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# ANTHROPOLOGICAL AND METHODOLOGICAL (DIDACTIC) ASPECTS OF WORK IN CONTEMPORARY SPORTS

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## SUMMARY

Theoretical and methodological issues, solving of which may give a new impulse to the development of sport and sports achievements, are recently generated by newly established centers for scientific and professional work in sports, like sport science institutes, or institutes for applicative theory and methodology of training. Anthropological and methodological scientific investigation within the framework of the centers should solve issues put forward by sport practice, and vice versa, findings and inferences of scientific research into sport should be as quickly as possible built into actual sport practice. It is the only way in which the gap between science and practice can really be bridged over, or in which these two areas can be associated to benefit top-level sports achievements.

**Key Words:** anthropological research, didactic research, professional work in sports..

## INTRODUCTION

Consistent development and preservation of sports achievements of individuals and teams alike is achievable only through the synergy of anthropological and methodological premises of professional work in sports regardless of sport branch, quality level, or age of trainees. Scientific research facilitates and improves solving of various theoretical and methodological issues that occure in sports training. It further contributes to the establishment of objective criteria for the selection of athletes and to the definition of preconditions needed for optimal level of fitness and sports form accomplishment, all in the function of the highest possible competition achievements.

Consequently, the main orientation in the professional sports training work regards the issue of how to design successfully the process of both the long- and short-term sports preparation to suit selected athletes on the basis of scientifically obtained information about the current level of athletes' shape and by implementing the admissible training technologies and recovery methods while simultaneously observing the given, sport-specific competition systems. Recently, sport science has been enriched with new concepts and insights into the previously mentioned factors of sport achievements that should be transferred to and substantiated with everyday sport practice.

Scientific research into sport depends on the participation of scholars and researchers not only from kinesiology of sport, or sport sciences, but also from other social-humanistic, biomedical and natural sciences as well and of experts of research methodology (Mraković, 1992; Reilly, 2007). Out of various social-humanistic sciences certain should be singled out like, primarily, kinesiology, understood as the science of movement and programmed processes of exercise and learning the target of which is optimal development and protection of human abilities, features and motor skills (knowledge), as well as several other social-humanistic scientific disciplines, like philosophy and sociology of sports, sport psychology, ethics, pedagogy, sports legislation, economics and marketing. From the area of biomedical sciences, contributions of kinesiological physiology and anthropology, sports medicine, pharmacology and nutrition science to sports should also be highlighted here. Additionally, fair proficiency in mathematics, information science, statistics and kinesiometry is indispens-

able to advance research methodology in the area of sports.

Quite a number of experimental scientific studies has been published from the area of *anthropological research* providing opportunities for the verification of hypotheses regarding the structure of various anthropological characteristics and motor skills and associations among them, as well as hypotheses on quantitative and qualitative transformations of features, abilities, motor skills, behaviour and health status that have been induced by the influence of various training programmes. These explorations primarily focus on the determination of quantitative indicators and on the establishment of latent structure of various anthropological variables, then on the analysis of relations between particular anthropological characteristics of athletes and their performance in sports activities, and the last but not the least, on the analysis of the effects of the involvement with particular sporting activities on changes in diverse anthropological characteristics. The other important research area regards the analysis of differences in anthropological characteristics among athletes pertaining to diverse sports branches, or among group of athletes of various age and gender within the same sport discipline.

*Methodological research* is focused on the analysis of effects diverse methods of physical conditioning and technical-tactical training as well as programmed training programmes have on athletes' performance and on their states in particular stages of fitness and sports form development across typical cycles of both the annual and perennial periodization.

The purpose of the so defined scientific research orientations in the area of sports and sports training can be expressed in short as the determination of *kinesiological, anthropological, and methodological* (covering the research and didactical methodology alike) principles or laws of planning, programming and control of the processes of sports training, competition participation and recovery in different cycles of sports preparation (Milanović, 2013).

## ANTHROPOLOGICAL RESEARCH AS A FACTOR OF PROFESSIONAL WORK IN SPORTS

Each and every sport, that is, each sport branch has its own specific structure of performance factors, which are translated into sport-specific anthropological requirements imposed on the involved athletes. If an athlete possesses the required influencing features, then he/she meets the premises that define the status of an elite, high-performance athlete. The athlete who does not meet the sport-specific requirements remains at the threshold of elite-level sport and probably will never accomplish any outstanding sport achievement. *Anthropological research in sport* can be classified into several categories:

- Construction and validation of measuring instruments aimed at assessing anthropological features of athletes,
- Diagnostics of athletes' basic anthropological characteristics,
- Training fitness status assessment – model characteristics,
- Effects of anthropological characteristics on performance in sporting activities,
- Establishment of the differences in anthropological characteristics among athletes of various age, gender and sport orientation,
- Developmental characteristics of anthropological features of athletes across typical stages of one's sports career.

High performances and outstanding sport achievements are results of quality training plans and programmes as well as their realization. To design and realize such a programme one must get an insight into sport-specific requirements as well as into actual status of relevant abilities, features and skills (knowledge) of either individual athletes or of a group of athletes (Cardinale, Newton, & Nosaka, 2011). Such insights are provided by quality scientific research processes. Therefore the following performance-relevant indicators must be determined and monitored: morphological, functional (cardio-respiratory and metabolic), biochemical, biomechanical, motor (basic and sport-specific alike) and psycho-social ones. The information based on the listed indicators allows a successful diagnostics of the initial, transitive and final (post-programme application status) states of fitness in the function of top-level performances and sports achievements. Validation of current fitness and sports form is a basic precondition for optimal planning, programming and control of the process of sports preparation, containing clearly defined targets and tasks, cycles and working conditions (planning) as well as prescribed loads, training contents (means) and training methods (programming).

### Preparedness evaluation of one group of top-level basketball players, members of the national team

An example of research into preparedness level will be analysed. The investigation in question was

conducted with elite basketball players at the beginning of a training cycle within the scope of preparation for the main competition. In Table 1 average scores are presented of the members of one national senior basketball team and model values of scores on the tests assessing basic and specific physical conditioning abilities, presumed to be target values for the basketball players aspiring to be elite athletes in terms of top-level performances and sports achievements.

The presented results make the following inference viable: the status of physical condition of the observed basketball players is satisfying just in certain indicators; therefore it should be improved considerably during the preparation period. Most of attention the coaching team should direct at developing predominant motor and functional abilities, like explosive and speed strength, agility and speed endurance in order to bring, that is to elevate, the status of physical condition of the observed group of basketball players closer to the model values (scores of basketball players with the highest level of physical condition). The results of the comparison of individual characteristics with the model values are a basis for the design of group and individual physical conditioning programmes

The axes of preparedness profiles of elite athletes have being defined for a long time now. Also, there are many investigations into the relationships among anthropometric, functional (cardio-respiratory and metabolic), motor, social, cognitive dimensions as well as personality traits and certain other dimensions, on the one hand, and variously defined performance variables of a particular sport, on the other.

**TABLE 1**

*Average scores of the national team players (x) vs. model scores of elite basketball players (Source: Milanović & Fattorini, 1990).*

| Tests | Scores | Model (required) scores |
|---|---|---|
| $SAR_1$ (cm) | 68.50 | 70.00 |
| $SAR_2$ (cm) | 77.70* | 80.00 |
| $SAR_3$ (cm) | 84.40* | 90.00 |
| BLG (cm) | 17.20* | 18.00 |
| TROS (cm) | 7.83* | 8.00 |
| TROJ (cm) | 8.07* | 8.50 |
| SPR (s) | 11.37* | 11.25 |
| 20VS (s) | 2.97 | 3.00 |
| OSMB (s) | 8.57* | 8.50 |
| OSMS (s) | 8.94 | 9.00 |
| 4x5B (s) | 4.87* | 5.00 |
| 4x5S (s) | 5.02 | 4.80 |
| TRB (No) | 35.90 | 36.00 |
| SMB (s) | 27.72* | 26.00 |
| SUT (%) | 79.60 | 80.00 |
| VUK (s) | 56.17* | 55.00 |
| $VO_2$ (m/kg/min) | 64.85 | 66.00 |

Legend: **$SAR_1$** - Explosive strength of jumping type; **$SAR_2$** - Explosive strength of jumping type;. **$SAR_3$** - Explosive strength of jumping type; **BLG** - Specific strength of throwing type; **TROS** - Explosive strength of repetitive jumping type; **TROJ** - Explosive strength of repetitive jumping type; **SPR** - Speed strength; **20VS** - Explosive strength of sprinting type; **OSMB** - Agility; **OSMS** - Specific agility; **4x5B** - Speed coordination; **4x5S** - Specific speed coordination; **TRB** - Trunk strength - endurance; **SMB** - Specific speed endurance; **SUT** - Accuracy; **VUK** - Lactic speed endurance; **$VO_2$** - Aerobic endurance; ***** - Tests in which members of the team scored lower than required model values.

## Determination of differences between members of the Croatian national handball cadet and senior teams in the physical condition indicators

Vuleta, Milanović, and Jukić (1999) analysed the differences in nine physical condition indicators of handball players between the members of the cadet ($n$ = 16) and senior ($n$ = 16) national team. Statistically significant differences were obtained in six variables of flexibility (MFLPRR), absolute strength of arms (MFABPT), trunk repetitive strength (MRCPRE), specific speed of dribbling (MFESVM2), specific speed while dribble the ball (SRBV30), and specific explosive strength of throwing type (SRSBLT) (Table 2). The differences were attributed to the players' age and quality of the long-lasting sports training, especially to the well programmed training loads. specific speed of dribbling

**TABLE 2**

*Differences in nine physical condition indicators of handball players between the members of the cadet and senior national team (Source: Vuleta et al., 1999).*

| Variable | $M_C$ | $M_S$ | $SD_C$ | $SD_S$ | Max D | $t$ | $df$ | $p$ |
|---|---|---|---|---|---|---|---|---|
| MFLPRP | 55.69 | 74.31 | 10.33 | 14.69 | .09 | -4.11 | 29 | **.00** |
| MFABPT | 60.63 | 74.69 | 11.24 | 14.43 | .13 | -3.08 | 30 | **.00** |
| MRCPRE | 30.50 | 32.81 | 2.56 | 3.64 | .20 | -2.08 | 30 | **.05** |
| MFE30V | 4.49 | 4.34 | .18 | .15 | .08 | 2.67 | 30 | .12 |
| MFESVM1 | 63.69 | 61.33 | 6.17 | 5.48 | .14 | 1.27 | 30 | .21 |
| MFESVM2 | 80.81 | 73.04 | 7.03 | 4.45 | .09 | 3.74 | 30 | **.00** |
| MFEBM1 | 248.35 | 269.60 | 35.41 | 28.01 | .10 | -1.88 | 30 | .07 |
| SRBV30 | 4.75 | 4.38 | .22 | .19 | .10 | 5.05 | 30 | **.00** |
| SRSBLT | 226.15 | 257.00 | 41.00 | 33.11 | .09 | -2.34 | 30 | **.03** |

Legend: **MFLPRP** - Flexibility; **MFABPT** - Absolute strength of arms; **MRCPRE** - Trunk repetitive strength; **MFE30V** - Explosive strength of sprinting type; **MFESVM1** - Specific speed; **MFESVM2** - Specific speed of dribbling; **MFEBM1** - Explosive strength of jumping type; **SRBV30** - Specific speed while dribble the ball; **SRSBLT** - Specific explosive strength of throwing type; $\mathbf{M_C}$ - Mean cadets; $\mathbf{M_S}$ - Mean seniors; $\mathbf{SD_C}$ - Standard deviation cadets; $\mathbf{SD_S}$ - Standard deviation seniors; **Max D** - Empirical relative cumulative frequency deviation from the theoretical cumulative frequency; **t** - T-test; **df** - Degrees of freedom; **p** - Probability.

## Physiological and biochemical requirements of sportaerobics (citated at Rodriguez, Iglesias, Marina, & Fado, 1998)

Portable telemetric systems make it possible nowadays to continuously and simultaneously measure oxygen consumption and heart rate. These indicators, together with blood lactate concentration determination, allow us to get an insight into the physiological requirements of a particular sport, in this instance the one of sportaerobics. The aim of research was to analyse heart rate (HR), oxygen consumption, and blood lactate concentration in the group of elite athletes of both genders as obtained during their competition performances. Further, the aim was also to describe their anthropological and physiological profiles. A group of 13 Spanish elite athletes (6 women and 7 men) of sportaerobics, out of which three were world champions, participated in the experiment that was conucted simultaneously with their competition season (competitions in the following categories: singles, mixed pairs, trios). During two weeks of the execution of experimental training programme, oxygen consumption and heart rate (HR) were measured by means of suitable equipment. Training programme drills lasted two minutes on average. Blood lactate concentration was analysed on the capillary blood samples taken at rest (min 1, 3, 4, 5, 7, 10, 12).

Moderate values of maximal aerobic power were obtained (moderate especially when compared to body weight), as well as considerable individual differences among subjects of both genders. Competition routines, lasting two minutes on average, are characterised with very intensive cardio-respiratory and metabolic re-

quirements, and equalized at the maximum values about 88% of maximal oxygen consumption (quick oxygen kinetics), and average values of blood lactate concentration above 13 mmol/l (intensive glycolytic activation) with values ranging from 9.4 to 20 mmol/L. Higher metabolic values were obtained in singles and mixed pairs performances. Aerobics pertains to a group of sports with high cardio-respiratory and metabolic requirements, which intensively activate all metabolic sources. Competition-specific drills primarily aimed at the physiological activation of both the aerobic and anaerobic energy supply processes, with a high contribution of strength/power, flexibility, coordination and balance.

**TABLE 3**

*Anthropometric characteristics and spirometry values of elite aerobics athletes obtained from all-out test on ergometer and during competition (Source: Rodriguez et al., 1998).*

| Varibales | *M*±*SD* Men | *M*±*SD* Women |
|---|---|---|
| Age (Years) | 24.6±4.3 | 24.6±3.4 |
| Body Height (cm) | 173.8±1.1 | 157.9±4.9 |
| Body Weight (kg) | 72.4±5.8 | 51.8±3.1 |
| Fatty Tissue (Yuhasz-Carater, %) | 7.51±.9 | 12.77±2.7 |
| Somatotype (Carter) | 1.89-5.48-2.00 | 2.26-4.37-2.45 |
| All-out ergometer test | | |
| fHRmax (beat/min) | 191±7 | 185±3 |
| VO2max (mL/min) | 4521±530 | 3015±162 |
| rel VO2max (mL/kg/min) | 65.4±6.8 | 58.6±4.0 |
| VEmax (L/min) | 146±7.2 | 106±8.2 |
| During cometition | | |
| fHRmax (beat/min) | 185±4 | 184±7 |
| VO2max (mL/min) | 3828±412 | 2750±190 |
| rel VO2max (mL/kg/min) | 54.2±4.9 | 53.5±4.8 |
| %VO2max | 85.3±9.3 | 89.2±7.2 |
| Blood Lactate (mmol/L) | 13.4±3.6 | 13.0±2.0 |

Legend: **M** - Mean; **SD** - Standard deviation; **fHRmax** - Maximum heart rate; **VO2max** - Maximum oxygen uptake; **rel VO2max** - Relative oxygen uptake; **VEmax** - Pulmonary ventilation; **%VO2max** - Percentage of maximal oxygen uptake.

## METHODOLOGICAL (DIDACTICS) RESEARCH AS A FACTOR OF WORK IN SPORTS

Unfortunately, the fewest scientific evidences have so far been provided of the efficiency of certain exercise and teaching methods. Investigations are needed to obtain information on the most quality methods for the development of particular abilities in conjunction with age, gender and quality level of athletes. On the other hand, investigations are also needed to determine efficacy of diverse methods in particular cycles of both the annual and perennial periodization. Special scientific interest has recently been arosed by explorations into the effects of integral preparation on the comprehensive development of all components relevant to optimal preparedness of athletes.

In the last thirty years numerous research studies have been published in the world that determined quantitative and qualitative changes in physical condition characteristics of subjects after the implementation of transformational procedures. Various quantitative changes have been investigated that have been generated under the influence of differently designed transformational procedures aimed at developing cardio-respiratory and metabolic capabilities (functional abilities) (Baquet., van Praagh, & Berthoin, 2003; Gettman, Ayres, Pollock, & Jackson, 1978; Hickson, Rosenkoetter, & Brown, 1988; Jones & Carter, 2000), motor abilities (Heitkamp, Horstmann, Mayer, Weller, & Dickhuth, 2001; Hunter & Marshall, 2002; Sale, MacDaugall, Jacobs, & Garner, 1990;

Zafeiridis et al., 2005) and morphological characteristics (Blazevich, Gill, Bronks, & Newton, 2003; Fry, 2004; Gettman et al., 1978; Tremblay, Despres, & Bouchard, 1985). Within the body of scientific research studies the greatest interest has been payed to training programmes intended for the development of various types of strength and their influence on adaptative transformations in human organism. This is espe-

**TABLE 4**

*Review of the selected studies on the effects of various physical conditioning training methods (Source: Milanović, Barić, Jukić, Šimek, & Vuleta, 2007).*

| Study | Aim | Groups | Treatment | Results | Conclusion |
|---|---|---|---|---|---|
| Handel, Horstmann, Dickhuth, and Gulch (1997) | Efects of 8-wk unilateral isometric flexibility training (post-isometric contraction passive stretching) on muscular activity. | 16 athletes. | Unilateral stretching drills; contraction – relaxation – stretching. | ↑ active and passive flexibility. ↑ maximum force (up to 21.6%) and work (up to 12.9%) under the conditions of excentric loads. | Muscular activity under the conditions of ex--centric loads has probably been infringed by mental processes.. |
| Lephart, Abt, Ferris, Sell, Nagai, Myers, and Irrgang (2005) | To determine efects of 8-wk plyometric and resistance training programmes on the neuromuscular and biomechanical characteristics of female athletes. | 27 female secondary--school athletes in each group. | Plyometric training and basic resistance training programme. | ↑ isokinetic power of knee extensors. EMG values for m.gluteus medius prior to the ground contact and EMG for m.gluteus medius at and post the ground contact were significantly higher in both groups. | Basic resistance training programme causes positive neuromuscular and biomechanical transformations. Plyometric training programme is beneficial to mastering muscular abilities. |
| Helgerud, Engen, Wisloff, and Hoff (2001) | To determine aerobic training effects on performance in footballl matchesand specific tests. | 10 subjects – elite football players (C). 9 subjects – football players (E). | Interval aerobic training, 4x4 min at the 90-95% Max-HR with 3 min jogging between the intervals. 2x8-week. | Experimental group: augmentation of VO2max, lactic threshold, running economy, specific abilities in perfomances with ball. Control group: no changes. | Advanced aerobic training enhances distances covered by running, activity intensity and nzmber of sprints during the game. |
| Olsen and Hopkins (2003) | To analyse effects of: a) attempted ballistic training (explosive movement performance with elastic ribbon) and b) conventional resistance training. | 13 subjects (E) 9 subjects (C) – regular martial arts training. | Ballistic training and conventional resistance training. | Resistance training generated increase of 12% in the frontal kick power. Both training modalities reduced the side kick power by 15%±14%, but they also increased its speed by 11-21%±13-17%. | Balistic training may be efficient for the athletes with quality kicking technique in the sports requiring speed and not strength. |
| Tricoli, Lamas, Carnevale, and Ugrinowitsch (2005). | To determine short-term effects of large resistance training combined with vertical jumping training or with weightlifting | Weightlifting group (WL) (E1) = 12 subjects. Vertical jumps group (E2) = 12 subjects. 8 subjects (C) | 8 weeks WL training programme Jumping training. In addition, each group performed 4x6RM semi squats | WL programme significantly increased running speed. Both experimental groups increased vertical jumping ability, with a greater rate of increments in group E1 than in group E2. In rement in 1RM semi squat than group E1 (47.8 vs. 43.7%). Only group E1 improves scores of squat jumps (9.5%). Control group – no significant changes. | It seems WL drills have a more significant effect on the improvement of performances of physically active athletes than jumping drills. |

| | | | | | |
|---|---|---|---|---|---|
| Marković (2004) | To determine the influence of sprinting and plyometric training. | Plyometric and sprinting experimental group, n = 50 in each group; control group, n = 51. | 10 weeks, 3 times a week jumping and sprinting training. | Both experimental procedures = changes in the space of strength/power. Plyometric training had a significant effect on all strength/power dimensions, except on maximum muscular force and elastic strength especially. Sprinting training did not improve scores of isometric squat and weighted jump. | Sprinting training has a more versatile influence the measured strength manifestations than plyometric training. |
| Šimek (2006) | Determination of the proprioceptive training effects. | 38 (E), 37 (K). | 10 weeks (3x60 min a week). | Proprioceptive training improved performance of a two-legged vertical jumps, sprinting, frontal agility and balance. | Proprioceptive training is recommendable as a supplement to physical conditioning. |

cially valid for the determination of changes in the indicators of subjects' physical condition provoked by the explosive and maximal strength developmental training programmes (Colliander & Tesch, 1990; Crewther, Cronin, & Keogh, 2005; Delacluse, 1997; Little, Wilson, & Ostrowski, 1996; Peterson, Rhea, & Alvar, 2005; van den Tillaar, 2004; Wilson, Murphy, & Giorgi, 1996).

## Research on the effects of various physical conditioning methods

Table 4 represents a selection of methodological research studies conducted in Croatia and abroad. Although forming a firm foundation, these investigations have not managed to elicit which transformation procedures, and to which extent, generate adaptations of functional and motor abilies and morphological characteristics of subjects. Thus the explorations into transfromations of physical condition features under the influence of various modalities of training work and various sizes of loads become even more important, as well as the investigations into integral effects of particular transformational procedures

The findings of research into the effects of various physical conditioning methods, like the concrete examples presented in Table 4, make it viable to advance methodology of training work aimed at developing conditioning abilities. Findings of single research studies on the effects of particular physical conditioning methods are frequently grouped according to target orientations (development of abilities, particular training system applications, specific training programmes…) and analysed through meta-analyses that, eventually, offer syntheses of a particular method or training system efficiency for the development and sustainment of physical condition abilities.

Peterson, MD., Rhea, MR; Alvar (2004) published their meta-analysis on strength development. Efficiency and safety of strength training programmes are extremely important to sport performance. If variables of training methods are optimal, then they are maximally efficient in strength development over a time unit and in overtraining or overloading risk reduction. The aim of the analysis was to determine optimal ratio of training variables in athletes. A meta-analysis of 37 research studies indicates the maximum effects of strength training are realized when 85% 1RM training is implemented 2 times a week, with the average volume of 8 series per muscular group. Previous research demonstrated differences between athletes and non-athletes in training methodology and in defining the optimal relationship between training variables. The findings of this meta-analysis are directly applicable to sports practice for strength training optimal effects. The meta-analysis of plyometric training influence on jump height suggests positive effects of the training on jumping ability development (Marković, 2007). The analysis of 26 research studies indicates statistically significant and relevant improvement of vertical jumping ability ranging from 4.7% for the squat jump and depth jump, and up to 8.7% for the counter-movement jump after the application of plyometric training. Also, there are many meta-analyses of studies dealing with investigation into methodical parameters of preventive training and incidence of certain injuries incurred in sports. The meta-analysis by Hewett, Ford, and Myer (2006) established positive preventive effects of neuromuscular interventions on the anterior cruciate ligament (ACL) injuries in female athletes. A huge disproportion in the number of ACL injuries between female and male athletes (4-6 times higher incidence in female athletes) led to a great number of explorations into this health-threatening issue and the effects of neuromuscular interventions, designed to facilitate avoidance of injuries. Meta-analysis of published studies (Ibid) indicates a significant effect of most neuromuscular programmes on the reduced incidence of the anterior cruciate ligament injuries in female athletes involved in the strength, jumping, stability and agility

training programmes (total effect, $z = 4.31$; $p < .0001$). This review summarizes evidence-based conclusions through compiling common parts of diverse interventions, thus enabling understanding of potential of certain programmes and their combinations as well as of their efficient application in practice.

A meta-analysis embraced 27 explorations into the effects of taper on sports form (Basquet et al., 2003). Performance was the dependent variable, whereas the reduced exercise intensity, exercise extensity and frequency as well as a type and duration of taper were the independent variables. This meta-analysis indicates the optimal strategy of timely enhanced sports form for a competition would be an intervention in the form of a two-week taper prior to competition. In it training volume is exponentially lowered by 41-60% with or without modifications of intensity and work-out frequency.

Sports practitioners use findings of individual investigations, reviews and meta-analysis as to continually adjust training methods and procedures in accordance with characteristics of sport groups they are working with, then with working conditions and specific features of a particular cycle of sports preparation.

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