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Review paper

Kondicioni trening u svijetlu najnovijih naučnih saznanja

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Sažetak: Čovjek je oduvijek bio svjestan da mu više fizičke aktivnosti, uz optimalnost drugih parametara kakvi su odmor i ishrana, donosi nadmoć u odnosu na ostale pripadnike njegove uže i šire zajednice. Primarno je to bilo vezano za vještine lova i ratničke vještine. Sa druge strane u periodima mira i blagostanja, čovjekova iskonska potreba za dokazivanjem i dominacijom nad drugima oko sebe, biće demonstrirana u različitim oblicima nadmetanja u čovjekovim fizičkim potencijalima, prije svega snazi i brzini. Znanja o mogućnosti povećanja tih potencijala putem upražnjavanja različitih oblika fizičke aktivnosti, odnosno vježbanja, a koja su stečena u prethodnim periodima, počeće se organizovano primjenjivati. To će se prije svega desiti u vojnim strukturama, a kasnije i kao dio dešavanja koja su prepoznata kao daleki počeci onoga što danas predstavlja sport. Koja su najnovija naučna saznanja o tome?
Ključne riječi: kondicioni trening, ogledalo neurona, genetika.

Uvod

Čovjek je oduvijek bio svjestan da mu više fizičke aktivnosti, uz optimalnost drugih parametara kakvi su odmor i ishrana, donosi nadmoć u odnosu na ostale pripadnike njegove uže i šire zajednice. Ta svoja znanja započeće primjenjivati u osposobljavanjima za sve svoje obaveze u kojima je morao pokazati viši stepen fizičkih kvaliteta od onih koji su bili dovoljni za svakodnevni život. Primarno je to bilo vezano za vještine lova i ratničke vještine. Sa druge strane u periodima mira i blagostanja, čovjekova iskonska potreba za dokazivanjem i dominacijom nad drugima oko sebe, biće demonstrirana u različitim oblicima nadmetanja u čovjekovim fizičkim potencijalima, prije svega snazi i brzini. Znanja o mogućnosti povećanja tih potencijala putem upražnjavanja različitih oblika fizičke aktivnosti, odnosno vježbanja, a koja su stečena u prethodnim

Physical Conditioning Training in the Light of the Latest Scientific Knowledge

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Abstract: A man has always been aware that more physical activities, together with optimality of other parameters such as leisure and nutrition, bring him supremacy over other members of his wider community. This was primarily linked to the skills in hunting and warfare. On the other side, in times of peace and abundance, a man's aboriginal need for an boastfulness and dominance over other people around him will be demonstrated in various shapes of competitions in the area of man's physical capacities, a strength and speed first of all. The knowledge about the possibility of the increase of these capacities by practicing of different shapes of a physical activity, namely an exercising, attained in the previous periods, will start to be applied in an organized manner. First of all, it will occur in military structures, and then as a part of events recognised as the very beginnings of what sport today is. Which is the latest knowledge about that?
Key words: physical conditioning, miror neurons, genomics.

Introduction

A man has always been aware that more physical activities, together with optimality of other parameters such as leisure and nutrition, bring him supremacy over other members of his wider community. His mentioned knowledge will start to be applied in the preparations for all his obligations where he had to show a higher degree of physical qualities than those qualities which were sufficient for everyday life. This was primarily linked to the skills in hunting and warfare. On the other side, in times of peace and abundance, a man's aboriginal need for an boastfulness and dominance over other people around him will be demonstrated in various shapes of competitions in the area of man's physical capacities, a strength and speed first of all. The knowledge about the possibility of the increase of these capacities by practicing of different shapes of a physical activity, namely an exercising, attained in the previous periods, will start to

periodima, počeće se organizovano primjenjivati. To će se prije svega desiti u vojnim strukturama, a kasnije i kao dio dešavanja koja su prepoznata kao daleki počeci onoga što danas predstavlja sport.

Čustonja i Jajčević (2003) u svom pregledu razvoja kondicione pripreme navode osnovne podatke koji govore o prethodnom. „Postoje dokazi o primjeni kondicionog treninga (tačnije treninga snage sa opterećenjima) u mnogim ranim civilizacijama. Takav trening je bio vrlo raznolik i primjenjivao se kako za razvoj sposobnosti sportista, tako i u vojne svrhe (Todd, 1985). U egipatskim grobnicama (oko 2500 g.p.n.e.) otkriveni su umjetnički radovi na zidovima koji su prikazivali razne manifestacije snage i nadmetanja u snazi... Stanovnici antičke Irske su se takmičili u bacanju kamena još prije 3800 godina. Na drugoj strani svijeta u Kini su se upotrebljavali testovi snage za vrijeme dinastije Chou (1122-255. g.p.n.e.). Sasvim je izvjesno da su mnoge civilizacije prije samih Grka ili Rimljana trenirali i koristili snagu u svrhu zabave ili vojnih potreba... Poznati grčki ljekar Galen (129-199.) vjerovatno je prvi ljekar koji je govorio o efektima treninga snage, promoviše upotrebu tereta i opisuje vježbe jačanja (Kreamer i Hakkinen, 2002)... Grci prvi organizuju trening prema određenim periodima. Tako na olimpijskim igrama nisu mogli učestvovati oni koji nisu mogli potvrditi da su se barem 10 mjeseci spremali za učešće na olimpijskim igrama... Lucije Flavije Filostrat (170-244/249.) napisao je djelo o grčkom sportu i antičkim olimpijskim igrama u kojem govori o svojevrsnim sportskim zvijezdama onog doba, prikazuje način života i rada trenera i sportista, kao i njihove međusobne odnose. Filostrat, nam između ostalog, govori o tome kako trener koji prenosi svoja bogata iskustva na svoje učenike treba posjedovati veliko znanje o trenerskoj nauci, ... koja nije ni u čemu nižeg roda od ostalih nauka... “

Tokom narednih perioda manje ili više, dobro ili manje dobro, kondiciona priprema je nastavljala da se koristi svim onim saznanjima do kojih je dolazila nauka, kao i oblika i metoda rada koje je potvrđivao praktičan rad. Uglavnom, druga polovina devetnaestog vijeka, kao i cjelokupan dvadesti vijek donijeli su ogroman broj novih aplikativnih informacija, kao i potvrdu nekih ranijih, koje su već stotinama, pa i hiljadama godina imale upotrebu.

U posljednjoj deceniji, naučna produkcija je dosegla nekada nezamisliv nivo, međutim, sa druge strane, veliki broj istraživanja na svim svjetskim meridijanima ne daje istovremeno i proporcionalno odgovarajući broj novih saznanja. Uglavnom se radi o istraživanjima

be applied in an organized manner. First of all, it will occur in military structures, and then as a part of events recognised as the very beginnings of what sport today is.

Čustonja and Jajčević (2003), in their review of the development of conditioning preparation, name the basic data which tell about the abovementioned. “There are the evidences about the application of a conditioning training (more accurately, strength training with ballasts) in many early civilisations. Such a training was a very versatile and was applied both in the development of athletes and for military purposes (Todd, 1985). In the Egyptian tombs (about 2500 BC) the artificial works showing the various manifestations of a strength and competitions in a strengthwere found on walls… The settlers of the antique Ireland performed competitions in a stone throwing even 3800 years ago. On the other side of the world, in China, strength tests were carried out in the times of Chou dynasty (1122-255 BC). It is quite obvious that many civilisations before the Greekshad trainings and used a strength for the purposes of entertaining or military needs… Famous Greek physician Galen, (129-199) was probably the first physician who had told about the effects of strength training, promoted the use of a ballasts and described the exercises for strengthening (Kreamer and Hakkinen, 2002). The Greeks were the first who organised a training according to certain periods. So, those who could not prove that they had been training for the Olympic games for at least ten months could not participate in the Olympic games… Lucie Flavije Filostrat (170-244/249) wrote a book about the Greek sport and antique Olympic games where he writes about certain athlete stars of those times, showing the life styles and works of athletes and their coaches, and their mutual relations. Filostrat, among the rest, argues that a coach which transfers his abundant skills to his students should have a great knowledge about the coaching science, … which in no case is of a value lower than other sciences...“

More or less, during the following periods, good or less good, a conditioning preparation had continued to use both all those knowledge obtained by the sciences and forms and work methods that ascertained a practical work. Mostly, the second half of the nineteenth century, and complete the twentieth century, brought a huge number of new applicative findings, and a proof for some earlier ones which had been in use for hundreds or even thousands of years.

In the last decade, the scientific production had reached a level which was unfathomable in these times, however, on the other side, a big number of researches at all world meridians do not simultaneously give a propor-

koja su oslonjena na već postojeće naučne činjenice i sagledavaju ih sa stanovišta koja povremeno budu nova. Uglavnom veliki broj radova, moglo bi se reći renovira, ili inovira već postojeća znanja. Takođe, nova tehnološka rješenja, zatim promjene pravila, kao i promjene koja ona donose u pojedine sportske discipline, omogućavaju naučnim radnicima da istražuju nova, do tada ne- istražena polja.

Cilj ovog rada je da predstavi dvije naučne aktivnosti, koje su došle do informacija koje će u kondicionom treningu budućnosti imati sigurno veoma značajno mjesto, odnosno kako će se kondicioni trening u svijetlu tih informacija dalje razvijati.

Dvije nove osnove za kondicioni trening

Prva: Strukturu motoričkog ponašanja čovjeka sačinjavaju njegov motorički razvoj (permanentno sticanje novih motoričkih znanja i razvoj motoričkih sposobnosti), motorička kontrola (proces tokom kojeg ljudi koriste svoj neuromuskularni sistem za aktivaciju i koordinaciju mišićne aktivnosti i aktivnosti djelova tijela koji su uključeni u savladavanje i manifestaciju motoričkih znanja) i motoričko učenje. Motoričko učenje podrazumijeva niz procesa povezanih sa tjelesnim vježbanjem kroz koje vježbač usvaja nova motorička znanja, a svoje motoričke sposobnosti podiže na veći nivo. Klasičan pristup u razumijevanju motoričkog učenja, odnosno procesa usvajanja nove motoričke vještine pretpostavlja tri uzajamno povezane faze: 1. kognitivnu fazu (učenje pravila specifične motoričke vještine); 2. asocijativnu fazu (raščlanjivanje motoričkog zadatka na elementarne motoričke komponente, razdvajanje značajnih i neznačajnih informacija za izvođenje zadatka) i 3. Automatizaciju ili automatsku fazu (uvježbanost i iskustvo u izvođenju motoričkog zadatka, tako da se zadatak izvodi automatski). Saznanja do kojih se došlo posljednjih godina, a koja se upravo tiču čovjekovog motoričkog ponašanja dovode u pitanje ovakvo mišljenje.

Buccino i Riggio (2006) ističu da spoznaje o motoričkom sistemu kod čovjeka, kao i kod čovjekolikih majmuna, u novije su se vrijeme radikalno promijenile te se danas smatra da uključuje velik broj područja mozga. Jedno od njih, područje F5 ventralne premotoričke kore mozga čovjekolikih majmuna, sadrži motoričku reprezentaciju prema cilju usmjerenih radnji ustiju i šaka (Rizzolatti i sar., 1988). U tom je području otkrivena skupina neurona kod kojih je prisutno izbijanje i kad sama životinja izvodi specifičnu, cilju usmjerenu radnju (npr. posezanje za komadom hrane), ali i u slučaju kad ona samo posmatra jednaku ili sličnu radnju u izvođenju

tionally adequate number of a new findings. These are mostly the researches based on already existing scientific facts, considering them from the standpoints which are new sometimes. It could be said that, mostly, a big number of works renovate or improve already existing findings. Also, new technological solutions, like the changes of provisions, and the changes brought with them in certain sport disciplines, enable the scientific workers to research the new fields, unexplored so far.

The goal of this paper is to represent two scientific activities, which obtained the findings which surely will have a very important place in a future conditioning training, namely to define in which way a conditioning training will further develop in the light of these findings.

Two new bases for a physical conditioning training

The first. The structure of men's motor behaviour is made of his motor development (a permanent state of a new motor knowledge and development of motor abilities), motor control (a process during which men use their neuromuscular system both for an activation and the coordination of a muscle activity and activities of body parts included in attaining and manifestation of motor knowledge) and motor learning. The motor learning purports to the series of processes related to body exercises through which an athlete adopts new motor skills, and raise his motor abilities on a higher level. The classical approach in the understanding of motor learning, namely a process of adoption of a new motor skill, supposes three mutually related phases: 1. Cognitive phase (learning of rules of a specific motor skill), 2. Associative phase (dividing of a motor task into elementary motor components, dividing the important and unimportant information for the execution of a task) and 3. Automation or automatic phase (skill and experience in the execution of a motor task, so as to a task is automatically carried out). The skills attained during the last years, and those which are just related to men's motor behaviour challenge this opinion.

Buccino and Riggio (2006) highlight that the knowledge about a man's motor system, and of man-like monkeys' motor system, have radically been changed during the last years and, today, it is considered that it includes a big number of brain areas. On of them, an area of F5 ventral pre-motor brain crust of man-like monkeys, contains a motor representation according to a goal of directed activities of mouth and hands (Rizzolatti et al., 1988). In this area there was discovered the group of neurons with present emergence even when an animal preforms a specific goal-directed activity (for example a grabbing of a piece of food), and also in a case when an

druge životinje ili pak istraživača (Gallese i sar., 1996; Rizzolatti i sar., 1996). Ti se neuroni nazivaju ogledalo neuronima jer se ima utisak kao da se posmatrana radnja "reflektuje" u posmatračevoj motoričkoj reprezentaciji iste radnje, kao u ogledalu. Od samog otkrića, pretpostavljalo se da ogledalo neuroni igraju važnu ulogu, kako u prepoznavanju radnje, tako i u motoričkom učenju (Jeannerod, 1994). Te je pretpostavke u potpunosti poduprlo skorije elektrofiziološko istraživanje (Umiltà i sar., 2001). Jedan od novijih eksperimenata pokazao je da oko 15% ogledalo neurona, osim na vizuelna svojstva, reagira i na prezentaciju specifičnog zvuka određene radnje. Ti se neuroni nazivaju audio-vizuelnim ogledalo neuronima (Kohler i sar., 2002).

Sve je više dokaza o postojanju sistema ogledalo neurona i kod čovjeka (Buccino i Riggio, 2006). Oni dalje navode da prvi, iako samo indirektni, dokaz o postojanju sistema ogledalo neurona kod čovjeka pruža istraživanje u kojem je primijenjena transkranijalna magnetska stimulacija (TMS) kod zdravih dobrovoljaca koji su posmatrali istraživača u izvođenju različitih, cilju usmjerenih, kretanja šake (Fadiga i sar., 1995). Ti su rezultati nedavno potvrđeni (Strafella i Paus, 2000; Gangitano i sar., 2001). Naredna istraživanja na tom području koristila su se magnetoencefalografijom (MEG) (Hari i sar., 1998), kvantifikovanom elektroencefalografijom (Cochin i sar., 1999) i trajno implantiranim subduralnim elektrodama (Tremblay i sar., 2004).

Generalno, istraživanja su pokazala da se tokom zadataka motoričkog zamišljanja značajno aktiviraju različita područja, uključujući ona koja pripadaju sistemu ogledalo neurona. To upućuje na postojanje složenog distribuiranog neuralnog kruga motoričke zamišljanja koji uključuje i različita kortikalna područja u osnovi uključena u izvođenje i opažanje radnje (Buccino i Riggio, 2006).

Učestvovanje sistema ogledalo neurona u imitaciji nedavno je dokazano nizom istraživanja metodama prikaza mozga (Koski i sar., 2002; Grèzes i sar., 2003; Heiser i sar., 2003, prema Buccino i Riggio, 2006). U nedavnom istraživanju proučavalo se motoričko učenje novog motoričkog obrasca posmatranjem kretanja (Buccino et al., 2004). Od muzički needukovanih ispitanika zatraženo je da nauče odsvirati različite gitarističke akorde na osnovu posmatranja i oponašanja profesionalnog gitariste koji je svirao akorde. Uočeno je da je sistem ogledalo neurona bio aktivan u svim fazama procesa motoričkog učenja, odnosno od opažanja primjera do samog izvođenja primjera od strane ispitanika. Ti rezultati snažno podupiru teoriju prema kojoj učenje novog motoričkog obrasca

animal only observes the same or similar activity performed by other animal or even by a researcher (Gallese et al.,1996; Rizzolatti et al., 1996). These neurons are called the mirror neurons because they incite an impression like the observed activity is "reflected" in an observer's motor presentation of the same activity, like in a mirror. Since this discovery, it have been supposed that the mirror neurons play an important role both in a recognition of an activity and in a motor learning (Jeannerod, 1994). These assumptions were entirely supported by a recent electro-physiological research (Umilta et al., 2001). One of the latest experiments has shown that about 15% of mirror neurons, except on visual properties, react also on the presentation of the specific sound of particular activity. These neurons are called audio-visual mirror neurons (Kohler et al., 2002).

There are more and more proofs about the existence of the mirror neuron system in a man (Buccino and Riggio, 2006). They further argue that the first, although only indirect, proof about the existence of the system of mirror neurons in a man is given in the research where the transcranial magnetic stimulus (TMS) was applied on health volunteers who observed the researcher executing the various, goal-directed, hand motions (Fadigra et al., 1995). These results have been ascertained lately (Strafella and Paus, 2000;Gangitano et al., 2001). The next researches in that area used a magnetoencephalography (MEG) (Hari et al., 1998), by a quantified electroencephalography (Cochin et al., 1999) and the permanently implanted subdural electrodes (Tremblay et al.,, 2004).

Generally, during the task of motor imagination, the researches have shown that different areas are activated, including those belonging to the mirror neuron system. This indicates to an existence of a complex distributed neural circle of motor thinking which also includes various cortical areas basically included in the execution and noticing of an activity (Buccio and Riggio, 2006).

The participation of the mirror neuron system in an imitation has been lately ascertained by a series of exploration of methods for a brain presentation (Koski et al., 2002; Grezes et al., 2003; Heiser et al., 2003, according to Buccino and Riggio, 2006). The recent research dealt with the studying of a motor learning of a new motor pattern by the observation of motion (Buccino et al., 2004). Amusically uneducated person was asked to learn to play different guitar accords on the basis of an observation and imitation of a professional guitarist who played accords. It was noticed that the system of mirror neurons was active in all phases of the process of a motor learning, namely since the perception of an example to the very performing of an example by the examinee.

podrazumijeva preraspodjelu osnovnih motoričkih kretnji koje ga sačinjavaju radi uklapanja u zadani model. Čini se da je to operacija koju mozak izvodi u potpunosti unutar motoričkog sistema, bez uključivanja specifičnih asocijativnih područja (Buccino i Riggio, 2006).

Druga: Malacko i Doder (2008) navode da istraživanja antropološke (humane) genetike, a naročito genetike u sportu, ukazuju na to da se vrhunski rezultati u sportu ne mogu postići samo primjenom savremenih metoda treninga, već da oni zavise i od genske uslovljenosti pojedinih antropoloških osobina, sposobnosti i karakteristika sportista, čime sportsko antropološka genetika dobija još važnije mjesto u u području sportske antropologije.

Isti autori takođe navode da postoje dva značajna elementa u istraživanju genske uslovljenosti antropoloških karakteristika: *mehanizam nasljeđivanja*, koji se odnosi na broj i način prenošenja gena sa roditelja na djecu i *fenomen nasljednosti*, koji se odnosi na udio genskog faktora u odnosu na faktor sredine u fenotipskoj promjenljivosti osobina.

Začetnikom moderne genetike se smatra naučnik Gregor Johann Mendel (1822-1884). Gregor Mendel je bio češki sveštenik, botaničar i zoolog, koji se zapravo smatra ocem genetike, jer je dokazao paritkularno nasljeđivanje. Pod partikularnim nasljeđivanjem se podrazumijeva da su osobine definisane nasljednim faktorima koji se prilikom prenošenja sa roditelja na potomstvo ne miješaju, već se pri nastanku gameta prvo razdvajaju, a potom nezavisno kombinuju u procesu oplođenja.

Genetika je nauka koja proučava nasleđivanje i promjenljivost osobina. Skup svih osobina jednog organizma je *fenotip* (skup svih osobina jedne ljudske individue, koji predstavlja rezultat interakcije nasljednih faktora i vanjske sredine), a skup svih gena je *genotip* (manifestacija specifičnog sklopa bazičnih jedinica nasljednosti, gena). Pojmove fenotip i genotip je prvi koristio danski botaničar Wilhelm Johannsen (1857–1927). Gen je osnovna materijalna i funkcionalna jedinica genetičkog materijala, odnosno biološkog nasljeđivanja.

Genom nekog organizma su svi njegovi nasljedni podaci kodirani u DNK. Time su obuhvaćeni kako geni tako i ne-kodirajuće sekvence DNK. Izraz genom je osmislio njemački botaničar Hans Karl Albert Winkler (1877-1945) 1920. godine, kao složenicu, koju je sastavio od riječi gen i hromosom.

Genomika je nauka koja izučava strukturu i organizaciju genoma. Prema tome, genomika je nauka o genomu i mogućnostima njegovih arteficijelnih izmjena,odnosno ciljane rekompozicije. To predstavlja područje genetike koje pročava metode rekombinantne

These results strongly support the theory saying that the learning of a new motor pattern purports to the distribution of basic motor motions which made it because of a fitting in the given task. It seems that this is an operation performed by a brain completely inside the motor system, without the inclusion of specific associative areas (Buccino and Riggio, 2006).

The second. Malacko and Doder (2008) say that the researches of anthropologic (human) genetics, especially a genetics in sport, suggest that the top results in sport cannot be accomplished only by the use of contemporary methods of training, but they also depend on the genetic condition of some anthropologic traits, abilities and characteristics of sport, by which the sport anthropologic genetics attains a more important place in the area of a sport anthropology.

The same authors also argue that there are two important elements in the research of condition for the anthropologic characteristics: *mechanism of inheritance*, related to the number and way of transferring of genes from parents to children and *phenomenon of inherited*, related to the share of a genetic factor in relation to the factor of an environment in a phenotype changeability of properties.

Gregor Johann Mendel, a scientist, (1822-1884) is considered to be the founder of modern genetics. Gregor Mendel was a Czech bishop, botanist and zoologist which is actually considered to be the father of genetics, because he had ascertained the particular inheritance. This term means that the traits are defined by inheritance factors which do not mix during the transfer from parents to children, but firstly separate in the development of a gamete and then independently combine into the process of fertilisation.

Genetics is a science dealing with an inheritance and changeability of traits. An aggregate of all properties of an organism is a *phenotype* (aggregate of all properties of one human individual representing the result of interaction of inherited factors and external environment), and the aggregate of all genes is a *genotype* (manifestation of a specific system of basic units of inheritance, genes). The terms phenotype and genotype were firstly used by Danish botanist Wilhelm Johansen (1857-1927). A gene is a basic material and functional unit of a genetic material, namely a biological inheritance.

A genome of any organism represents all his inheritance data coded in DNA. This comprises not only genes but also non-coding sequences of DNA. The term genome was coined by German botanist Hans Karl Albert Winkler (1877-1945) as a compound made of words *gene* and *chromosome.*

Genomics is a science dealing with the structure and organisation of genomes. Therefore, genomics is a

DNK, metode analize DNK i bioinformatiku sekvenci, montažu i analizu strukture i funkcije genoma (u cjelokupnom sistemu DNK unutar jedne ćelije organizma) (Culver i sar., 2002).

Analiza pojedinačnog genoma do sada se uglavnom usredsređivala na istraživanje porijekla, statusa prenosilaca kritičniih gena, zdravstvenih rizika ili odgovora na farmakološka sredstva. Sa druge strane, sport predstavlja relativno novo područje primjene genetske analize u cilju identifikacije urođenih kapaciteta pojedinca za vrhunsko sportsko dostignuće, ili rizika od povrede. Trenutno su genetska istraživanja, koja su povezana sa sportskim dostignućem, relativno rijetka (Swan, 2012, prema Ostojić i sar., 2013).

Brojnim pokušajima u posljednjih nekoliko godina da otkriju genetske varijante povezane sa elitnom sportskom izvedbom, ili preciznije vrhunskim sportskim statusom, došlo je do određenog napretka zahvaljujući malom broju koordiniranih istraživačkih napora koji su se uglavnom oslanjali na gene kandidate odnosno mali broj jednonukleotidnih polimorfizama (SNP) i strukturnih varijanti. Trenutno je identifikovano 52 varijante (polimorfizama) kod 36 gena podijeljenih u pet kategorija sportskog dostignuća: izdržljivost, mišićne karakteristike, kapacitet kardiorespiratornog sistema, metaboličke karakteristike i kvalitet tetivno-ligamentnog sistema (Roth i sar., 2012).

Slično kao i u drugim područjima istraživanja, porodične analize parova blizanaca su u početku bile glavni predmet istraživanja genetske osnove sposobnosti i izvedbe čovjeka (Pitsiladis i sar., 2013). U istraživanju 4488 odraslih britanskih blizanaca, heritabilnost „sportskog statusa“ se procjenjuje na 66% (De Moor i sar., 2007).

Napredak u molekularnoj tehnologiji omogućio je naučnicima široko usmjeren pristup povezanosti genoma (genom-wide association GWAS) na ljudske osobine. GWAS istražuje povezanost genetskih varijacija sa ishodom odnosno fenotipom koji je predmet interesovanja, analizirajući od 100 000 do nekoliko miliona različitih polimorfizama bez ikakvih prethodnih pretpostavki o mogućim mehanizmima.

Genotipizacija sportista najvišeg ranga i performansi kao što su svjetski rekorderi, svjetski prvaci, olimpijci, vrlo je poželjna, ali do sada je provedeno malo kohortnih analiza sportista svjetske klase (Pitsiladis i sar., 2013).

U ovom trenutku postoji oko 20 međunarodnih preduzeća/laboratorija koja nude genetsko profilisanje u cilju prepoznavanja sportskiih potencijala. Standardizacija dijagnostičkih procedura nije usaglašena i manje od 25%

science about a genome and contingencies of its artificial changes, namely a target re-composition. This represents the area of genetics studying the methods of recombinant DNA, methods of analysis of DNA and bioinformatics of sequences, assembly and analysis of a structure and function of genomes (in an entire system of DNA, inside one cell of an organism) (Culver et al., 2002).

The analysis of an individual genome have so far been focused mostly on the research of an origin, the status of transmitter of critical genes, health risks or answers toto pharmacological means. On the other side, sport represents a relatively new area of use of genetic analysis for the purpose of an identification of inborn capacities for top sport achievement, or risks form an injury. The genetic researches related to sport accomplishments currently are relatively rare. (Swan, 2012, according to Ostojić et al., 2013).

A certain advancement was accomplished during last several years by numerous efforts to discover genetic variances related to an elite sport performance, or, more precisely, to a top sport status, thanks to a small number of coordinated researching efforts mostly based on gene candidates, namely on a small number of one-nucleotide polymorphisms (SNP) and structural variances. 52 variances (of polymorphisms) are currently identified for 36 genes divided into five categories of a sport accomplishment: endurance, muscular characteristics, capacity of cardio respiratory system, metabolic characteristics and a quality of a hamstring-ligament system (Roth et al., 2012).

Like in other areas of research, the family analyses of pairs of tweens were in the beginning a main topis of research of a genetic basis of ability and creation of a man (Pitsiladis et al., 2013). In the research of 4488 adult British tweens, heritability of “sport status” is estimated to be 66% (De Moor et al., 2007).

An advancement in the molecular technology provided the scientists with an approach of (*genome-wide association* GWAS) on human properties. The GWAS researches the association of genetic variances with the result, namely a phenotype which is the topic of interest, analysing from 100 000 to several millions of different polymorphisms without any previous assumptions about many mechanisms.

The genotyping of athletes of the highest ranking and performances like world record-holders, world champions, Olympics games participants, is very desirable, but a little cohort analyses of world class athletes have been carried out so far (Pitsiladis et al., 2013).

In this moment, there are about 20 international enterprises/laboratories offering a genetic profiling for the purpose of recognition of sport potentials. The standardi-

laboratorija posjeduje AABB i CLIA standarde kvaliteta. Sami testovi se veoma razlikuju po obimu, cijeni i načinu uzimanja uzoraka (Wagner i Royal, 2012). Osim etičkih ograničenja genetskog profilisanja, testovnim procedurama nedostaje i apsolutna metrijska valjanost, odnosno rezultati se ne odnose na cjelokupnu ljudsku populaciju, jer su zasnovani na istraživanjima genotipizacije osoba evropskog porijekla (nedostaju podaci drugih etničkih i rasnih grupa), niti obuhvataju analizu poligenskih interakcija (Wagner i Royal, 2012).

Tabela 1. *Glavni geni kandidati povezani sa ljudskim performansama (Lippi i sar., 2010)*

KAPACITETI IZDRŽLJIVOSTI
PPARD
Ćelijski respiratorni faktori (NRF2)
PGC-1 alfa
HIF-1 alfa
EPAS-1 i HIF-2 alfa
Hemoglobin
Glikogen sinteza skeletnog mišića (GYS1)
ADRB2
CHRM2
VEGF
MIŠIĆNEPERFORMANSE
CK-MM
ACTN3
MLCK
ACE
AMPD1
IGF-1
VEZIVNI APARAT
ABO krvna grupa
COL1A1 i COL5A1
TNC
PSIHOLOŠKA SPOSOBNOST
Serotonin transporter gen (5HTT)
BDNF
UCP2

sation of diagnostic procedures is not determined and less than 25% of laboratories possesses the AABB and the CLIA quality standards. The tests are very different by a volume, price and a way of sample taking (Wagner and Royal, 2012). Except ethical constraints of a genetic profiling, the test procedure lacks an absolute metric validity, namely the results are not related to the entire human population, because they are based on the researches of a genotyping of persons with the European origin (there are no data about other ethic and racial groups), and they also do not comprise an analyses of polygene interactions (Wagner and Royal, 2012).

Table 1. *Major candidate genes associated with human athletic performances (Lippi et al., 2010).*

ENDURANCE CAPACITY
PPARD
Nuclear respiratory factors (NRF2)
PGC-1 alfa
HIF-1 alfa
EPAS-1 i HIF-2 alfa
Hemoglobin
Skeletal muscle glycogen synthase (GYS1)
ADRB2
CHRM2
VEGF
MUSCLE PERFORMANCE
CK-MM
ACTN3
MLCK
ACE
AMPD1
IGF-1
TENDON APPARATUS
ABO blood group
COL1A1 i COL5A1
TNC
PSYCHOLOGICAL APTITUDE
Serotonin transporter gene (5HTT)
BDNF
UCP2

Zaključak

Budućnost kondicionog treninga će se neminovno kao i do sada usmjeravati i razvijati u skladu sa najnovijim naučnim saznanjima i praktičnim postignućima. Pored, u ovom radu navedenih saznanja, svakako da će se pojaviti i neka nova, koja će takođe, kondicionom treningu, pružiti informacije na osnovu koji će biti moguće poboljšati već postojeće metode i oblike rada.

Kao zaključak na dva saznanja koja su predstavljena u ovom radu, prije svega je potrebno istaći da rezultati dosadašnjih istraživanja jasno pokazuju da motorički sistem nije uključen samo u izvođenje aktivnosti, nego i u druge, kognitivne motoričke funkcije. Savladavanje novih motoričkih struktura, bi takođe, moglo predstavljati, kombinovanje osnovnih motoričkih kretnji, koje ga sačinjavaju na sada nov, odnosno inoviran način. Izgleda da se to rekombinovanje zbiva unutar sistema ogledalo neurona, bez uključivanja specifičnih asocijativnih područja.

Sa druge strane, procedurama moderne molekularne biologije pokušava se doći do genetskih markera, gena, polimorfnih varijacija, i faktora koji određuju fenotipe svih funkcionalno-motoričkih sposobnosti. Veoma složena mapiranja traju i permanentno se sprovode nova istraživanja, iako je postavka pojedinih koncepata genetske mape vrhunskih sportista djelimično utvrđena i prezentirana u mnogim naučnim radovima (Williams i Folland, 2008; Bray i sar., 2009; Bouchard i Hoffman, 2011).

Dakle, više se ne može postavljati pitanje da li su sposobnosti čovjeka genetski zavisne, već koji konkretno genetski faktori to uslovljavaju. Traganje i mapiranje genetskih markera neminovno će se nastaviti i u budućnosti. Do kada, jednog dana će se saznati.

Conclusion

The future of a conditioning training will unavoidably, like so far, be directed and developed in accordance with the newest scientific findings and practical achievements. Beside this, in this work of mentioned knowledge, it is obviously that some new findings which also give information to the conditioning training will emerge and, on the basis of these findings, it will be possible to improve the existing methods and ways of work.

As the conclusion of two findings presented in this work, it is, first of all, necessary to mention that the results of previous researches obviously show that the motor system is included not only in the execution of activities, but also in other cognitive motor functions. The learning of new motor structures would also present the combination of the basic motor activities, which make it in now a new, namely innovated manner. It seems that this recombination occurs inside a system of mirror neurons without the inclusion of specific associative areas.

On the other side, there are efforts to reach to the genetic markers, genes, polymorph variances and factors determining the phenotypes of all functional-motor abilities with the procedures of a modern molecular biology. A very complex mappings lasts and new researches are permanently being carried out, although the assumption of some concepts of a genetic map of elite athletes is partly determined and presented in many scientific works (Williams and Folland, 2008; Bray et al., 2009; Bouchard and Hoffman, 2011).

Therefore, the question asking if the man's abilities are related cannot be raised any longer, but it should be asked which concrete factors condition this. The search and mapping of genetic markers will unavoidably be continued in the future. One day it will be obvious to which moment it will last.

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