing and in the first part of the recovery of the arms (the aerial motion).

The tactical component

Tactics ”represent the activity whereby a sportsman performs all his technical, physical and psychological possibilities in order to obtain the best results in different conditions and before different opponents.”(Epuran et al., 2001)

”Tactics converge a system of principles, ideas and rules of approaching competitions by the sportsman whereby he capitalizes on all his technical, physical and psychological capacities in order to solve problematic (competitional) situations created by his opponents, team members, environment in order to attain succes.” (A. Dragnea, S. Mate-Teodorescu, 2002)

The psychological component

The psychological preparation comprises the area of moral and volitive factors, but it also involves the intellectual ones, thus creating manifestations of the human personality and psyche.

”The psychological preparation determines through the means of training and educational activities the enhancement of the psychological capacity in order to allow the sportsman to perform an efficient action and to obtain superior results in competitions. ” (Epuran et al., 2001).

The theoretical component

The theoretical training represents the ”series of information acquired by the sportsman with the purpose of knowing and explaining the principles, rules and methods which determine the enhancement of his effort and performance capacity such as the anticipation of the next competition in order to approach it approapriately.”(A. Nicu, 1973)

The theoretical preparation comprises the ”series of specialty knowledge transmitted by the coaches in order to put into practice certain notions, principles, rules meant to optimize the yield in training and competitions. ”(A. Dragnea, S. Mate-Teodorescu, 2002)

The physical component

”The physical preparation is done through a series of measures which ensure an enhanced functional capacity through the high level of development of basic and specific driving skills, through optimal values of the morphofunctional indicators, through the mastery of the techno-tactical procedures used and perfect health. The essential element is represented by the manner in which their use influences the energetic source of the sportsman’s preparation as close as possible to the one specific to competition”. (Cârstea, 2000)

The physical preparation on dry land uses exercises which involve the muscle groups used in swimming, which imitate the motions in the water, with large amplitude a fast-paced work rhythm, the apparata will be used predominantly from a lying position. The mobility and stretching exercises are very important in warming up and preparation. The simulator, the mini-gym, chest extensors, rubber stretch resistance bands, weights, dumb-bells, medicine balls, floor exercises for the abdomen, trunk, arms and legs are used in dry land preparation.

The specific preparation in the water is meant to develop the following driving skills: speed (S), strength (Sth), speed-strength (S-Sth), strength-speed (Sth-S), organic aerobic resistance, muscular aerobic resistance, organic anaerobic resistance, muscular anaerobic resistance, resistance-speed (R-S), speed-resistance (S-R), resistance-strength (R-Sth), strength-resistance (Sth-R).

In swimming the basic driving skills which determine the achievement of sport performance manifest themselves in a combined and not in a clear manner, manner which is determined by the specific of the event and the respective stroke.

The biological component – the recovery of the body after effort

”Guided recovery, biological rebalancing or food chain rebalancing is believed to be a complex method-pedagogical and medical-biological process whereby, with the help of guided use of certain physiological, natural or synthesis means which come from the internal or external environment, is intended the recovery to the homeostasis of the body at the level it had previous to the effort and even trespassing it by the realization of overcompensations.” (N. Alexe, 1993)

Chapter 4 – presents theories and concepts regarding physical effort, types of physical effort, the characteristics of aerobic and anaerobic physical effort, the morphological and functional basis of the effort capacity, the aerobic and anaerobic metabolism, the physiological effects of aerobic and anaerobic training, types of effort in swimming.

In *The Theory of Training*, D. Harre (1973) states that swimming is completely a resistance sport. This statement is no longer valid when we compare the effort put into swimming (taking water resistance into account) with other sports which are performed in normal conditions. By analyzing the swimming events we can notice the following (Table 9.):

- the 50m event: anaerobic alactacid effort, it is a speed effort;
- the 100m event takes place in the conditions of high debt of O_2 (63% out of the total consumption of O_2), in turn specifically structured: 25% phosphocreatine component (alactacid) of the O_2 debt and 38% lactacid component;
- the 200m event is, according to some authors, 50% aerobic - 50% anaerobic, other authors indicate 65% aerobic – 35% anaerobic. The difference from the 100m event resides in the supply of energy. The general O_2 debt is higher in all events 0,70ml/kg or 8-11, which would equal 100m (A. Lundin and B. Saltin quoted by Şalgău and Marinescu, 2005); The mixed aerobic-anaerobic effort – the 100m breaststroke event and the 200m any stroke (the duration of the effort is between 1-3/5 minutes);
- the 400m event is characterized by a 70% aerobic and 30% anaerobic percentage. Although the O_2 debt is more reduced than in the speed events,

this is a rough resistance event when it comes to O_2 debt (A. Lundin and B. Saltin quoted by Şalgău and Marinescu, 2005) ;

- the 800-1500m events are predominantly an aerobic effort (90-92%), with a reduced structure of anaerobic effect (8-10%), which grows depending on the intensity one swims at (under 1 minute per 100m).

Chapter 5 – The bio-psycho-motrical evolution of swimmers between 11 – 14 years old, this refers to growth and development at the age of 11-14 (the nervous system and the analyzers, the muscular system, the cardio-pulmonary system), motricity at the age 11-14.

Chapter 6 – THE ORGANIZATION OF THE RESEARCH

6.1. The Purpose, the objectives and the premises of the research

The purpose of the research

The purpose of the paper resides in the rethinking and restructuring of already existing strategies by introducing helpful materials and devices with the objective to develop strength and power, as well as to establish a connection between these two and speed on short distances.

The objectives of the research

The objectives of the paper reside in:

- the need to apply a number of programs of physical development which aim mainly at the driving skills strength and power in order to improve sports performance;
- establishing the content and the structure of the experimental program for the physical preparation of swimmers;
- the elaboration, by the author in collaboration with the scientific coordinator as well as together with other experts in the field, of a number of specific technical and physical preparation programs;
- the introduction of special technical and physical training in the instruction of the swimmers;
- the enhancement of sport performance in swimming through the approach of physical preparation, namely through the development of strength and power.

The premises of the research

The improvement of sports performance at international level has known both qualitative and quantitative developments, these depending on the type of amelioration in the preparation process. In preparation the focus is directed towards driving skills, the effort capacity, technique, all of which through improvement determine a raised level of the values of the results.

We start from the premise that speed in short distance swim events will improve continuously if we improve strength and power, as well as by identifying in the traditional methods and means principles which form the basis of the development of these qualities and then we will be able to apply them in real work conditions.

Work hypotheses

- the measurement of the strength and power can prove the contribution these driving skills have in determining the final results of each sportsman;
- by knowing the variability of these driving skills we can intervene in order to improve the general performance by acting on strength and power during training;
- there can be conceived a training methodology especially for strength and power with the purpose of objectifying this type of training.

6.2. Research methods

I. Hanţiu, (2013) defines the concept of method as being ”an organized, systematic manner of working”. In order to obtain knowledge, information necessary for the respective area, ”the realization of the generalization functions of current experience and the prospection of the effects of physical education and sport at new levels require that we use methods of scientific research”.

For our research we have used the following investigation methods: the method of the study of the specialty bibliography based on which we will obtain the theoretical founding of the ensuing paper, the observation method throughout the research activity, the experimental method will ensure an objective basis in order to answer the formulated hypotheses and the statistical-mathematical method for the processing and interpretation of data.

The method of the study of the specialty bibliography (documentation method)

This method is indispensable to scientific research and it involves the study of the specialty material in the researched area as well as in related areas. The documentation method or that of the study of the bibliography and specialized publications offer the researcher the possibility to collect information about the researched phenomenon, to get in contact with similar interests of specialists in that field, to deepen the theme of their research. (I. Hanţiu, 2013)

In order to fulfill this documentation stage successfully, I studied specialty papers of Romanian as well as international authors in my field of interest (training and sport performance in swimming) and in fields such as: physiology, psychology, statistical mathematics.

The observation method

Observation plays an important role in knowing the sportsman, it has to be ”continuous, objective, systematic and all data obtained this way will be registered, classified, processed and they will contribute to the formulation of conclusions” (P. Dungaciu, 1967, quoted by A. Nuţ, 2015)

Observation is the first moment of the exeprimental research ” when one practices independently in developed sciences and one approaches the experiment with the intention to find the soundest arguments in order to affirm the existence of a causal relationship.” (Rotariu and Iluţ, 2006)

The experimental method

The experimental method has ensured an objective basis whereby I was able to argument scientifically the answers to the hypotheses formulated in this study. According to Festinger and Ratz (1963, quoted by A. Nuţ, 2015), experiment is the ”observation and measurement of the effect of manipulating an independent variable on a dependent variable in a situation where the action of other factors (effectively present but not pertaining to the study) is reduced to a minimum.”

The statistical-mathematical method

Statistical indicators

Here were calculated elements of descriptive statistics, the data being presented by using indicators of centrality, localization and distribution.

Statistical analysis

The Shapiro-Wilk test was used in order to test normal distribution. The variance was tested with the F or Levene and/or Bartlett tests.

Test t (Student) was used with regard to data with normal distribution and in the case of values with non-uniform distribution or ranks there were used the non-parametric tests Mann-Whitney (U) for two unpaired events, or the Wilcoxon test in the case of two paired events. In order to analyze three or more events, the ANOVA test was used in the case of data with normal distribution or the Kruskal-Wallis non-parametric test in the case of values with non-uniform distribution or ranks.

The significance threshold for the used tests was $\alpha = 0,05$ (5%), $\alpha = 0,01$ (1%) or $\alpha = 0,001$, thus:

- $0,01 < p < 0,05$ –significant difference from the statistical point of view;
- $0,001 < p < 0,01$– very significant difference from the statistical point of view;
- $p < 0,001$– highly significant difference from the statistical point of view;
- $p > 0,05$ – non-significant difference from the statistical point of view.

The Pearson (r) correlation coefficient was used for the deceleration of the correlation between two continuous quantitative variables with normal (uniform) distribution. The Spearman (ρ) coefficient of rank correlations was used in the case of non-uniform distribution. The analysis of the correlation coefficients was performed by using Colton's rule. Thus, starting from the properties of the correlation coefficient which say that this is a number between -1 and 1 and that the "intensity" of the linear relationship between the two variables will be higher as the correlation coefficient gets closer to 1 in absolute value, Colton (1974) suggested the following empirical rules with regard to the interpretation of the correlation coefficient:

- weak/null correlation if $r \in [-0,25, +0,25]$ – noted *
- acceptable correlation if $r \in (+0,25, +0,5] \cup [-0,5, -0,25)$ – noted **
- good correlation if $r \in (+0,5, +0,75] \cup [-0,75, -0,5)$ – noted ***
- very good correlation if $r \in (+0,75, +1] \cup [-1, -0,75)$ – noted ****

The polynomial regression was the method used in order to obtain the mathematical equation of the dependency of one variable on another variable.

The statistical processing was done with Excel (from the Microsoft Office 2007 package), with the program StatsDirect v.2.7.2. The graphic representation of the results was done with Excel (from the Microsoft Office 2007 package).

Chapter 7 –The relationship between specific dry land training and swimming performance in children between 11-14 years old

7.1. Batches of human subjects

In this study participated swimmers who are members of the Sport Club ”Swim to Perfection” Cluj-Napoca, having as coach the undersigned, Adrian Marius Suciu.

The batch consisted of a number of 10 swimmers. The research was done with the clearance of the Ethics Committee of the ” Babeş-Bolyai” University of Cluj-Napoca. The inclusion of the subjects in the experiment was done based on the informed consent with regard to the purpose of the study and the work program.

The purpose of the preliminary study is to select and validate tests, the apparata that will be used in the study as well as the conditions for the course of the future actual study.

7.2. Objectives

To highlight the importance of strength and power training on dry land by using the swim bench.

To ensure the basic methodological conditions of the experiment.

To test, verify and validate the apparata used to measure strength and power.

7.3. Hypothesis

In the realization of this study I started from the premise that most performance swimmers use swim benches in dry land strength training and to diagnose performances. By testing specific apparata we will be able to validate its application in training in order to develop strength and power in swimmers and thus to enhance sports performance.

7.4. Methods

The pilot study was carried out in Cluj-Napoca at Complexul de Nataţie ”Universitas” of the ”Babeş-Bolyai” University in the space made available by the administration of the complex.

The swimmers carried out a specific training three times a week (Monday-Wednesday-Friday), a number of 5 repeats of 35 seconds each (butterfly). The training took place on the swim bench, Biometer Isokinetik Trainer. We performed two tests on the 50 m distance (butterfly), day 1 and day 28, after a low intensity warm-up (1000m).

7.5. Statistical processing

The results were processed statistically according to the technique described in Chapter 6, subchapter 6.2.

7.6. Results

During the statistical analysis of the values registered in the 50m butterfly event there were noticed differences that were higly significant from a statistical point of view between moments T1-T2 ($p < 0.01$).

7.7. Conclusions

The obtained results underline the importance of using the swim bench in dry land training. Strength training on dry land with swim benches can stimulate the ability to produce the propelling force in water, especially in short events.

Our studies reveal the importance of dry land training on the swim bench, Biometer Isokinetik Trainer, which had beneficial effects after four weeks of training, that is it enhanced the strength and, implicitly, the sports performance. Through these performed tests the testing instruments and the experimental conditions were validated as a result of the preliminary study. Thus the results obtained during the measurements (tests) done on the swim bench enable us to conclude that the hypotheses advanced in the preliminary study are validated, which gives us the possibility to continue our study.

7.8. Discussions

Studies made on female swimmers with a suppletion of Creatine showed that suppletion did not have beneficial effects on performance as it did not improve speed, whereas training on the swim bench did have beneficial effects on performance. (B. Dawson et al. 2002).

Training on the conditions simulator brings along the clear growth of strength where also the number of imposed cycles has grown, this giving the sportsman the possibility to ”mobilize” more strength in an event. (Ignat Constantin, 2006)

Swimming simulators (swim benches) are useful in order to diagnose individual performance if mechanic power is obtained. (Heller et al., 2004)

During simulated swimming the legs can sustain more power when compared with the arms. At the same time the intra-subject variability in measuring the strength is low by using these ergometers on dry land. These evaluation methods might prove useful in explaining swim performance and in monitoring the changes which take place during training. (I.L. Swain, 2000).

In the third part of the doctoral thesis paper are presented the personal contributions in establishing and verifying the methods and the efficient and defining means of the strength and power parameters. This part is structured in three chapters.

Chapter 8 Determinations with regard to the strength of the extensor muscles of the knee articulations in swimmers

8.1. Batches of human subjects

In this study participated swimmers who are members of the Sport Club ”Swim to Perfection” Cluj-Napoca, having as coach the undersigned, Adrian Marius Suciu.

The subjects had a moderate training specific to swimming and they also wore weight belts (4.520kg) around their waist and they had to perform undulating vertical motions (specific to butterfly) in this order: 4 times 35 seconds with a 3 minutes’ break between the rounds at the start of the training; after the warm-up part in water, 3 times a week for 6 weeks.

The batch consisted of 15 swimmers. The inclusion of the subjects in the experiment was done based on informal consent with regard to the purpose of the study and the work program.

8.2. Objectives

The influence of vertical training in water on the development of strength and power.

To establish the relationship between strength-power and speed.

8.3. Hypothesis

By using weight belts in the vertical water training we will enhance sthrength and power and, implicitly, the speed of traverse.

8.4. Methods

The study was carried out in the Laboratory of Experimental Research of the Faculty of Physical Education and Sport (”Babeş-Bolyai” University, Cluj-Napoca).

We focused on the following indicators: RL (right leg, 1000 and 1200, maximum strength and average values per 5 seconds), LL (left leg, 1000 and 1200, maximum strength and average values per 5 seconds); First test (T1) and second test (T2).

We established the maximum atrength of the knee extensor muscles (quadriceps femoris), measured with the isokinetic dynamometer, KIN-COM® (Chattanooga Group Inc., USA)

We ran two tests, the first test (T1) was done before the start of the training period and it consisted of 2 maximum isometric contractions for 5 seconds at different angles for each leg separately. We recorded 4 values for each swimmer separately, at 1000 and 1200 angles. The second test (T2) was done after 6 weeks of training.

8.5. Statistical processing

The results were processed statistically according to the technique described in Chapter 6, subchapter 6.2.

During the statistical analysis of the maximum values we noticed differences that were statistically very significant between moments T1-T2 for RL120^0, LL100^0 and LL120^0 ($p < 0,01$).

During the statistical analyis of the average values per 5 seconds we noticed differences that were statistically significant at moment T1 between RL100^0- RL120^0 and LL100^0- LL120^0 ($p<0,05$) and differences that were statistically very significant between moments T1-T2 for RL120^0, LL100^0 and LL120^0 ($p < 0,01$).

We found good and very good correlations between the maximum values of some of the studied indicators at moment T1 and T2 and very good and good correlations between the average values per 5 seconds for some of the studied indicators at moment T1 and T2.

8.6. Conclusions

There are few studies (data) both in our literature and in specialty literature with regard to the studied theme so that we believe this research to be of real interest in order to understand and confirm the role of the vertical undulation motion (doplhin kick) in the building of strength and its importance in enhancing speed in short distance events.

The undulating motion of the legs is used during start and turns in three out of the four competition events and it has an important role in the final performance materialized in the timed times (after the latest modifications of the International Association of Amateur Swimmers – FINA, the undulating leg motion has also been accepted in the start of the breaststroke event).

Our studies have shown that vertical water training with weight belts has a positive influence on the strength of the extensor muscles of the knees of swimmers. By using them we obtain a rise of the maximum strength on both legs at an angle of 120^0 and on the left leg at an angle of 100^0 after 6 weeks of training.

8.7. Discussions

The angle between 100^0 and 120^0 in the knee articulation is optimal in making the turns and efficient from two points of view: that of the short time spent during the turn and that of a very low level of energy consumption without applying excessive force being necessary. (L. Araujo et al., 2010)

Studies on professional swimmers show the importance of the undulating motion in swimming: swimming speed drops once the role of the propulsion of the undulation motion (doplhin kick) grows. (Gatta et al., 2012)

The importance of an efficient undulation motion in establishing the values of speed has been shown in a study done on 13 swimmers. The study data show that in the first 5-15 meters after the turn velocity is sustained essentially by the general strength applied by the swimmer when pushing against the wall, whereas it can also be an indicator of an efficient underwater undulating motion (and a correct body position) in this phase of the race. (Zamparo et al., 2012)

The performance of the underwater undulating motion is influenced by the symmetry in the sagittal plane both in the ascending and descending phase. The studies on athletes, swimmers using an underwater video camera, underline the importance of the ascending phase in the propulsion of the body. (R. Atkinson et al., 2014)

In order to improve the capacity to perform undulating motions and determine a positive growth in strength, one must also develop the flexibility of the ankles. (McCullough et al., 2009) The gross strength of the swimmer has an indirect connection with the flexibility of the ankles. An optimal undulating motion keeps a balance between the minimization of the drag force and of the energy costs; corroborated with the maximization of the force moment (R.C.Cohen et al., 2012).

Chapter 9 Means of action in dry land training and their influence on the development of strength and power

9.1. Batches of human subjects

In this study participated swimmers who are members of the Sport Club ”Swim to Perfection” Cluj-Napoca, having as coach the undersigned, Adrian Marius Suciu. The batch consisted of three swimmers from the national and extended olympic lot of the Romanian Swimming and Modern Pentathlon Federation - Federaţia Română de Nataţie şi Pentatlon Modern. (FRNPM). The small number of participants is a result of the high travel costs involved (accommodation, tests/measurements), as well as their training level.

The subjects followed a moderate training schedule specific to swimming and beside this they also had twice a week (Tuesdays before the water training and Thursdays after water training) dry land training in order to develop strength and power, except for the transition periods, throughout the duration of the research studies (2011-2014). The training sessions consisted of performing strength circuits, plyometric, isometric exercises, vertical jumps, diverse exercises with medical balls (pushing from the chest, ball throwing, etc.). Duration of the trainings: approximately 30 minutes.

The inclusion of the subjects in the experiment was done based on the informed consent with regard to the purpose of the study and the work program.

9.2. Objectives

The influence of using specific exercises in dry land training on the development of strength and power.

To establish the relationship between strength-power and sports performance.

9.3. Hypothesis

By using specific exercises in dry land training we will improve strength and power, thus enhancing sports performance.

9.4. Methods

The study took place in Spain, High Altitude Training Center of Sierra Nevada located at an altitude of 2320 meters. This training center is an excellence center that is being used by athletes from all over Europe from different sport branches. The center is provided with an olympic pool, stadium, running track, sport halls and different laboratories (biomechanics, biochemistry, etc.).

The swimmers performed exercises with the weights, that is:

- half squats (HS);

- pushing while lying (PL);

- rowing, face down – pushing towards the chest (PC).

Maximum repetitions were performed for each exercise and workshop, the best values being considered. For each athlete we calculated work intensities, in percentages, in relation to their body mass: 25% (HS1, BP1, HR1), 50% (HS2, BP2, HR2) and 75% (HS3, BP3 show, HR3) reaching 100% of the maximum possibilities (HS4).

We conducted two tests, the first test was carried out in 2012 and the second test was carried out in 2014.

The tests were performed with a device specially designed to determine the strength and power of the athletes as accurate as possible.

The device used was T-STRENGTH, which provides us with useful and detailed information for monitoring, diagnosis and understanding of the athletes' features, to optimize the training. The device registers and saves in real-time the speed and power profile for various loads.

T-STRENGTH is a dynamic system of measurement, an isoinertial dynamometer which records and displays the following biomechanical parameters:

Biomechanical parameters	Biomechanical parameters	Biomechanical parameters
weight	weight	weight
average speed	average speed	average speed
average speed to achieve maximum speed	average speed to achieve maximum speed	average speed to achieve maximum speed
average speed- propulsive phase	average speed- propulsive phase	average speed- propulsive phase
maximum Speed	maximum Speed	maximum Speed
time elapsed to achieve maximum speed	time elapsed to achieve maximum speed	time elapsed to achieve maximum speed
average acceleration	average acceleration	average acceleration
average acceleration to achieve maximum speed	average acceleration to achieve maximum speed	average acceleration to achieve maximum speed
average acceleration - propulsive phase	average acceleration - propulsive phase	average acceleration - propulsive phase
maximum acceleration	maximum acceleration	maximum acceleration
time elapsed to achieve maximum acceleration	time elapsed to achieve maximum acceleration	time elapsed to achieve maximum acceleration
the duration of the propulsive phase	the duration of the propulsive phase	the duration of the propulsive phase
the duration of the propulsive phase	the duration of the propulsive phase	the duration of the propulsive phase
average strength	average strength	average strength
average strength to achieve maximum speed	average strength to achieve maximum speed	average strength to achieve maximum speed
average strength - propulsive phase	average strength - propulsive phase	average strength - propulsive phase
maximum strength	maximum strength	maximum strength
time elapsed to achieve maximum strength	time elapsed to achieve maximum strength	time elapsed to achieve maximum strength
average power	average power	average power
average power to achieve maximum speed	average power to achieve maximum speed	average power to achieve maximum speed
average power - propulsive phase	average power - propulsive phase	average power - propulsive phase
maximum power	maximum power	maximum power
time elapsed to achieve maximum power	time elapsed to achieve maximum power	time elapsed to achieve maximum power
mechanical impulse	mechanical impulse	mechanical impulse
integral of power	integral of power	integral of power
integral of speed	integral of speed	integral of speed
maximum strength development rate	maximum strength development rate	maximum strength development rate
time elapsed to achieve maximum strength development rate	time elapsed to achieve maximum strength development rate	time elapsed to achieve maximum strength development rate
mechanical work	mechanical work	mechanical work

9.5. Statistical processing

The results were statistically analyzed according to the technique described in Chapter 6, section 6.2.

9.6. Results: half squats (HS)

The statistical analysis of the correlation between the indicators studied in **2012** showed:

- for weight HS1:

  - very good correlation and in the same direction between W - F max, W - P max, A max - F max, A max - I.P., V max - P max, L - F max, L - I.P., F max - I.P.

- very good correlation, but opposite, between I.V. – P max, Imp(P) – P max

- very good correlation, and in the same direction, between I.V. – I.P.

- acceptable correlation and in the same direction between Imp (P) - I.P.

- acceptable correlation but in opposite direction between A max - P max, V max - I.P., L - P max, P max - I.P.

- for weight HS2:

  - very good correlation and in the same direction between W – P max, A max – F max, A max – I.P., V max – F max, V max – P max, V max – I.P., I.V. - F max, IV – P max, I.V. – I.P., L – F max, L – P max, L – I.P., Imp(P) – F max, Imp(P) – P max, Imp(P) – I.P., F max – P max, F max – I.P., P max – I.P.

  - good correlation and in the same direction between W - I.P.

  - acceptable correlation and in the same direction between W - F max, A max - P max.

- for weight HS3:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., V max – F max, V max – P max, V max – I.P., I.V. – F max, IV – P max, I.V. – I.P., L – F max, L – P max, L – I.P., Imp(P) – I.P., F max – P max, F max – I.P., P max – I.P.

  - good correlation and in the same direction between Imp(P) – F max, Imp(P) – P max.

  - acceptable correlation but in the opposite direction between A max - I.P.

- for weight HS4:

  - very good correlation and in the same direction between W – F max, A max – P max, A max – I.P., V max – F max, V max – P max, V max – I.P., L – F max, L – P max, L – I.P., F max – P max, F max – I.P., P max – I.P.

  - very good correlation but in the opposite direction between Imp(P) – F max, Imp(P) – P max, Imp(P) - I.P.

- good correlation and in the same direction between W – P max, W – I.P., A max – F max.

- acceptable correlation, but in the opposite direction between I.V. – F max.

The statistical analysis of the correlation between the indicators studied in **2014** showed:

- for weight HS1:

  - very good correlation and in the same direction between W – F max, W – P max, A max – P max, V max – P max, L – I.P., Imp(P) – I.P., F max – P max.

  - very good correlation but in the opposite direction between A max – I.P., V max – I.P., I.V. – F max, IV – P max, L – P max, Imp(P) – P max

  - good correlation and in the same direction between A max – F max, V max – F max, I.V. - I.P.

  - good correlation but in the opposite direction between L – F max, Imp(P) – F max, F max – I.P.

- for weight HS2:

  - very good correlation and in the same direction between W – F max, W – I.P., V max – P max, I.V. – F max, IV – P max, I.V. – I.P., L – F max, L – P max, L – I.P., F max – P max, F max – I.P., P max – I.P.

  - good correlation and in the same direction between W – P max, V max – P max, V max – I.P.

  - acceptable correlation and in the same direction between A max – P max, Imp(P) – F max, Imp(P) – P max, Imp(P) – I.P.

- for weight HS3:

  - very good correlation and in the same direction between W – F max, W – I.P., V max – P max, L – F max, L – P max, L – I.P., Imp(P) – F max, Imp(P) – P max, Imp(P) – I.P., F max – P max, F max – I.P., P max – I.P.

- good correlation and in the same direction between W – P max, A max – P max, V max – F max.

- acceptable correlation and in the same direction between A max – F max, V max – I.P., I.V. – F max, IV – P max, I.V. – I.P.

- for weight HS4:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – P max, L – F max, L – P max, L – I.P., Imp(P) – F max, Imp(P) – I.P., F max – P max, F max – I.P., P max – I.P.

  - very good correlation and in the same direction between A max – F max, A max – I.P., V max – P max, I.V. – P max, Imp(P) – P max.

  - acceptable correlation and in the same direction between V max – F max, V max – I.P., I.V. – F max.

9.7. Results: pushing while lying (BP)

The statistical analysis of the correlation between the indicators studied in **2012** showed:

- for weight BP1:

  - very good correlation and in the same direction between W – P max, W – I.P., V max – P max, V max – I.P., I.V. – F max, IV – P max, I.V. – I.P., L – P max, L – I.P., Imp(P) – P max, Imp(P) – I.P., P max – I.P.

  - good correlation and in the same direction between V max – F max, L – F max, Imp(P) – F max, F max – I.P.

  - good correlation but in the opposite direction between A max – P max, A max – I.P.

  - acceptable correlation but in the opposite direction between A max – F max, F max – P max.

- for weight BP2:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., L – I.P., Imp(P) – P max, Imp(P) – I.P., F max – P max.

  - very good correlation but in opposite direction between A max – I.P., V max – F max, V max – P max, V max – I.P.

- very good correlation, and in the same direction, between I.V. – I.P., L – F max, L – P max, Imp(P) – F max, F max – I.P., P max – I.P.

- acceptable correlation but in the opposite direction between A max - P max.

The statistical analysis of the correlation between the indicators studied in **2014** showed:

- for weight BP1:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – F max, V max – P max, L – F max, L – P max, L – I.P., Imp(P) – F max, Imp(P) – P max, Imp(P) – I.P., F max – P max, F max – I.P., P max – I.P.

  - good correlation and in the same direction between A max – P max, A max – I.P., V max – I.P.

  - acceptable correlation and in the same direction between V max – F max.

  - acceptable correlation, but in the opposite direction between I.V. – F max.

- for weight BP2:

  - very good correlation and in the same direction between W – P max, W – I.P., A max – F max, A max – P max, A max – I.P., L – P max, L – I.P., Imp(P) – I.P., F max – P max, P max – I.P.

  - very good correlation, but opposite, between I.V. – P max, I.V. – I.P.

  - good correlation and in the same direction between Imp (P) - P max.

  - acceptable correlation and in the same direction between W – F max, V max – F max, V max – P max, L – F max, Imp(P) – F max, F max – I.P.

  - acceptable correlation but in the opposite direction between V max – I.P., I.V. – F max.

- for weight BP3:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – F max, A max – P max, A max – I.P., I.V. – P max, L – F max, L – P max, L – I.P., F max – P max, F max – I.P., P max – I.P.

- very good correlation, and in the same direction, between I.V. – F max.
- acceptable correlation and in the same direction between V max – I.P., Imp(P) – I.P.

9.8. Results: pushing while lying (HR)

The statistical analysis of the correlation between the indicators studied in **2012** showed:

- for weight HR1:
  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – F max, V max – P max, I.V. – P max, I.V. – I.P., L – P max, L – I.P., Imp(P) – F max, P max – I.P.
  - good correlation and in the same direction between A max – I.P., L – F max, F max – I.P.
  - acceptable correlation and in the same direction between V max – I.P., I.V. – F max, Imp(P) – I.P.
  - acceptable correlation but in the opposite direction between V max - F max.
- for weight HR2:
  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – F max, A max – I.P., V max – P max, I.V. – F max, IV – I.P., L – F max, L – P max, L – I.P., Imp(P) – F max, Imp(P) – I.P., F max – I.P., P max – I.P.
  - very good correlation, and in the same direction, between I.V. – P max, F max – P max.
  - acceptable correlation and in the same direction between A max – P max, V max – I.P.
- for weight HR3:
  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., V max – F max, V max – P max, V max – I.P.,

I.V. – F max, IV – I.P., L – F max, L – P max, L – I.P., F max – P max, F max – I.P., P max – I.P.

- very good correlation and in the same direction between Imp (P) - P max.

- good correlation and in the same direction between A max – F max, A max – P max, A max – I.P.

- good correlation and in the same direction between Imp (P) - F max.

- acceptable correlation, and in the same direction, between I.V. – P max.

- acceptable correlation but in the opposite direction between Imp(P) – I.P.

The statistical analysis of the correlation between the indicators studied in 2014 showed:

- for weight HR1:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – F max, A max – P max, V max – P max, I.V. – I.P., L – F max, L – I.P., Imp(P) – I.P., F max – P max, F max – I.P., P max – I.P.

  - good correlation and in the same direction between A max – I.P., I.V. – F max, L – P max, Imp(P) – F max.

  - acceptable correlation and in the same direction between V max – F max.

- for weight HR2:

  - very good correlation and in the same direction between W – F max, W – P max, W – I.P., A max – P max, A max – I.P., V max – I.P., L – P max, L – I.P., Imp(P) – F max, Imp(P) – P max, Imp(P) – I.P., P max – I.P.

  - good correlation and in the same direction between V max – P max, I.V. – P max, I.V. – I.P.

- acceptable correlation and in the same direction between A max – F max, V max – F max, I.V. – F max, L – F max, F max – P max, F max – I.P.

- for weight HR3:

  - very good correlation and in the same direction between W – F max, W – I.P., A max – P max, A max – I.P., V max – P max, V max – I.P., L – F max, L – P max, L – I.P., Imp(P) – F max, Imp(P) – P max, Imp(P) – I.P., F max – I.P., P max – I.P.

  - very good correlation, but in the opposite direction between I.V. – F max.

  - good correlation and in the same direction between V max – F max.

  - good correlation, but in the opposite direction between I.V. – I.P.

  - acceptable correlation and in the same direction between W – P max, A max – P max, F max – P max.

  - acceptable correlation, but in the opposite direction between I.V. – P max.

9.9. Conclusions

Dry land training is an important component in the training of swimmers, especially sprinters. Our research highlights the importance of using training methods: isotonic, isokinetic and isometric, plyometric, ballistic for the development of muscle strength and power.

In the comparative analysis of the parameters measured in 2012 and 2014, we notice the following statistically significant differences:

1. half squats: average speed, maximum speed, average strength to achieve maximum speed, maximum strength, average power, maximum power, medium strength - propulsive phase, average power to achieve maximum speed, average power - propulsive phase, integral of speed, maximum strength development rate, time elapsed to the maximum strength development rate.

2. pushed while lying: average speed, maximum speed, average speed - propulsive phase, maximum acceleration, average power, average power to achieve maximum speed, average power - propulsive phase, maximum power, time elapsed to

achieve the maximum power, integral of power, time elapsed to achieve the maximum strength development rate, mechanical work;

3. rowing with the bar: time elapsed to achieve maximum speed, time elapsed to achieve maximum power, mechanical impulse, integral of power, integral of speed, mechanical work.

This improvement of the studied parameters values is due to a better scheduling of the strength and power dry land training, a rigorous selection of the means and methods used and the effectiveness of their practice.

The results of our research show a close relationship between strength and speed, which act together as an entity, not as two separate components of power.

The statistical power of the results of the parameters studied given by the correlational connections and significant differences resulted in very high significance thresholds which support the research hypothesis.

9.10. Discussions

The use of ballistic method by repetitions on the pushing bench leads to the improvement of the maximum power after a five-week period. In this period, the athletes performed a maximal repetition of pushing while lying on the back with a weight of (80-100%) of the maximum capabilities or a repeat with moderate weight (40-55%) of the maximum capabilities, using the mentioned method. (K.P. Young et al., 2015)

Dry land training is a fundamental component in the training of rowers. Over a period of three years, we noticed an increase in power and performance scores. Repetitions were performed with maximum weight of pushing while lying on the back, the percentages increased by 13% in men and 6.5% in women, and the performance time increased by 1%. (M.R. McKean, B.J. Burkett, 2014)

To increase maximal and submaximal strength for higher train, it is recommended to prioritize and conduct trainings according to the individual needs. (C.O. Assumpção et al., 2013)

Research conducted on athletes (hockey players) have shown a strong relationship between strength and upper body power and speed in performance, and the ability to produce propulsion and high frequencies in combination is very important for sprint abilities in hockey players. (K. Skovereng et al., 2013)

During the adjustment period, for strength development it is recommended the use of a resistance program of high volume (9 sets per muscle group and 3 sets for each exercise), and during the in the competitive period, it is recommended to use resistance program of small volume (3 sets per muscle group and 1 set for each exercise). (F. Naclerio et al., 2013)

Maximum strength may be enhanced using repetitions of pushing while lying on the back (pushing while lying bench), the performance depending on the interval of rest between repetitions, as the shortest, the most specific volume may be obtained in women. (N.A. Ratamess et al., 2012)

High intensity training is needed to improve muscle strength in athletes with experience, this being possible by measuring the speed of execution of each repetition of pushing while lying on the back, for each weight. (J. Padulo et al.,2012)

Practice on the pushing while lying bench (with intensities ranging from 50-100% of the maximum possibilities, for three weeks), combined with various periods of rest has beneficial effects, for the development of strength, depending on sex peculiarities. (L.W. Judge, Burke Jr., 2012)

Resistance training, with high loads (90% of the maximum possibilities) is superior compared to a workout with medium loads (70%). This type of training determines an increase of the strength without change in muscle mass, which results in increased sprint capacity. Thus, the use of training with large loads is preferred when the goal is to develop maximum strength and power during sprints. (G.C. Bogdanis et al. 2011)

Maximum power necessary for half squats may determine the performance in sprint and high jump. Researches on professional football players recommend the use and concentration on concentric movements in strength and power training. (U. et al., 2004)

In swimming, in order to improve the maximum power, it is recommended to use a special training, namely pushes from the wall. (H.M. Toussaint, K. Vervoorn, 1990)

The use during warming-up of the exercises, implicitly of the half squats with the sub-maximal weights, carried out explosively, have effect in the short term to improve the performance of the vertical jump, this effect being more prevalent in athletes with a high level of strength and power. (V. Gourgoulis et al., 2003; K. Hiramaya, 2014)

Researches conducted on swimmers emphasize a positive effect of plyometric training, at start and turns, but not propulsion. Due to the practicality and relevance of a successful start and turns, the plyometric exercises are recommended to be included in the training of teenage swimmers. (F.J. Potdevin et al., 2011; D.C. Bishop et al., 2009).

Plyometric training in water determines the same improvements of the performance as the plyometric training on dry land, with significantly less muscle pain. (L.E. Robinson et al., 2004)

Chapter 10. Determinations on the swim bench regarding the strength and muscular power of arms traction

10.1. Batches of human subjects

Athletes, members of the Sports Club "Swim to Perfection" Cluj-Napoca, having as coach the undersigned, Adrian Marius Suciu, participated in the research. The batch of athletes consisted of 24 swimmers.

The subjects had a moderate workout specific to swimming and, additionally, they had a training with Biometer Isokinetic Trainer.

The device has 9 levels of intensity (1- low speed and high resistance; 5-medium; 9-high speed and low resistance). The training sessions were conducted twice a week, before entering the water. The training duration was approximately 20-30 minutes and consisted of sets of exercises on the device (specific movements for the butterfly stroke); the rest range of 2 minutes and 3 minutes between sets. The work schedule consisted of:

- 15-20 seconds for level 2; 15-20 seconds for level 8; 15 seconds for level 5;
- 15-20 seconds for level 3; 15-20 seconds for level 7; 15 seconds for level 5;
- 15-20 seconds for level 4; 15-20 seconds for level 6; 15 seconds for level 5;

After the training on the swim bench, the athletes entered the water where they performed 3 sets similar to those performed on the Biometer, respecting exactly the model performed on the bench. These consisted of sprints of 25 m, departing from the water:

- 15-20 seconds butterfly stroke, with parachute and swim paddles (of different sizes);
- 15-20 seconds butterfly stroke with an elastic chord (aided by coach to facilitate the movement in the water and return to the wall after elongation at the maximum point of the chord);
- 15 seconds butterfly stroke (without supporting means).

The inclusion of the subjects in the experiment was made based on the informed consent for the study and work program.

10.2. Objectives

Influence of using the Biometer Isokinetic Trainer on the development of power and strength of arms' traction.

Establishing the relationship between strength - power and speed and sports performance.

10.3. Hypothesis

Using the device Biometer Isokinetic Trainer for the dry land training, we will develop muscular strength and power of the arms, we will correct and improve the technique of butterfly stroke.

10.4. Methods

The study was conducted at the Swimming Complex "Universitas" of the "Babes-Bolyai" University, in area made available by the management of the complex, using the equipment of the sports club "Swim to Perfection" Cluj-Napoca, where I am the coach.

The athletes had a brief neuro-muscular warming up, by specific movement, on the swim bench, of 60-90 seconds, followed by the test. The tests were performed for 30 seconds (level 5 of intensity - considered the closest to the density of water), the time being determined according to the approximate period corresponding to the 50m butterfly. We conducted three tests: in 2012, 2013 and 2014.

We determined the following parameters:

- average strength (N) - abbreviated below as F med;
- mechanical work (J) - abbreviated below L;
- average power (W) - abbreviated below as P med;
- average speed (m/s) - abbreviated below as V med;
- length of traction (m) - abbreviated below Lt;
- time of active phase (sec) - abbreviated below as TFA;
- frequency of arms (no. / min) - abbreviated below as F-BR;
- number of arms' cycles (no.) - abbreviated below as C-BR;

10.5. Statistical processing

The results were statistically analyzed according to the technique described in Chapter 6, section 6.2.

10.6. Results

At the statistical analysis of the values **of the average strength** *for twin events,* we noticed significant statistical differences between the moments 2012-2013, 2012-2014 and 2013-2014 ($p < 0.001$).

At the statistical analysis of the values **of the mechanical work** *for twin events,* we noticed significant statistical differences between the moments 2012-2013, 2012-2014 and 2013-2014 ($p < 0.001$).

At the statistical analysis of the values **of the average power** *for twin events* we noticed significant statistical differences between the moments 2012-2013, 2012-2014 and 2013-2014 ($p < 0.001$).

At the statistical analysis of the values **of the average speed** *for twin events,* we noticed significant statistical differences between the moments 2012-2013 and 2012-2014 ($p < 0.05$).

At the statistical analysis of the values **length of traction, time during the active phase, frequency of arms, cycles of arms** *for twin events,* no significant statistical differences were noticed between any of the moments ($p > 0.05$).

The correlation statistical analysis between the indicators studied showed:

- in 2012 (see Figure 9):
  - very good correlation and in the same direction between F med – L, F med – P med, L – P med, Lt – TFA şi F-BR – C-BR.
  - good correlation and in the same direction between F med – TFA şi P med – TFA.
  - good correlation but in the opposite direction between V med – TFA, Lt – F-BR, Lt – C-BR, TFA – F-BR şi TFA – C-BR.
  - acceptable correlation between and in the same direction between L – V med, L – TFA, L – C-BR, V med – F-BR şi V med – C-BR.
  - acceptable correlation but in the opposite direction between F med – F-BR, P med – F-BR şi V med – Lt.
- in 2013 (see Figure 10):
  - very good correlation and in the same direction between F med – L, F med – P med, L – P med and F-BR - C-BR.
  - very good correlation, but in the opposite direction between TFA – C-BR.
  - good correlation and in the same direction between F med – TFA şi L – TFA.
  - good correlation but in the opposite direction between Lt – F-BR şi Lt – C-BR.
  - acceptable correlation and in the same direction between F med – Lt, L – V med, L – Lt, L – C-BR, P med – Lt, P med – TFA şi Lt – TFA.
  - acceptable correlation but in the opposite direction between L – F-BR.
- in 2014 (see Figure 11):
  - very good correlation and in the same direction between F med – L, F med – P med, L – P med, P med - TFA şi F-BR – C-BR.

- very good correlation but in the opposite direction between TFA – F-BR şi TFA – C-BR.
- good correlation and in the same direction between F med – Lt, F med – TFAm L – Lt, L – TFA, P med Lt şi L – TFA.
- good correlation but in the opposite direction between Lt – F-BR şi Lt – C-BR.
- acceptable correlation and in the same direction between V med – Lt.
- acceptable correlation but in the opposite direction between F med – V med şi F med – C-BR.

At the statistical analysis of values of **time in water** (sec) to 50 m butterfly, considering all three years, we noticed highly significant statistical differences between at least two of the years ($p = 0.0021$). According to the expectations, at the statistical analysis of the values of the time in water for 50 m butterfly *for twin events*, we noticed significant statistical differences between the years 2012-2013, 2012-2014 and 2013-2014 ($p < 0.0001$).

10.7. Conclusions

The swim bench (Biometer Isokinetic Trainer) develops strength at speeds close to those during the event, or even higher and improves the intermuscular synchronization, considering that each muscle group that participates in a movement acts in a certain order and at a certain time.

Trainer Biometer Isokinetic monitoring system enables real-time visualization of the various movement parameters. The monitoring in real time gives us information on their development and objective assessment of the volume and work intensity.

Following the research, we notice significant increase of strength, speed and power, also understood as improvement of water times for 50m distance. In most athletes, we notice a significant improvement of performances in water. Also, there were athletes who maintained approximately constant their speeds, marking only a slight increase (the consequence of a poor swim bench technique, lack of training). Only one athlete presents stabilization of the speed and strength parameters, but with a decrease in power.

The good results obtained on the swim bench were successfully transferred into the water. We notice an interdependent relationship between strength, power and mechanical work, each having an influence on the other. For the comparative analysis of the following parameters: strength, power, mechanical work, there are intensely significant differences during the three years of study (2012-2013-2014), demonstrating the effectiveness of training on this device.

Regarding the length of traction, frequency of arms, time of active phase and the number of arms' cycles, there are no statistically significant differences over the three years (2012-2013-2014). This is explained by the fact that we wanted to increase strength and power parameters without damaging the technique. Detection and correction of technical errors are an important aspect aimed at during the training with the Biometer and in water.

During the analysis of the results obtained after training on the swim bench, we noticed that the evolution of the athletes during the study period was better than their earlier developments. This evolution is due to the formation of correct movements (stereotype) using the machine constantly.

10.8. Discussions

The training on the ERGOSIM conditions simulator, with specific exercises with weight for maintaining strength at speed superior to the personal record speed, determines changes in the command structure, meaning expediting the contraction sequence of the muscle involved in the specific effort, with significant effects for the strength and speed increase in the effort specific to competition. (Pierre Joseph de Hillerin, 1997)

The use of ergometer in strength and power training has positive effects. (T.W. Lawton et al., 2011). Swim bench ergometry is a reliable method for measuring the maximum traction strength of arms in surfers. (D. J. Loveless and C. Minahan, 2010) This method of measuring power may be useful in explaining swim performance and monitoring of changes that occur in training. (I.L. Swaine, 2000)

Swim benches are used in dry land training by majority of swimmers to diagnose performance. These are helpful for individual performance if the mechanical power achieved over a period of time corresponds to competition times. (J. Edelmann-Nusser et al., 2004)

Simulated swimming is the preferred ergometric dry land training method in swimmers. (I.L.Swaine, E.M. Winter, 1999)

It is recommended to use the swim bench in the swimmers' training to optimize the biomechanics of the arms' movement and mechanical power resulted. (P. Zamparo et al., 2014) During training on swim bench, a great part of the muscle mass used in swimming is activated, the aerobic increases being transferred directly into the water. (T. J. Gergely et al., 1984)

To improve muscle strength of the arms during the preparatory period, the training only of the arms in swimming, with a percentage of 20% of weekly training distances, is an effective method. (M. Konstantaki et al., 2008)

Using the ergometer in training resulted in an improvement in maximum muscle power of arms in swimmers. (J.D. Trinity et al., 2006)

CHAPTER XI GENERAL CONCLUSIONS AND RECOMMENDATIONS

Preparing future champions in competitive swimming is always a challenge for specialists. The main concern is to provide the best level of development of driving skills which, later on, will be a physical substrate necessary to learn the technique of swimming strokes and therefore, our study provides benchmarks for the objective planning of muscle strength and power development.

The aim of this study was to monitor the development and improvement of the relevant driving skills (in our case the strength-power) to obtain performance in sports. For this purpose, we selected and presented some methods and tools that enhance and optimize training; the focus of our research being on increasing sports performance using strength-power development in swimmers by customizing training depending on the particularities and needs of athletes.

Pilot study (Chapter VII):

- our research highlights the importance of dry land training, on Biometer Isokinetik Trainer that after four weeks of training had beneficial effects in increasing strength and hence sports performance.

- following the preliminary research, we validated the testing tools and experimental conditions. The results obtained from tests carried out on the swim bench validate the hypotheses presented in the preliminary research, with the possibility of continuing the researches.

Study I (Chapter VIII):

- the research results showed that vertical training in water with weight belts has a positive influence on the strength of knee extensor muscle in swimmers, their use resulting in the increase of the maximum strength after a 6-week training period, in both legs, at an of angle 120^0 and the left leg at an angle of $100\ ^0$:
- training in water, specific to strength - power development, has positive effects, influencing the speed in water.

Study II (Chapter IX):

- dry land training is an important component in the training of swimmers, especially sprinters.
- for the analysis of recorded time, the results demonstrated that the evolution of athletes in training conditions had significant increases throughout the program, and later in competition conditions. Throughout the training program, the performances (both in training and in competition) were significant, with the improvement of times of several events, in the national competitions in which the athletes participated.
- compared to the beginning of the program, we noticed an increase in the strength - power parameters, which highlights the effectiveness of training methods and means used. An important aspect was also the improvement of the butterfly stroke technique, effect noticed in the evolution of times in training and competitions;
- most athletes included in the study have a good and very good evolution; three athletes were distinguished: Andreea Andonie, Alexia Dascăl and Ana Dascăl. Throughout the study, in competitions, they obtained excellent results, consolidated as national champions in various events and strokes, as well as in establishing new national records.

Here we will mention the most important ones, namely: national record in 50m butterfly, 100m freestyle, 100m backstroke, 200m freestyle, results achieved by athlete Ana Dascăl. In addition, she benefits from a grant received from the Romanian Olympic and Sports Committee, as she is an athlete for the future and she is appointed for the Olympic Games in Tokyo.

The athletes included in the study obtained multiple national championship titles, both individually and with the relay, setting a new national record in 4x50m freestyle, for their age group.

Study III (Chapter X):

- the good results obtained on the swim bench were successfully transferred into the water. We notice an interdependent relationship between strength, power and mechanical work, each having an influence on the other. For the comparative analysis of the following parameters: strength, power, mechanical work, there are intensely significant differences during the three years of study (2012-2013-2014), demonstrating the effectiveness of training on this device.
- the traction simulation exercises, on the swim bench, stimulates the effect of recruitment and leads to the increase in muscle mass. We recommend using it at the beginning of the training period for conducting non-specific force training, given the increase of the muscle mass, strength and power, and towards the end of the period to carry out traction simulation exercises with opposing force (on land and in water), to engage a greater number of muscle fibers previously developed;
- one athlete was advised to focus more on traction simulation exercises, and have less non-specific training to improve strength, not to increase muscle mass too much, this is because it tends to become "globulous";
- research has shown that strong athletes are also fast, the two components of the power being the muscle strength and speed of movement. Both having equally important roles;
- stronger athletes will not necessarily be faster only if they apply their strength at a high frequency. Backwards, swimmers who swim with high frequency will not win races unless they exercise a reasonable amount of strength on each traction.
- The results of the experiment highlight the need to use strength - power - speed exercises, plyometric means, swim bench, all helping to increase strength and power of the muscle groups used.
- these results may be used as practical recommendations in the training of high performance swimmers, being a practical guide for coaches and athletes. We also

recommend the use of Isokinetic Trainer Biometer in dry land training due to its very good results achieved in improving the technique, and the increase of strength - power parameters.

The results of our research confirm the work hypotheses, by which the improvement of the operational programs for the strength and power development in swimmers enhances the training, in line with the present trends in swimming, where strength and power are key factors.

Optimizing workouts to improve strength and power, is a "sine qua non" condition necessary to each swimmer who wants to reach the top of sports performance.

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