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VLADAN DJORDJEVIĆ, THE LIFE AND WORK OF A GYMNAST, SCIENTIST, POLITICIAN, WRITER AND THE PROGENITOR OF GYMNASTICS AND THE SOKOL MOVEMENT IN SERBIA

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Abstract
Vladan Djordjević belonged to a generation of Belgrade Lyceum students, who later became influential representatives of science, society and politics. Tireless engagement in the social life of Belgrade and the Kingdom of Serbia, diligent performance of government and diplomatic duties, and an imposing contribution to medicine, historiography and literature put Vladan Djordjević among the most respected figures of Serbian history. Beside achieving much in the establishment of socio-cultural, scientific and political life of Serbia, he also contributed greatly to the development of physical culture in the Kingdom of Serbia at the end of the 19th and the beginning of the 20th century. As a student of the Belgrade Lyceum, while practising gymnastics and martial arts, Djordjević became a great aficionado of physical exercising and gained insight into its importance for health and strengthening of spirit. Djordjević could not forget this beginning of organised gymnastics exercising and so, twenty-four years after finishing his studies, as a distinguished physician and the head of the Medical Department of the Serbian Ministry of the Interior, he became the progenitor of the idea to set up "a great gymnastic society in Belgrade with branches all over Serbia". The development of gymnastics in Serbia allowed the spread of the Sokol Movement and the advent of modern sport in this country. The goal of this paper is to apply the historical method in the study of authentic documents from 1895, 1908, 1910, 1925-27, 1938, etc., which are mostly unknown and unavailable to the wider and expert public and which illuminate the various contributions of Dr Vladan Djordjević, particularly in the domain of physical culture.

Key words: VLADAN DJORDJEVIĆ / PHYSICAL CULTURE / MEDICINE / LITERATURE / HISTORY / POLITICS / SERBIA

THE LIFE OF VLADAN DJORDJEVIĆ – IMMORTAL KNOWLEDGE, DEEDS AND VIRTUES

Dr Vladan Djordjević, a prominent figure from Serbian history, left a lasting mark on the scientific, cultural, social and political life of Serbia at the end of the 19th and the beginning of the 20th century through his intellectual and organisational work. This intellectual and physician, known even outside Serbia, left behind him a deep imprint, valuable works and ideas with which he had changed Serbia for better and created public life in its capital Belgrade. An erudite and an avant-garde, impulsive and persistent person, he modernised and contributed to medicine, military, politics, diplomacy, cultural and social life, literary and historical publishing, education, sport…, to every field where he found himself and which enticed him to work in it. He was tireless in any labour he undertook, determined, innovative, modern and significant for the advancement of both the Serbian society and the state.

Numerous data reveal Djordjević's various interests and organisational and labour potentials in a number of activities which he devoted himself to. What has been less researched is his contribution to the development of physical culture, i.e. physical exercising, and civilian and school gymnastics, which would lead to the advent of modern sport and the Sokol Movement in the Kingdom of Serbia at the end of the 19th and the beginning of the 20th century. The goal of this paper is to confirm the aforementioned statement of Dr Djordjević's excellence with facts

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obtained through the historical method. Besides this, the goal of the paper is also to serve as an unpretentious contribution to the study of works of famous and historically affirmed Serbian intellectuals.

THE ERUDITION AND AMBITION OD THE YOUNG IPOKRAT

Vladan Djordjević was born in Belgrade on 21 November 1844 in Gospodarska St. (today, Vasina St.) in an Aromanian family. His father Djordje Djordjević, a medic in the Serbian army, and later a lieutenant, originally from Epirus in Greece, and his mother Marija Leko, from an influential Belgrade Aromanian family, wanted their second child to become a physician and so gave him the name Ipokrat, after Hippocrates. The Djordjević family suffered tragedy with their offspring. In a short period, they lost three children. When he was seven Ipokrat also lost his mother, who died not long after giving birth. Ipokrat's father took him out of the Greek school and moved with his entire family to Sarajevo to start a pharmacy business. There Ipokrat graduated from the Serbian school with excellent marks. In order that he could continue his studies, the family returned to Belgrade. Having shown a considerable knowledge, he was immediately accepted into the second year of Belgrade's First Male High School (Djordjević, 1927).

When he enrolled at the Belgrade Lyceum in 1862 (the first college in Serbia), at the suggestion of the dean, the famous philologist Djura Daničić, Ipokrat changed his name into a more Serbian one – Vladan, which is a translation of the second part of his given name: Ipo-krat (in Greek *kratein* means *to rule*). Although he was already considered a student of linguistics and a future writer, after the first year at the Lyceum the dilemma over the continuance of his education was resolved by his professors. Estimating his capabilities at the Department of Natural Sciences, they decided that he should study medicine, and the greatest influence on this had had another professor of great repute – Josif Pančić (Subotić, 1910).

During his years at the Lyceum Djordjević was a member of *The Company for Gymnastics and Martial Arts*, operating within *The Painting School*, founded by Stevan Todorović in 1857. In his private institute Todorović taught drawing, painting, singing and acting, but since he was a great gymnastics and fencing enthusiast, he taught the Lyceum students these skills as well (Vukašinović, 2017). Despite its conservative stance, *the Company* attracted the student population, particularly because of the support it enjoyed from Prince Mihailo Obrenović. It was a time of patriotic exuberance directed at cultural changes and social advancement of the Principality of Serbia, as well as at the completion of the liberation from the Ottoman yoke.

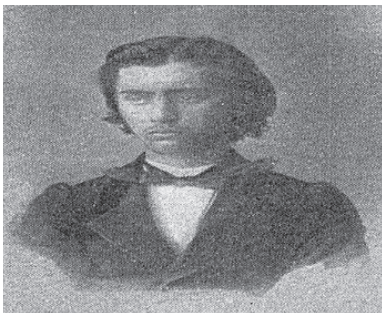

Photo 1. Vladan Djordjević as a high school student

Ipokrat Vladan Djordjević exercised in *The Painting School* together with other Lyceum students who would one day become well-known politicians and scientists: Miloš S. Milojević, Milan Kujundžić, Čeda Mijatović, Ljubomir Kaljević, Steva Popović – Crni, Andra Nikolić (Petrović, V. J., 1983). "Šćeva", as the young physical exercising enthusiasts had nicknamed their teacher Todorović, besides urging his students to exercise, he also endeavoured to enlighten and educate them in the patriotic spirit (ibid.). Djordjević was not only gifted for gymnastics and fencing, but he also started to exhibit interest in literature and to write dramatic works with great enthusiasm when he was still young. He studied history and languages, translated, and in the fifth class he was already reading novels and magazines in German; he also studied to paint and play the piano, and he acted in theatres (Djordjević, 1927). It can be said that he was well known for his numerous interests and the desire to improve himself.

DR VLADAN DJORDJEVIĆ – PROFESSIONAL DEDICATION, IN THE SERVICE OF THE SERBIAN PEOPLE

In autumn 1863 Vladan Djordjević was sent at the government's expense to study at a prestigious medical school in Vienna. He was taught by renowned medicine professors such as Hirtl, Brücke, Rokitansky, Škoda, Hebra, Sigmund, and the famous surgery professor Theodor Billroth, who would proclaim

Vladan his most gifted student. Djordjević confirmed this when he brilliantly defended his graduation thesis at the end of 1868, and in January 1869 he was granted the title of MD, while only five months later he received the title of surgeon, which was followed by a magister degree in obstetrics (Godišnjak Srpske kraljevske akademije 8, 1895 - Almanac of the Serbian Royal Academy, in the following text "Godišnjak SKA 8", 1895). During his studies and a two-year specialisation in Vienna, he acquired a considerable skill in surgery and he adopted Prussian punctuality, discipline and work organisation under the great influence of Professor Billroth. Even though he had started a practice at a surgical-gynaecological clinic in Prague, ambitious Djordjević returned to Vienna to specialise in surgery (1869-1871). He attracted attention early with his first scientific papers, which he wrote in German and then translated into Serbian for "The Serbian Learned Society". At the Vienna clinic, he gained a specialist diploma of a surgeon-operator.

To gain further specialisation "in war surgery techniques", he asked from the Serbian government to allow him to join the Prussian medical corps during the Franco-Prussian War. In a large war hospital in Frankfurt Djordjević distinguished himself as a practising physician and the head of one ward, and for his contributions, he was granted the rank of reserve medical lieutenant (Subotić, 1910). Djordjević's ambition, professional curiosity and results of his work could not go unnoticed. Though young, he was soon elected into the position of a permanent member of the "Serbian Learned Society" in 1869, "Society of Physicians" in 1870 and the Anthropological Society in Vienna in 1871 (Godišnjak SKA 8, 1895).

After eight years, Djordjević returned to Serbia in July 1871 as the first Serbian surgeon. He opened a medical practice in Belgrade and for a while, he worked as a private physician and operator. He was soon known as somebody who cared for the well-being of his people and treated the poor for free, helping them with financial donations. In public gatherings and lectures, he suggested the establishment of a poor people's home, hospitals for poor children, a pavilion for poor pregnant women, schools for deaf and blind children. He submitted a request to the Ministry of the Interior to be allowed to treat the poor for free and thus repay the country for the scholarship he had received to study abroad. Instead of receiving a response, five months later he was appointed a military physician of the second class and the chief of the surgical ward at the Belgrade General hospital (1871) by Prince Milan Obrenović. Besides holding this function, he also taught the first hospital service courses and he was the first professor of military surgery in the Artillery School, which would later become the Military Academy (Subotić, 1910). In 1872 he established "The Serbian Medical Association".

Photo 2. Dr Vladan Djordjević, the founder of the Serbian Medical Association, 1872

His successful medical career would, after two years, bring him to a life turning point. In 1873 he became the personal physician of the 18-year-old Prince Milan Obrenović (Jovanović, 1926). This had a decisive impact on further developments in Djordjević's career, his political affiliations and the fate of his family. In the Prince, he saw a ruler with a clear vision of modern and progressive Serbia, which Milan Obrenović did later manifest in his ability and wisdom regarding the foreign and internal policy, with his contributions to Serbia gaining independence and international recognition, the country's territorial expansion as well as modernisation of the government institutions. During his early years of service, he had tremendous influence over the young Prince, and for that reason, many of his initiatives were realised in a short time period. With the Prince's both moral and material support he initiated the founding and the development of important institutions, such as the civilian and the military medical services, Serbian Medical Society and the Red Cross of Serbia. Over the seventeen years of service to the Obrenović crown (on multiple occasions), as a physician and later a government official, he shared the ups and downs of the country and several times he suffered from the Obrenović dynasty turning their backs on him or using him for their own ends.

During the first six years, he had spent at the royal court he had often suffered unpleasantness due to Prince Milan's unpredictable and difficult temper, but also due to Princess Natalia's animosity, which was the result of his honesty. The service at the court, with its intrigues and affairs, was a great burden to him. When he left the court he spent some ten years managing the military medical service in both Serbian-Turkish Wars (1876-1878), and in the Serb-Bulgarian War (1885-1886), as well as the civilian med-

ical service during the peacetime. For the successful organisation of the military medical service he was supposed to be promoted to the rank of colonel after the First Serbian-Turkish War, but Princess Natalia tore the corresponding decree of Prince Milan. Vladan resigned, but the Prince did not accept it and decorated him with the Order of the Cross of Takovo, which up to that point only the Russian general Mikhail Chernyayev had received. In the Serb-Bulgarian War, he was moved back from the reserve into the active service, and that was when he received the rank of medical colonel. Until then, the highest rank a physician could have in the Serbian army was that of a major (Subotić, 1910).

Photo 3. Dr Vladan Djordjević, chief of the Military medical service

VLADAN DJORDJEVIĆ – INEXHAUSTIBLE STRENGTH AND CONSISTENCY IN PRINCIPLES

Dr Djordjević started participating in the Serbian politics in 1883, even though until then he was politically independent. He propagated progressive ideas, the cult of science and the enlightenment of the people. He spoke of being "an Obrenović supporter through his father", but that the idea close to his heart was that of "the spirit of enlightenment", i.e. the faith in science and its power to bring progress and understanding, since the "enlightenment of the people is the initiator of historical processes" (Rajić, 2005). He opposed the involvement of the masses in the politics, seeing the dangers brought by radicalism. His fierce temper and bitter disputes with the leaders of political parties, and even with the members of the royal family, caused him many troubles.

When he could no longer be dealt with, Dr Djordjević was made the mayor of Belgrade in 1884, and the first thing he did was get rid of bureaucrats. During his two years as mayor, he successfully dealt with the challenges of running a town. The municipality employees respected him even though he was strict and couldn't tolerate laziness. Such traits he referred to as "the oriental decadence". Due to his life motto ***"Laboremus"*** **(**"let's work" in Latin), and a long-discussed and quoted statement of his, from a lecture he gave, which was then printed in the magazine "Otadžbina" – ***"Serbian enthusiasm is like a brass stove, which heats up quickly, but cools just as fast"***, he was considered an atypical resident of the Balkans (Subotić, 1910). On one occasion he kicked out of his office a representative of a cement factory and revealed that the man had tried to bribe him. True to his principles, he resigned from the mayor's office because of a dispute with the Minister of the Interior over the introduction of an excise duty, but only after he received the vote of confidence from the municipal assembly (Archives of Serbia, the personal fund of Vladan Djordjević, 1969). Dr Djordjević knew quite well how to cause disturbances in the inert milieu of Belgrade of that time.

Djordjević considered telling truth very important, and occasionally he would be highly critical in his writings and speeches about King Milan's oversights and political moves which weakened the country and slowed its growth. King Milan didn't appreciate such criticisms. Their first major dispute occurred when Djordjević called for the King and his ministers to be held accountable for Serbia's defeat at the battle of Slivnitsa in November 1885, during the Serb-Bulgarian War. In "Otadžbina" he wrote "the naked and bitter" truth about the political and military conduct of the war (1887). King Milan, feeling offended, personally wrote the lawsuit against him, demanding that he be sent to prison, but the court proclaimed him innocent. Several months later, the King had to comply with the decision that Djordjević be made the Minister of Education and Church Affairs and the Minister of Economy (Godišnjak SKA 8, 1895). However, even after this, he was ill-favoured by the King because of him printing "the true history of Slivnitsa". That same year, with his own hand, the King erased Djordjević's name from the list of candidates for the first Serbian academics.

Djordjević's family faced great trouble when King Milan abdicated too early in 1889. Vladan Djordjević found the relinquishing of the throne and putting the

state in the care of the underage Prince Aleksandar and the Regency in the climate of unstable political relations in the country as irresponsible and selfish. For that reason, several days after the abdication, in October 1889, he was sent into early retirement (for the first time) (ibid.). With King Milan leaving the country Djordjević withdrew from the public life, but only for a short while. The Obrenović dynasty remembered him again because they need him.

Beside numerous duties that he performed, Dr Djordjević, being a great aficionado of physical exercising, founded in 1881 *The Belgrade Society for Gymnastics and Martial Arts*, with the idea to use this "central gymnastic society to establish similar ones in every town for the purpose of improving health and the physical strength of the people". This was a turning point for the development of gymnastics in other Serbian towns, including the Sokol Movement and certain sports soon after (Vukašinović, 2016, 2016a).

In 1891 Djordjević accepted the offer from the Regency to become the Serbian ambassador to the King of Greece in Athens. For three years he successfully worked on improving the friendship between Serbia and Greece, until January 1894, when, due to budget restrictions, he was sent into retirement again. Three months later he was appointed as the Serbian ambassador in Constantinople (in April 1894), an important and unpopular centre of the Serbian foreign policy. In difficult conditions imposed by the oriental spirit of cunning diplomats, he successfully struggled for the vital Serbian interests (Jovanović, 1925, 1929).

After King Milan returned from exile and young King Aleksandar removed from power the Radical Party led government, Djordjević was invited back to Serbia to form a new government. As the Prime Minister and the Minister of Foreign Affairs, he had a difficult task of serving two kings at the same time, both of whom wielded significant influence (the former king was granted the position of the supreme commander of the active military). He resigned when, during his term in office, an unsuccessful assassination of King Milan took place in 1899 in Belgrade. However, when the former king accused him of running away when it was most difficult, he withdrew his resignation (Ćorović, 2010; Jovanović, 1935).

Due to the dissatisfaction of the officers with the "unsuitable" engagement of King Aleksandar and the widow Draga Mašin, Djordjević tried in various ways to dissuade the young King from such a move and that was how they ended up in a bitter dispute. After the wedding, Djordjević resigned together with other ministers (1900) and found himself in another troublesome situation, thus putting himself and his family in serious danger. The daily press received orders from the palace to mercilessly attack him. His three years as the head of the government were called "Vladanism" and it took some time for the public to realise that "Vladanism and other widespread beliefs were myths corresponding little to the reality, because it had been the regime of kings Milan and Aleksandar that had held the power, not Vladan Djordjević" (Jovanović, 1935).

In an attempt to completely humiliate Djordjević, King Aleksandar sent him into retirement illegally (in 1900 – the third retirement). Pension, which he was owed because of his involvement in the government, was taken from him, along with the rank of a colonel. Disappointed, Vladan Djordjević left for Vienna, into a "voluntary exile", as he had called it himself, and there he spent six months writing for a number of Viennese, and one Berliner newspaper, until the government of Serbia annulled the King's illegal decree (Godišnjak SKA 21, 1908). After the bloody May Coup (Belgrade, 29 May 1903), when the royal couple were murdered, he spent two more years in Vienna, and then returned to Serbia. After that, as a retired former Prime Minister, he devoted himself to literary work, mostly writing history (in German and Serbian). In his memoirs titled "The End of a Dynasty", he described some ministers in such a manner that he ended up in prison under the charges of disclosing government secrets (1906). However, the true reason for this was him writing that "the Queen of England couldn't receive King Aleksandar". He spent six months in Belgrade's "Glavnjača" prison because he did not want to beg for mercy that had been offered to him (ibid.). In the book "A Minister in Jail", he wrote the following about his intention to go to Vienna after serving his sentence: "I'm leaving to take a breath in a country with some semblance of the rule of law, where patriotism is not a crime." During the Great War, he also ended up imprisoned, from 1915 until 1918, not far away from Vienna. Upon his return, he lived in Belgrade and occasionally visited Dubrovnik.

In his 86-year-long, eventful, and not at all easy life, Vladan Djordjević witnessed six wars, changes of constitutions, regimes, dynasties, and was a witness of numerous major historical events. His winding life path, closely tied to the Obrenović dynasty, brought him many things – renown, honour, high positions, but also sacrifices, conflicts, personal attacks, three retirements and two imprisonments. His three years younger German wife, Paulina Britner, love from his student days, gave birth to fifteen children, but only four survived. His eldest son Milan, a captain of the first class and a lawyer, died fighting in the first lines during the liberation of Dubrovnik from Austria-Hungary in 1918. His second son, Aleksandar, lived in Paris, where Djordjević's descendants can be

found even today. His two daughters have left numerous descendants in Deroko and Vlastari families.

VLADAN DJORDJEVIĆ, AN ERUDITE PLEDGED TO INCREASING THE PROSPERITY OF THE SERBIAN PEOPLE AND SOCIETY

Medicine, military and civilian medical service

Tremendous contributions to the development of Serbian medicine and military and civilian medical services are ascribed to Dr Vladan Djordjević. Because of his significant experience from working in different institutions, including internship in prestigious clinics, his private practise and involvement in military and civilian medical services, he had an encompassing and competent insight into the problems and needs of the Serbian society in the domain of health care and disease prevention, which were in their infancy in Serbia at that time.

The greatest credit for gathering 15 physicians from six different ethnic groups and the founding of the "Serbian Medical Association" (1872) goes to Djordjević. For three years he was the Society's first secretary, then he spent four years as vice president (1886-1889) and two years as president (1890-1891). He started the journal „Srpski arhiv za celokupno lekarstvo" - "Serbian Archive for All of Medicine" (1874) and worked on editing, translating and publishing its first issues. He had started the "Archive" with the intention that all Serbian physicians should be able to follow the new developments in medicine no matter where they lived. Thanks to the favourable position he enjoyed with King Milan, Djordjević ensured government support for the Association and thus the free publishing of the journal (Godišnjak SKA 8, 1995).

Vladan Djordjević also significantly contributed to the founding of the "Serbian Society of the Red Cross" (1876). He gathered several reputable individuals in the Principality of Serbia to serve as members of the managing board. The first task of the newly established Society was to take care of refugees coming to Serbia due to the Herzegovina Uprising. Thanks to his influence the foundations of the Society were laid in the first year of its existence and it was also formally recognised by the International Committee of the Red Cross. The work of the Society was well organised from the beginning – directed at collecting the financial and material aid, organising of hospitals, employing of physicians, training of volunteers, acquiring of medical equipment and providing assistance to the military medical service (Subotić, 1910).

Dr Djordjević worked in the military medical service in all the wars Serbia had fought at that time. In the First Serbian-Turkish War (1876) he was the chief of the medical service of the Morava-Timok Army. In the Second Serbian-Turkish War (1877-1878), and later in the Serb-Bulgarian War (1885), he was the chief of the medical service within the high command of the Serbian military. In these situations, he showed extraordinary organisational abilities. He founded and was the first manager of the Niš Military Hospital (January 1878), also known as "Moravian Military Hospital". Due to the efforts of Djordjević, the organisation of the Niš hospital was established, and at that time it was the central institution of the military medical service in the south and east of Serbia, which would later, during the Balkan Wars and the Great War, prove to be of major significance (Savić, 2014).

While teaching to the medical company of the Serbian army at the Belgrade Military Hospital and later giving lectures on army hygiene at the Military Academy, he wrote two textbooks – "Hospital Service" and "The Principles of Army Hygiene" (1874). He was awarded for writing the book "Manual for the Military Medical Service of the Standing and People's Army in Peace and War Times" (1876). He put into motion the establishment of the military medical corps for the Serbian army. He initiated numerous debates on the reform of the medical profession (1879-1881) (Subotić, 1910).

As the chief of the civilian medical service of Serbia (from 1879), he started and successfully reorganised the medical service in 1881. To implement a wide reform, he spent several years carrying out correspondence with medicine professors from universities in Paris, Vienna, Stockholm and Geneva. Numerous letters testifying to this have been preserved and they contain the highest praises of European experts regarding the reform (Archives of Serbia, Vladan Djordjević fund).

Djordjević was the author of laws and books on health care. His extraordinary speech, given in the National Assembly, on infectious and animal diseases, child delivery hygiene, infant care, unqualified mid-wives, quality nutrition, prejudices and customs

detrimental to the health of the uneducated populace, and other things, is rather famous. This speech accelerated the passing of the first Law on health care in Serbia (in 1881 – it was referred to as "Vladan's health care law"). Not long after, he published several books pertaining to this area: "A Corpus of Laws and Regulations on Health Care (official comments, instructions and rules on how to apply these laws) and others. He also participated in the writing of veterinary legislation and formulating of the terms of the veterinary convention between Serbia and Austria-Hungary, as well as the founding of the "National Health Care Fund". He also started running a weekly on hygiene – "Public Health" (1881), which he edited until 1884. As the chief of the civilian medical service, he represented Serbia at congresses on hygiene in Geneva, Turin and Vienna (Subotić, 1910).

Detailed records from the meetings of the "Serbian Medical Society" show that Vladan Djordjević wrote about and referred to various surgical procedures he performed in Belgrade's Town and Military hospitals, and sometimes even in private homes. He translated most of his works on performing surgery (Čolović, 2007). Even in his seventies, he was still socially active and he participated in the work of the "Serbian Medical Association", where he gave lectures and contributed to the establishment of the Department for the History of Medicine at University of Belgrade's Faculty of Medicine (1920). This department was, however, abolished six years after his death.

Social appointments, politics, diplomacy

Vladan Djordjević, though a conservative Obrenović supporter, was an avant-garde person. A great optimist and fighter, devoted to the development of his country, while also knowledgeable about the achievements of more advanced societies, had a lot of work to do on changing the social and political life of the Kingdom of Serbia. In his youth, as a government scholarship holder, a Republican in his beliefs and secretary of the organisation "United Serbian Youth" he advocated "the improvement of education and people's awareness" and "the equality of women with men" among the young people. Due to the "more open" ideas which he had expressed at the Moscow Slavic Congress, where he opposed Russian becoming the Slavic lingua franca, the Minister of Education took his scholarship away, which King Milan later returned (Subotić, 1910). Djordjević changed his political beliefs, from being a liberal during his student days to becoming an Obrenović loyalist due to the influence of King Milan from whom he had great expectations. For that loyalty, he was with reason considered a monarchist.

By the decree of King Milan, Djordjvić was appointed the mayor of Belgrade (1884-1885). After reorganising administration, he set the foundations for the planning and construction of infrastructure in Belgrade: he initiated the construction of the water supply system and sewers, the modernisation of street lighting by introducing gas lamps, then he started the refurbishment of the Sava Quay (Savamala), the tracing of the tram lines, the paving of streets; he set up a market on Cvetni trg, planted 1,000 trees, moved the town cemetery from Tašmajdan to a large estate of his, which he gave to Belgrade as a gift (nowadays Belgrade's New Cemetery, then known as "Vladanovac"), he increased the municipal revenue by introducing excise taxes; he also introduced the planning of financial assets for health care affairs in the municipal and government budgets, started the work on the comprehensive project "Belgrade Municipal Affairs", and introduced harsh fines for those who broke sanitary regulations (1-4, 1884-1885) (Archives of Serbia, Vladan Djordjević fund, 1969; Subotić, 1910).

Whenever anarchy and chaos threatened the country he would criticise the Radical Party in the Progressive Party paper "Videlo" for "poisoning the people" with its demagogy, which would eventually lead to the Timok Rebellion (1883). He emphasised the need for the legal order to be defended. After the defeat of the Timok Rebellion, the Progressive Party appointed him (for the first time) a member of parliament. As an MP he remained a defender of the crown and its rights, but was also an advocate of civil and political liberties and he called for the institutions to be rid of corruption (Rajić, 2005). Djordjević's fiery temperament, "sharp tongue" and strong words of his newspaper articles, as well as debates with the political party leaders, and even with the members of the Obrenović dynasty, caused him much unpleasantness. He spoke rather harshly against the socialists, radicals, progressives and liberals and for that reason was a thorn in the eye to many. It was being said that "Dr Vladan cuts his opponents mercilessly, with both knife and his tongue". He called for regular (non-violent) political trends and criticised Svetozar Marković for his ideas about causing a coup, thinking of them as wrong and harmful. He wrote that it was better to gain "true civil liberties" through legal means and the freedom of speech and the press. He contributed to the passing of numerous tax reforms and useful laws. He proposed the construction of a railway network

for the purpose of development of the country and its society. He called for independent courts to be established and the governance, education and military to be better regulated. He could not tolerate inert state of government institutions, and because of that he wrote an article in the paper "Otadžbina" titled "Comparison of Several Government Budgets" (1891), demanding that true government budget be discussed in the National Assembly (Archives of Serbia, Vladan Djordjević fund, 1969; Godišnjak SKA 21, 1908).

In 1888 he was appointed Minister of Education and Church Affairs and a representative of the Minister of Economy. After that, his diplomatic career started. First, he was the Serbian ambassador in Athens from 1891, and in 1894 he was sent to Constantinople (1894-1897). During that time governments kept changing in Serbia – Radical, neutralist and Progressive, but each one was satisfied with his diplomatic work (Jovanović, 1925; Rajić, 2005). Thanks to his "tireless manoeuvring" and personal charisma he managed to build good relations with Russian diplomats and Sultan Abdul Hamid II, which was helpful in resolving disputes with Bulgaria and Greece. It was then that the position of the Serbian populace and the Serbian Orthodox Church in the Ottoman-controlled Old Serbia (Rascia, Kosovo, Metohija and Vardar Macedonia) and Macedonia (Thessaloniki and Manastir vilayets) was improved, by the Ecumenical Patriarch and Sublime Porte approving the appointment of Serbian bishops (in Eparchies of Raška and Prizren and Skopje) and opening of Serbian schools (Jovanović, 1929). After that, he was appointed as the Prime Minister and Minister of Foreign Affairs (1897-1900). It is well known that his "neutralist" government worked on the economic and military strengthening of Serbia, mitigating of fierce inter-party conflicts and enacting of a large number of laws.

Interesting information is that Djordjević had influenced King Aleksandar Obrenović to visit the Hilandar monastery at Mt. Athos upon his return from Constantinople and Greece (1894). Over the course of this visit, the first visit of a Serbian monarch since the Middle Ages, the ownership dispute with Bulgarians over the monastery was finally resolved by the King buying off the monastery's debts. In return, the Hilandar monks gifted him with priceless national treasures – The Gospel of Miroslav, the original monastery founding charter issued by the Grand Prince Stefan Nemanja and several valuable manuscripts (Lukić, 2010).

Photo 4. King Aleksandar Obrenović, in front of the Hilandar monastery church, 1894

Publishing, literature and history

Djordjević was considered one of the most prolific Serbian authors even during his life. He was appreciated because of his large literary opus, and the energy which he invested into his novels, short stories, dramas, novellas and poems. He published his first short story when he was in the second year of high school (1860), and after that, he wrote ceaselessly. In the sixth year, he received royalties for dramas, tragedies, comedies and translations. When he was a university student he had already had 29 literary works published in magazines "Danica", "Vidovdan", "Vila", etc. (Jovanović, 1925; Godišnjak SKA 8, 1895).

He actively participated in the work of the literary society "Zora", and he initiated its merger with the society "Srbijanac". That was how "The United Serbian Youth" was formed in Novi Sad in 1866, and its membership consisted of people from Austria-Hungary and Serbia. When he was chosen as the organisation's first secretary and editor of books aimed at the younger audience he immediately started a translation department whose task was the translation of the best works of world literature so as to bring about the enlightenment of the common people (Subotić, 1910).

Djordjević's varied and rich biography represents a valuable source for the seven decades of Serbian history which cover his life. Critiques from Europe-

an literary circles regarding the majority of Djordjević's novels were rather positive. These works were described as "documentary, artistic, objective, poetic, thorough, and they show great knowledge of Serbian history and oriental relations, and are written in excellent German". He wrote in many languages, and some of his three-volume novels exceed 1,500 pages. He translated into Serbian from Russian, French, German and Greek (Tolstoy's "Anna Karenina", Moliere's "The Miser", then Balzac, Berthold Auerbach, Goldoni and others) (ibid.). He also contributed to Serbian and Greek cultures coming together: he wrote a great study about the Serbian and Greek representatives of the Enlightenment – Dositej Obradović and Adamantios Korais ("Grčka i srpska prosveta" - The Greek and Serbian Enlightenment, 1896); he translated into Greek some short stories by the Serbian author and his best man Dr Laza K. Lazarević, and wrote with great interest about the contemporary Greek culture. Besides some 180 papers on medicine, history and literature, a considerable collection of manuscripts of his scientific and literary works was preserved, together with orations, polemics, articles, lectures, feuilletons, memoirs, diplomatic reports, proposed laws, letters and reviews published in various Serbian and international weekly and daily newspapers, as well as some unpublished ("Srbija i Rusi" – Serbia and Russians…) (Godišnjak SKA 8, 1895; Slapšik, 1988).

The list of Djordjević's most important works includes: "The History of the Serbian Military Medical Service", 1-4 (1879-1886), "The End of a Dynasty", 1-3 (1897-1900), "Serbia at the Congress of Berlin" (1890), "Serbian-Turkish War", 1-2 (1907), "The History of the Serbo-Bulgarian War", 1-2 (1908, the Ministry of Defence bought 200 copies, stating that it was "the true history of the war from the perspective of the Chief of Staff HQ"), "Golgotha" (1909, 31 extraordinary reviews), "A Minister in Jail" (1909), "Serbica" (1909, a historical study based on a collection of 800 documents about the history of Serbia and Montenegro from 1804 to 1815 – currently kept in the Serbian Academy of Sciences and Arts), "Albanesen und die Grossmachte" (1913, Albanians and the Great Powers, author's note), "Emperor Dušan", 1-3 (1919-1920), "Montenegro and Austria 1814-1894" (1924), "Memories", 1-5 (1927)[1] (Subotić, 1910; Djordjević, 1909).

"Djordjević published and edited the literary magazine "Otadžbina" (1875-1892), one of the most significant literary magazines in the 19th century Serbia, where the works of some of the most important authors of 1880s and 1890s were published (Slapšak, 1988). He financed the magazine with his own money, considering it a matter of honour and an opportunity for truthful and educational content to reach the readers without censorship. The header of each issue's front page contained the lyrics from Djura Jakšić's famed poem "Otadžbina" (Fatherland in English) to awaken pride in every Serb reader, and Djordjević was particularly fond of this. After having a rather enjoyable meal which Djordjević had paid for him, Jakšić, who also had a sharp tongue like Vladan, wrote the poem in the "Dardaneli" kafana (A traditional Serbian restaurant, now the location of Palace Albanija), from his soul and without making any later corrections. On a torn piece of a newspaper, he wrote: "I ovaj kamen zemlje Srbije, što preteć suncu dere kroz oblak… - which in English means "And this rock of Serbia, which despite the Sun breaches the clouds..." (Lukić, 2010).

FROM GYMNASTICS AND MARTIAL ARTS TO CIVIL AND NATIONAL VIRTUES THROUGH EXERCISING

The 1881-1891 period in Djordjević's life was rather busy. He worked on reorganising medical service, compiling of laws on health care and animal care. He participated in the tumultuous political life as an MP and kept proposing tax reforms and changes in the government institutions. He successfully managed Belgrade as its mayor and found time to write three multi-volume works from the domains of medicine and history, all the while suffering blows with his family from King Milan Obrenović. He even managed to establish civilian gymnastic societies throughout Serbia. In October 1881 he initiated the founding of *The Belgrade Society for Gymnastics and Martial Arts* (the modern day *Sokol Society Belgrade Matica*) which would soon receive great support and assistance from the people, philanthropists and Ministries of Education, the Interior and Defence. With his friends, former Lyceum students and well-regarded individuals in important positions and thanks to his long-term affection towards gymnastics and his stunning physical strength, he successfully worked on improving the reputation of the Society and helped the founding of other gymnastic societies and training of gymnastics teachers (Vukašinović, 2016).

1 TN: The titles of all of these works were translated from Serbian into English.

Photo 5. Belgrade Society for Gymnastics and Martial Arts, 1889

Physical exercising, physical education in schools and sports

As a Lyceum student, young Ipokrat fell in love with gymnastics and saw how important it was for health and the development of physical and intellectual abilities. Vladan never forgot this beginning of organised gymnastics practising and the enthusiasm of the Lyceum students with Stevan Todorvić's pedagogical skill to teach them both art and sports in his *Painting School*.

Some twenty-five years later, as a respected surgeon, military physician and the chief of the civilian and medical services, Dr Vladan Djordjević started spreading the idea about founding a gymnastic society by appealing in a letter to the Minister of the Interior Milutin Garašanin. Garašanin did not require much convincing because the positive news about the Sokol Movement and sports had been reaching Serbia more and more often, and for that reason, he gave support to the initiative for a large gymnastic society to be established, with branches throughout the entire Kingdom of Serbia. He sent a lengthy letter to Stojan Novaković, the Minister of Education and Church Affairs. The contents and the style of the letter signed by Garašanin clearly indicate that the author had actually been the dedicated and systematic Dr Vladan Djordjević, considering the thoroughness in depicting the terrible state of health of the young people and the rest of the populace. Djordjević also listed numerous suggestions on how to solve institutional, material and personnel issues regarding the introduction of school and civilian gymnastics:

"I know quite well that until now gymnastics could not receive as much attention in our schools as the physical development deserves, according to the conviction of all contemporary pedagogues and physicians, only because for this subject we have had almost no qualified personnel. But, it is for that reason that I believe that it is finally time to think about the way how to get more good gymnastics teachers…"

"There is irrefutable evidence that our people are starting to falter in their height and physical strength due to various unhygienic behaviours. One glance at any battalion of our standing army, which consists of recruits from the entire country, is enough to show the consequences of such degeneration on the intellectual and material future of our people. On this occasion, it is not necessary to go into details about this. To both you and me it is completely clear that the government needs to devote serious attention to this decrease of strength in our people, and that was why I took the liberty to propose to you to jointly do as much as we can, from our specific ministerial positions, on improving the health and physical strength of our people." – *from the letter of Milutin Garašanin to Stojan Novakivić, 13 October 1881.*

This elaborate letter, sent to the Minister of Education and Church Affairs Novaković, proposes solutions for numerous important issues regarding the health care, education system, sport and child upbringing: "the es-

Photo 6. Ipokrat Vladan Djordjević, an oil painting by Stevan Todorović

Photo 7. Medical colonel Dr Vladan Djordjević

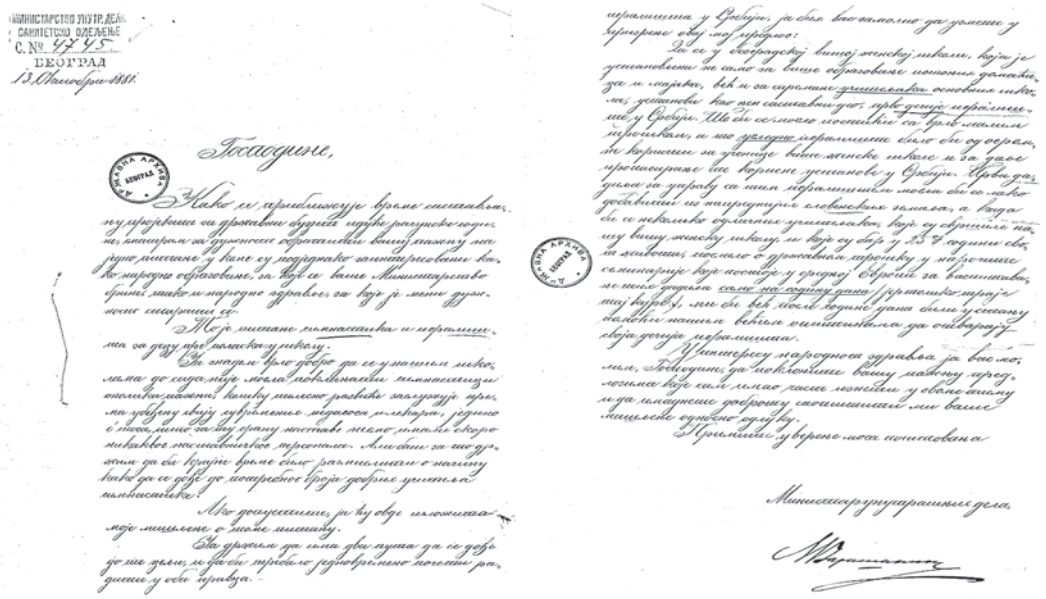

Photo 8. Milutin Garašanin's letter to Stojan Novaković, the first and the last page, 1881

tablishment of a large gymnastic society in Belgrade, with as many physicians and teachers as members, numbering at least several hundred; the construction of a building where gymnastics could be practised in both summer and winter; the training of gymnastics teachers for the work in middle, and later in elementary schools, who should not be amateurs or dilettantes, but thoroughly and specially educated experts in this line of work; the training of gymnasts who would gradually establish gymnastic societies in their own small towns; these local societies would maintain contact with the central gymnastic society in Belgrade, thus making one huge network of institutions, which would, by avoiding pointless entertainment, and working in accordance with a common hygiene plan, drastically improve the level of physical health in Serbia in several years; setting aside certain funds in the Ministry budget for the purpose of sending a few intelligent, healthy and successful gymnastics students to Stockholm for further training as gymnastics teachers; a legal equalisation of gymnastics teachers with the other ones; opening of playgrounds for pre-schoolers – "Fröbel's Playground", also known as "Kindergarten", first in the Women's Higher School; sending several female teachers to Central Europe to a one-year seminar at the government expense…" (Archives of Serbia, Ministry of Education s-p, 1881).

Although Minister Novaković had differing opinions on a number of issues, he supported the proposal to establish a gymnastic society, because this idea had already taken root in the public. Dr Vladan Djordjević was at that time admired as a politician and a writer and for that reason, he easily convinced gymnastics teachers Stevan Todorović, Ferdo Mihoković and Ljubomir Ilić to teach gymnastics for free. Because of Mihoković's illness, Dr Dragiša Stanojević joined the society (Trujić, 1976).

So as to avoid the waining of enthusiasm, Djordjević immediately gathered respected residents of Belgrade in "Srpska kruna" kafana (20 October 1881) – a total of 33 signatories, excited with this noble idea useful for the people, invited to form the founding board. Among them, there were Dr Laza Kostić, Milan Dj. Milićević, Dr Laza K. Lazarević, Milorad Šapčanin, Mita Cenić, as well as Radivoj Milojković, Milutin Garašanin and Nikola Pašić, the leaders of Liberal, Progressive and Radical parties. The decision to establish *The Belgrade Society for Gymnastics and Martial Arts* was made on 20 December, while the first session of its assembly and managing body were held on 3 January 1882 in "Srpska kruna". A former minister, general Tihomir Nikolić, was elected as the president, Stevan Todorović as vice-president, while Dr Vladan Djordjević and Dr Laza Kostić, along with the other gentlemen, became the "managing members" (Srpske novine, 1882). With this, *The First Serbian Company for Gymnastics and Martial Arts*, which had arisen from Stevan Todorović's *Painting School* (1857), was restored.

The course for older children and women and the course for 6-10-year-old children were introduced during the very first days of the Society's existence. The course for women was taught by Women's Higher School gymnastics teacher Stanislava Višekova (from February 1882), while men practised fencing at Delijska fountain from July 1882 (Trujić, 1976; Petrović, 1983). After two and a half months, Dr Vladan Djordjević replaced general Nikolić as the president of the Society, and over the next ten years he would serve as president on two occasions (1882-1884 and 1889-1891), and once as vice-president (1886-1888) (Ilić and Mijatović, 2006).

Djordjević and Stevan Todorović signed the Statute on the Work of the Society, where they listed the Society's specific goals and the program of activities in five points (Ilić and Mijatović, 2006):

- the physical strength and health of the greatly respected members are to be improved through "systematic physical exercises, going out on picnics, marching, fencing and fighting with pencils";
- "care is to be taken to establish suitable companies throughout the country, which would work on spreading the national consciousness, besides improving physical strength of the people";
- "particular gymnastics classes and practical exercises aimed at members of both sex are to be organised";
- "particular care is to be taken when organising official exercising events, about national games aimed at physical strengthening", and
- "gymnastics teachers are to be trained at the Society's expense".

The Society became ambitious and its program institutionalised. Gymnastics was promoted and the establishment of gymnastic societies in other towns in the Kingdom of Serbia was assisted: in Zaječar and Šabac in 1882, in Smederevo in 1885, in Kragujevac… (Vukašinović et al., 2015). Djordjević joined the difficult endeavour of introducing physical exercising with his duties in the civilian medical service. While calling for the gymnastic societies to be established in other towns he wrote and spoke that the "Serbian youth is becoming more and more malformed, and this can be seen on the recruits from the entire country". Though he held a privileged position, he was devoted to and persistent in his mission. He was known for not having left anyone without an answer. Such devotion and politeness encouraged sports enthusiasts (ibid.).

Djordjević made it possible for the information about gymnastic activities and the experiences of gymnasts to be published in the weekly "People's Health". Belgrade residents sent "Instructions", "Statutes", "Gymnasium Rules" and their membership card forms as evidence of attendance, which was considered a basis for the establishment of the organisation. In this paper, Djordjević published an article titled "Gymnastics for Small Children" (1881). Besides giving their moral and expert support in joint public exercising events, the Belgrade residents also assisted various societies with the purchasing of equipment (Vukašinović, 2016). Djordjević also wrote an article titled "Children's Playground" ("Fröbel's Gardens"). He gave a lecture on this topic in the National Theatre at the second yearly banquet of the Society (1883), and on that occasion, the comedy "A Woman's Tears and Gymnastics", which he wrote a year earlier, was performed (Subotić, 1910).

Over time two gymnastic movements – "Soko" and "Dušan the Mighty" – emerged from the gymnastic "tournament" system, and Djordjević, who considered their rivalry detrimental to the development of gymnastics in Serbia, continued his support of this sport, and later of the Sokol Movement, even though he was no longer directly involved in gymnastic societies. The significance of Djordjević's contribution to the development of gymnastics and the Sokol Movement is immense. With the establishment of the First Belgrade Society for Gymnastics and Martial Arts organised physical exercising was continued after two decades of inactivity in this field, along with the founding of similar civilian gymnastic organisations throughout Serbia, instructing of members on the importance of exercising and training of teachers. That was how the conditions were made for the gymnastic organisation to one day readily adopt the Czech Sokol exercising system, which would, with its further developments, serve as a good basis for the advent and development of modern sports in Serbia (Vukašinović, 2016a).

Time soon showed how visionary Djordjević was in predicting the important role civilian gymnastic societies would play in Serbia in the development and popularisation of physical culture – physical exercising, PE in schools and sport in general. For his contributions to the development of physical exercising in the Kingdom of Serbia, the Sokol Movement representatives in the Kingdom of Yugoslavia granted him the status of the honorary founding member (1938) and proclaimed him "the father of gymnastic societies and a pioneer of the Sokol Movement" (Dragić, 1938).

VLADAN DJORDJEVIĆ, A VISIONARY OF SERBIAN, EASTERN AND WESTERN PROVENIENCE

Medical colonel Dr Vladan Djordjević, the first Serbian surgeon, academic, diplomat, prime minister, minister, politician, scientist, writer, historian, chief of civilian and military medical services, founder of the Serbian Medical Association, the Red Cross of Serbia, Niš Military Hospital, founder of numerous educational and sport institutions, gave much to Serbia towards the end of the 19th and the beginning of the 20th century with his fruitful mission. He was a visionary and an author of inexhaustible energy and spirit, an erudite ahead of his time. He had been elected a regular, correspondent and an honorary member of 17 medical, historical, literary and diplomatic societies in Serbia, Germany, France, Belgium, Switzerland, Spain, Russia and Greece. When he was 25 he was elected to the position of a regular member of the Board for Natural Sciences and Mathematics and the Board for Philosophy in the Serbian Learned Society. In 1888 he was elected a correspondent member for philosophy in the Serbian Royal Academy, and for the regular one in 1892. His list of decorations includes 29 medals, orders and war memorials awarded to him by European emperors, kings and science academies.

Alone, old and ill, Vladan Djordjević passed away on 31 August 1930 in Baden. The people gave this great man, who faithfully followed his passion for work and truth throughout his life, all the while being respectful of himself and his nation, a modest funeral, without publicity or pomp. The residents of Belgrade soon forgot him, as is usually the case among the Serbian people. He wasn't honoured with even a street or an alley being named after him.

Photo 9. Vladan Djordjević at an advanced age

Dr Vojislav Subotić wrote the following about Vladan Djordjević: "I always admired his great mind, superb intelligence, tireless effort, diligence and persistence in work". […] "He was great and mighty, he was attacked and he attacked others, he was respected and hated, sharp with his pen, indomitable in speech – and the most important thing of all – an honest man his entire life" (15 February 1910). Vladan Djordjević wrote this on the last pages of his book "A Minister in Jail": "Imprisonment was the first time in my life that I had nothing to do" […] "If I were to live again I would change absolutely nothing; I would live that new life exactly as this one". […] "Life without all of that would be nothing more than despicable" (1909).

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VLADAN DJORDJEVIC, VIDA Y OBRA DEL ATLETA, CIENTÍFICO, POLÍTICO, ESCRITOR, FUNDADOR DE LA GIMNASIA SERBIA Y DEL MOVIMIENTO SOKOL

Resumen
Vladan Djordjevic pertenecía a una generación de los estudiantes del Liceo de Belgrado, que posteriormente llegaron a ser influyentes trabajadores científicos, culturales, sociales y políticos. Una actividad sin descanso en la vida pública social de Belgrado y del Reino de Serbia, el desempeño destacado de los oficios estatales y las funciones diplomáticas, una imponente obra creativa en medicina, historia y literatura, ponen a Vladan Djordjevic en el mismo tope de las personalidades importantes de la historia de Serbia. Además de los méritos en trazar la vida social, cultural, científica y política de Serbia ha dado una enorme contribución al desarrollo de la cultura física en el Reino de Serbia a finales del siglo 19 y al principio del siglo 20. Como estudiante del Liceo de Belgrado, practicando gimnasia y artes marciales, Djordjevic se hizo amante de ejercicios físicos y se dio cuenta de su importancia para la salud y fortalecimiento del espíritu y se les adjuntó. Djordjevic no podía olvidar este inicio de gimnasia organizada y veinte cuatro años después, como un médico respetable y jefe del Departamento de Sanidad en el Ministerio de Asuntos Interiores, llega a ser el autor de la idea de fundar „una gran sociedad gimnástica en Belgrado con las sucursales por toda Serbia". El desarrollo de la gimnasia en Serbia condicionó dentro de poco la aceptación del movimiento Sokol y la aparición del deporte moderno. El objetivo del trabajo es estudiar y elaborar, aplicando el metido histórico, los documentos auténticos de 1895, 1908, 1910, 1925-1927, 1938, etc., en general desconocidos y no disponibles al público en general y profesional que alumbran las contribuciones multifacéticas del doctor Vladan Djordjevic y sobre todo en la cultura física.

Palabras claves: VLADAN DJORDJEVIC / CULTURA FÍSICA / MEDICINA / LITERATURA / HISTORIA / POLÍTICA / SERBIA

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CREATINE KINAZA AS TRANSIENT MUSCULAR DAMAGE INDICATOR - ANALYZES AND IMPORTANCE FOR TECHNOLOGY OF SPORTS TRAINING

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SUMMARY

Previous research suggests that there is no single marker that would be sufficiently reliable indicator of muscle damage and overtraining. Monitoring several physiological indicators can lead to the desired response. Among them is the creatine kinase serum as one of the best indicators of muscle damage accompanying physical activity. In addition to other properties, it is a direct indicator of muscle damage and overtraining. The aim of this paper is the organization of knowledge published in relevant scientific journals that directly concern creatine kinase and its relation with other markers, as well as the limit of its use. By measuring the level of creatine kinase before and after exercise, the existence of myopathy without muscle biopsy can be predetermined, which is one of the most important functions of this serum. In the future, research should include other factors that indicate muscle damage and overtraining, their synergistic activity, and new findings in assessing transient muscle damage due to physical activity.

Keywords: CREATINE KINAZA / PREVENTION / DAMAGE OF MUSCLE / SPORT

INTRODUCTION

Location of creatine kinase (CK) is in the sarcolemma and mitochondrial intermembrane space of healthy muscle cells. CK catalyzes the movement of phosphate from phosphocreatine to adenosine diphosphate, forming adenosine triphosphate (ATP) and creatine (Anugweje, Okonko, 2012). When we talk about isoforms, there is a several isoforms of CK: three isoenzymes in the cytoplasm (CK-MM, CK-MB, CK-BB), and two isoenzymes in mitochondria.

The best indirect indicator of muscle damage is serum enzyme activities of creatine kinase, which leads to damaged muscle circulation (Brancaccio at all., 2010, Nigro et al., 1983). When we talk about sport and physical activity, the concentration of serum creatine kinase is one of the main indicators of damage skeletal muscles (Mougios, 2014). In response to a physical activity, even though the serum CK varies among individuals, its blood level is certainly widely used as an indicator to reflect the muscle breakdown (Heled et al., 2007). Muscle damage due to physical activity characterized by delayed onset muscle soreness [DOMS], increasing the level of muscle protein in the blood and reduced muscle function, especially in people who are not on the level of given training (Gomes et al., 2014).

The first characteristic of muscle disorder is pain, fatigue, weakness, and increases in serum CK (Brancaccio et al., 2010). High CK level can be produced by many factors: alcohol, heat, dehydration, drugs, stress and crush trauma (Clarkson et al., 2006). On the other hand, there is a possibility that the CK response after physical activity depends on personal abilities and training background. Therefore, the focus of investigation should be correlation between serum CK level following the exercises and body structure and other characteristics of the individual (Fehrenbach et al., 2010).

Previous studies were based mainly on long-distance runners and most activity data CK coming analyzing these athletes, although it has been estab-

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lished that short intensive interval activities stimulate growth in serum CK, especially if it is an eccentric muscular contraction (Fehrenbach et al., 2010). High serum levels of CK is the result of cracking sarkolemal membrane and has been correlated with the extent and intensity of exercise, and is related to the severity of muscle soreness (Brancaccio et al., 2010).

FACTORS THAT DETERMINE THE DYNAMICS AND INTENSITY OF CREATINE KINASE SERUM

The level of CK activity depends on the sex, muscle mass, volume and intensity of exercise, as well as the individual physical condition (Malaguti et al., 2009). In a study of CK level in trained and untrained individuals, it was higher in people who were trained, regardless of sex and age (Heled et al., 2007). There are gender differences in the level of CK at rest, where more enzymes are observed in men. Lower values in women appear after exercise, which, according to some studies, is the result of estrogen that prevents leakage of serum CK from damaged muscle (Haramizu et al., 2011).

Some research suggests that there is a difference in the oxidative stress and antioxidant protection during aging. In examining the effect of exercise on the level of CK in the elderly, the results indicate that exercise in the elderly increases the level of markers that induce muscle damage, as well as markers of oxidative stress (Brancaccio et al., 2007), therefore elderly people are not equally subject to muscle damage compared to young people (Newham et al., 1987).

In the newborn, CK serum levels are higher than those in adults and are dependent on gestational age, with values that reach adult levels within the first 10 days of life (Clarkson et al., 2006). In early pregnancy, the level of CK is increased in order to reduce the period of late pregnancy, however, remain high levels of CK-MB (Brancaccio et al., 2007).

Young adult males have high serum levels of CK, which decline slightly with age during the geriatric period (Brancaccio et al., 2007).

In relation to race, black men has higher CK levels compared to Caucasians, although some studies have shown that there are no racial differences in the level of CK in athletes, despite the fact that black people generally tend to and have a higher density of bones than white people (Brancaccio et al., 2007).

Therefore, the values of CK show great variability among individuals. Some athletes have lower reactions to physical activity with chronic low serum CK levels. Other athletes have a high level of response with higher values of this enzyme. There is a breaking point at a CK concentration of 300-500 IU / l when it is released into the blood after physical activity. The level of CK enzyme depends on muscle characteristics (Brancaccio et al., 2007). Schumann and Klauk (Schumann, Klauke 2003) proposed the limit values of CK which are 350 in men and 200 IU / l in women. The second study shows different limits for men, 391 and 398 IU / l and 240 and 207 IU / l for women (Mougios, 2007). The main difference between the results of individual studies is probably due to the different level of training of the respondents, as well as athletes of different sports branches and disciplines involved in the research. Namely, if athletes and non-athletes are doing the same physical activity test, the serum level of CK athletes is lower than those observed with the control group of non-athletes (Nigro et al., 1983, Anugweje, Okonoko, 2012). Also, a large increase in serum CK levels combined with reduced tolerance to effort can be a marker of overtraining (Anugweje, Okonoko, 2012). The release time of CK depends primarily on the level of training, type, intensity and duration of the activity. After prolonged exercise, activity of total serum CK increases significantly during the 24 hours after exercise. However, if an athlete continues to practice, the level of CK may remain much longer (Clarkson, Hubal, 2008). The highest values of serum CK occur 8 hours after power training.

CREATINE KINASE IN ATHLETES OF VARIOUS SPORTS BRANCHES AND DISCIPLINES

High serum CK was observed after long-term physical activity such as ultramarathon (Fehrenbach et al., 2010), Ironman triathlon (Neubauer et al., 2008) and triathlon (Brancaccio et al., 2010), where after these activities it is inevitable muscle collapse. Ultratriatlon is associated with high changes in CK activity (54 to 1849 IU / l), as well as changes in other markers of muscle damage (Gastmann et al., 1998). Most of the serum CK monitoring data comes from long-bugs, but there are also studies that show that

the short physical activity of an eccentric type of muscle contraction increases the level of CK (Brancaccio et al., 2007).

Mougios and colleagues (Mougios et al., 2007) measured CK activity in footballers and swimmers, where the lowest reference level for footballers was 83 IU / l, while for swimmers it was about 70 IU / l. The upper limit was in the order of 1492 and 523 IU / l.

Major changes in the CK as a marker of muscle damage (~ 900 IU • l^{-1}), as well as a fall after 20 meters of the sprint test (-2%) and a maximum jump (-10%) after 24 hours of the match, was observed in elite young football players (Fatouros et al., 2010). There was also a significant increase in CK activity (~ 1000 IU • l^{-1}), after the rugby match (Takarada, 2003). In the study of Hovatson and Milak (Howatson, Milak, 2009), the conditions of muscle inflammation and activity of CK (~ 800 IU • l^{-1}) are monitored, 24 hours after 15 sprints at 30 meters in young athletes. Moreira and colleagues (Moreira et al., 2014) in their study suggest that the analyzed basketball game leads to small muscle inflammation and there is no significant release of proteins from the muscle after that. These data can also indicate that top athletes are resistant to large CK oscillations and possible transitional damage to the muscles. Gil and colleagues (Gill et al., 2006) followed rugby players and found that the level of CK before and after the match was very high, in the order of 1023.0 (308.3) and 2194.0 (833.7) IU / l. Negative consequences of muscle damage in tennis players with reduced production of strength were also noted, which can affect performance during the match (Gomes et al., 2014). The highest values of each player in the study ranged from 105 to 498 IU • l^{-1}, and a significant increase in plasma CK activity was recorded 24 hours and 48 hours after the match.

LEVEL OF SERUMA CK - CHALLENGE FOR SPORTS AND TECHNOLOGY OF TRAINING

In order to increase exercise performance and reduce muscle damage, studies and research try to figure out the most effective way to recover the body after physical activity. For that purpose, there are numerous supplements and methods that have been found in practice, with or without justified reasons.

Hydration state and creatine kinase

There are numerous studies related to the use of liquids during the training process (water, juices, energy drinks), as well as studies dealing with the effect of dehydration on the body and physical performance. Ozkan and Ibrachim (Ozkan, Ibrachim, 2016) examined whether there is a difference between wrestlers that are and which are not dehydrated and found that there is a high serum CK in the dehydrated group, which had a negative impact on muscle pain performance. The second study examined the consumption of green tea during exercise and concluded that green tea is an excellent antioxidant, and that it reduces the release of CK during exercise (Kuo et al., 2015). By consuming black currant juice after high-intensity training, it reduces damage and muscle inflammation by reducing CK 48 to 96 hours after exercise (Hutchison et al., 2016). Consumption of electrocytically modified water significantly reduces muscular damage caused by exercise and accelerates recovery (Borsa et al., 2013).

Supplementation and creatine kinase levels

One of the supplements in the reduction of muscle damage, and therefore the level of serum CK activity, which is widely used in recovery after high-intensity activities is creatine (Kim et al., 2015). A combination of amino acids supplements from the group BCAA (branched chain amino acid) and taurine, as well as preparations from the group of anti-inflammatory and antioxidant acids, can be an effective means of delaying muscle inflammation and muscle damage (Ra et al., 2013). On the other hand, the same authors concluded that the addition of taurine alone does not affect the level of CK in healthy individuals after exercise. Fouré and colleagues (Fouré et al., 2010) found that the damaged muscle was unable to take advantage of the BCAA consuming after exercise. Also, another study concludes that supplements with amino acids before and after 100 kilometers of ultramarathon also have no effect on serum CK levels (Knechtle et al., 2011). Consumption of curcumin increases the strength and duration of exercise and reduces the level of CK after physical activity (Huang et al., 2015), also relieves muscle inflammation, which is associated with a lower blood CK (Nicol et al., 2015) and reduces muscle damage to the syringes induced exercise (McFarlin et al., 2016). Supplementation of the saffron (10 days for 300 mg) also has a preventative effect on muscle inflammation and significantly

reduces the concentration of CK, and 4 grams of ginger after exercise simplifies the recovery of the body, but does not affect the damage and delay of muscle inflammation (Matsumura et al., 2015).

Cryotherapy and creatine kinase

According to recent research, the treatment of dipping in cold water has no effect as previously thought. Takeda and colleagues (Takeda et al., 2014) did not find that cold water has an effect on the level of CK after rugby and football match. Immersion in cold water immediately after 24 hours did not influence the observed indicators of physical performance (Rupp et al., 2012), that is, only the immersion of the body follows minimal effects on the deposition of muscle inflammation (Glasgow et al., 2014). However, Machado and colleagues (Machado et al., 2016) indicate that immersion in the water temperature between 11 and 15 ° C for a time of 11 to 15 minutes may have an effect.

Creatine kinase and effects of massage and vibration therapy

There is no clear record of the effects of massage in combination with hypoxia compared to using only massage at the CK level after a football game (Gatterer et al., 2013). Whole-body vibration therapy after exercise shows lower pressure, pain and muscle inflammation with less reduction in maximal isometric and isokinetic muscle strength and lower blood creatine kinase levels (Veqar, Imtiyaz, 2014). In contrast, vibration therapy is not more effective than standard massage and stretching when it comes to the level of CK after exercise (Fuller et al., 2015).

OTHER MARKERS AND MUSLE DAMAGE

Considering previous research and findings, we can conclude that there is no single marker that can be considered an indicator of damage and overtrain. Because of that investigators recommend using more than one marker to provide the answer. Creatine kinase, lactate dehydrogenase, aldolase, aspartate transferase myoglobin, troponin and carbonic anhydrase are the most useful serum markers of muscle injury (Brancaccio et al., 2010). The more markers you consider, you get more precise results.

Serum lactate dehydrogenase (LDH) activity is a marker of cell damage, and it increases in isoenzymes may be useful for the diagnosis in non-traumatic acute rhabdomyolysis (Brancaccio at al., 2010).

Aldolase can be used in conjunction with CK to assess the condition of adaptation muscles in training (Brancaccio et al., 2010). In chronic muscular injuries, both aspartate transferase (AST) and alanine aminotransferase (ALT) (Nathwani et al., 2005) have been increased and is rarely increased in non-sick people and having normal CK activity, suggesting the existence of AST macroenzymes Cabrera-Abrev et al., 2008).

In some athletes, the increase in serum AST should be considered together with the activity of CK (Brancaccio et al., 2010). Mioglobin is a useful marker for monitoring the efficacy of muscle tissue loading at training (Speranza et al., 2007).

Studies have found that in myopathy, there is a close correlation between TnT (one of two troponin isoforms) and CK (Collinson et al., 1995). In patients with chronic muscular disease, the concentration of TnT (Prellwitz et al., 1996) increased.

Carbonic anhydrase III is another useful marker of muscle damage because it is present in the skeletal muscle but not in the myocardium and is released into the bloodstream after injury (Fu et al., 2009). Increasing and decreasing its concentration is faster than in aldolase, CK, AST and LDH (Shima, 1984). Whatever marker is taken into consideration, complementing one or more of them will only show more accurate results, since none of them, by itself, is sufficient to reliably conclude.

LIMITATIONS IN THE APPLICATION OF CREATINE KINASE MONITORING RESULTS

In the diagnosis of diseases of the brain, heart and muscle activity, CK is widely used as a marker of possible disease condition (Brancaccio et al., 2006). In normal conditions, in the serum of skeletal muscle there is only CK-MM, CK-BB is mostly found in the brain and, CK-MB is cardiac isoenzym. On the other hand, there are cases when other enzymes, beside CK-MM, can be found in skeletal muscle, such as CK-MB in ultramarathon runners (Denvir at al., 1999) and CK-BB in boxers (Brancaccio et al., 2007). The CK level grows 6 hours after exercise and can stay

elevated and two days after exercise. If after these periods the presence of these isoenzymes in the muscles continues to be, it is about some nonphysiological condition. Some people who have very high levels of CK after exercising may have some kind of muscular disease requiring additional analysis. Increased levels of CK levels in healthy non-athletes require further research (Brancaccio et al., 2006).

The level of CK can also be elevated by drug consumption, asthma, hypothyroidism, the use of anabolic steroids (Dekkers et al., 1996). If there is an increase in CK levels and atypical symptoms, muscle biopsy is the best way of diagnosis. So far, it has determined that: 18% of these patients suffer from muscular disease, almost 39% have atypical muscular anomalies, while the rest of the subjects were of normal health (Stanhouders et al., 1999). One of the most important role of creatine kinase is the fact that monitoring its level before and after exercise can point to myopathy and without muscle biopsy, which is a far more invasive method (Brancaccio et al., 2010). However, the increase in serum levels of the CK does not necessarily result from exercise and damage to muscles caused by exercise. On the other hand, there are athletes who do not have any symptoms of applied sports activities. By increasing the intensity and volume of exercise, such athletes can be accessed, but in this case there is a possibility of a negative effect of prolonged exercise and training in the form of loss of muscle proteins (Brancaccio et al., 2006).

NEW INDICATORS IN ASSESSMENT OF TRANSIENT MUSCLE DAMAGE

New discoveries should go in the direction of more precise detection of muscle damage, finding a faster, more accurate, discriminatory and specific marker that would be affordable, easily measurable and inexpensive, whose measurement indicates only transitional damage to the muscles without linking with possible pathological conditions organism. The practice lacks a marker that would be efficient and with a lower amplitude of measured values, as is the case so far (Brancaccio et al., 2011). Such a marker should indicate differences in gender, individual differences and the same differences regardless of which part of the body is subjected to physical activity (Koch et al., 2014). In view of this, an accurate and unified measurement protocol should be defined, which has not been the case so far. One of the future markers, which is in the process of research and detection and which could replace the rest of the known markers of muscle damage, is gonidine acetic acid (GAA). As a natural creatine precursor, in the conditions when creatinine availability is undisturbed, the role of GAA as a substrate is negligible, while, on the other hand, in the case of creatine deficiency, it can fully saturate creatine kinase and act as a replacement phosphagen (Ostojić, 2015). The results of the study that examined the impact of endurance training (treadmill training) and repetitive strength training (benchmark-to-failure) on the level of GAA and creatine obtained results suggest that creatine levels increased in both types of exercise, especially when running, as and that the concentration of GAA dropped significantly in both cases, more in running training (Steier et al., 2016). The conclusion of this study is precisely that in the future the serum level of GAA can be used as a new fatigue biomarker in the physically active population.

CONCLUSION

Creatine kinase (CK) is one of several markers of muscle damage caused by exercise. The CK level remains raised 24 hours after exercise, after which it returns to the initial level. If, after that time, it continues to be elevated, it is probably overtraining. In addition, muscle damage may occur after physiological and pathological conditions. A better evaluation and a compact picture of the muscle state give a blood test and urine.

The level of creatine kinase depends on a number of factors, such as sex, race, body weight, physical activity, etc. A high level of CK in healthy people is mainly associated with training.

The highest values of CK were found mainly in longrunners and long training, such as ultramaratone, activities that require eccentric muscle contraction.

The assessment of CK before and after physical activity is a "diagnostic tool" for the detection of myopathy, which is far less invasive than necessary for muscle biopsy. This is probably the most important use of serum creatine kinase for diagnostic purposes in sports and physical activity.

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CREATINA QUINASA COMO INDICADOR DEL DAÑO TRANSITORIO DE LOS MÚSCULOS – ANÁLISIS Y SIGNIFICADO PARA LA TECNOLOGÍA DE ENTRENAMIENTO DEPORTIVO PRINT-A-MAIL

Resumen
Las investigaciones de hasta el momento demuestran que no existe un marcador único que sería el indicador suficientemente fiable del daño muscular y de sobreentrenamiento. Seguir varios indicadores fisiológicos puede llevar hasta la respuesta deseada. Entre ellos está también el suero de creatina quinasa como uno de los mejores indicadores del daño muscular que acompaña la actividad física. Además de otras características, ella es el indicador directo del daño muscular y de sobreentrenamiento. El objetivo del presente trabajo es organizar los conocimientos publicados en las revistas científicas relevantes, referidos directamente a la creatina quinasa y sus vínculos con otros marcadores, así como también, el límite de su uso. Midiendo el nivel de creatina quinasa antes y después de los ejercicios se puede predeterminar la existencia de miopatía sin la biopsia del musculo, lo que es una de las funciones más importantes de este suero. En el futuro, las investigaciones deberían abarcar también otros factores que indican los daños musculares y sobreentrenamiento, su actividad sinérgica, pero también nuevos descubrimientos en la estimación de los daños musculares transitorios por la actividad física.

Palabras claves: CREATINA QUINASA/ SOBREENTRENAMIENTO/ DAÑO MUSCULAR /DEPORTE/ TECNOLOGÍA DE ENTRENAMIENTO

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SOCIAL SUPPORT AND PHYSICAL ACTIVITY LEVEL OF ELEMENTARY SCHOOL STUDENTS

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Abstract
The aim of this research was to determine whether differences among elementary school students of both genders in levels of physical activity in relation to their individual perception of different social support domains are present. 165 fifth graders participated in this research (88 girls and 77 boys). Social Support Scale for Children, SSSC (Harter, 1985) which consists of four subscales: 1. social support of parents; 2. social support of peers; 3. social support of teachers; and 4. social support of close friends, was administered and used. Evaluation of the level of physical activity has been assessed via the questionnaire method which was based on self-evaluation and self-perception of levels of physical activity by applying the International Physical Activity Questionnaire (Craig et al., 2003). Results of multiple regression analysis show that the system of prediction variables of specific domain of social support has a statistically significant influence on strenuous physical activity levels of boys. Social support of close friends has displayed itself as the absolute best predictor on their strenuous and total physical activity. Statistically significant influence of system of prediction variables on any type and level of physical activity hasn't been noticed among girls. By observing the influence of certain variables of social support social support from parents has the strongest influence on moderate level of physical activity among girls. This research paper contributes to the identification of factors which influence the participation level of students in physical activity programs. The goal of this research paper was to contribute to the development of fruitful strategies and interventions which will ensure motivation and enjoyment in physical activity participation.

Key words: SOCIAL INFLUENCE/SOCIAL PERCEPTION/TYPES OF PHYSICAL ACTIVITY

INTRODUCTION

The literature shows that social support correlates well with positive social and emotional outcomes in youth. These outcomes are as follows: self-confidence, self-concept, social skills and relationship with parents, teachers and their peers (Demaray, Malecki, Davidson, Hodgson, & Rebus, 2005). Social support is connected with lowers levels of troublesome behavior, drug abuse, bullying, insults and violence (Davidson & Demaray, 2007). Great number of research points out to the fact that support from parents and peers is positively correlated with higher levels of physical activity among youth (Gustafson, & Rhodes, 2006; Hohepa, Scragg, Schofield, Kolt, & Schaaf, 2007; Pugliese, & Tinsley, 2008; Heit; Woolger, & Power, 1993; Weiss & Hayashi 1995; Woolger & Power 1993; Brustad, 1996; Dowda, Dishman, Pfeiffer, Pate, 2007; Brustad, 1993; Eccles & Harold, 1991; Weiss & Hayashi, 1995), while on the other side of the spectrum, negative attitudes and behavior of parents has a negative correlation with the childs level of enjoyment and feelings of pleasure in physical activity participation. (Omundssen & Vaglum 1991; Scanlan & Lethwaite 1988; Anderssen, & Wold, 1992).

According to the results of one research study (Horst, Paw, Twisk & Mechelen, 2007), inter-relationship between social support and the level of participation in physical activity is strongly influenced by the age of the student. For example, research studies point out that among 4 to 12 year olds, factor that most strongly influences the level of physical activity participation is the social support of parents. In 13 to 18 years old adolescents, factor that most strongly influences the level of physical activity participation is the social support of friends and family (Allender,

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Cowburn, & Foster, 2006). This is confirmed by other authors, which indicate that children mature, spend more and more time with friends in relation to their family, and become more and more importantly their social support of their peers and friends (Beets, Vogel, Forlaw, Pitetti, & Cardinal, 2006; Voorhees, Murray, Welk, Birnbaum, Ribisl, Johnson, Pfeiffer, Saksvig & Jobe, 2005).

A better understanding of physical activity determinants could lead to the development of more efficient strategies in promoting physical activity, and such efforts could potentially lead to an improvement of current and future health status of the youth. Therefore, the main purpose of this research was to determine which specific domains of social support pose the strongest influence on different levels of physical activity among participants of both genders. Taking into consideration the results of previous research studies, as well as the goals of this research paper, a fundamental hypothesis has been set, according to which a prediction of different types of physical activity levels of elementary school students based on specific domains of observed social support is possible, and in addition that it is possible to stimulate them with a specifically geared influence of "significant others"

METHOD

Sample of participants consisted of n=165 fifth graders of elementary school, out of which n=77 were boys and n=88 girls. From the total number of participants (n=165), n=97 students were attending primary school "Prva Vojvodjanska Brigada", and n=68 students were attending primary school "Dositej Obradovic". Both school are located in the city of Novi Sad, Serbia.

Data of overall physical activity levels was obtained via the questionnaire method, which is based on self-evaluation and self-perception of the level of physical activity via the application of International Physical Activity Questionnaire (IPAQ, Craig et al., 2003). This questionnaire contains 7 questions about specific types of physical activity, while using the last 7 days as a reference period. The following specific physical activity types were estimated are walking, moderate physical activity, strenuous physical activity as well as sedentary activity. Total score, that is the total level of physical activity is calculated based on the first three variables (except sedentary). For each type of activity participants entered data which are related to physical activity duration (expressed in minutes) and the number of days per week when they were active, after that depending on the level of physical activity, each physical activity type was awarded with an appropriate MET (metabolic equivalent) number. This way the scores were obtained for walking, moderate and vigorous physical activity which were expressed in MET/min/week.

For the evaluation of social support, the Social Support Scale for Children, (SSSC) (Harter, 1985) was used. This instrument consists of four subscales; each subscale further consists of six claims. Each claim is formulated as a complex, bipolar sentence. The examinee has to determine whether a left or right part of the sentence better describes him or her; concurrently the examinee should evaluate whether that description fully relates and describes him or her or just partially in a certain part of the sentence. The score on each subscale represents an arithmetic average of the response on individual claims which are scored on a four level scale, where number 1 represents the lowest level of observed social support, and 4 represents the highest. The applied measurement instrument is designed and intended for evaluation of four distinct and separate specific levels of observed social support. Therefore SSSC consists of the following subscales:

Social support of parents – refers to the degree in which parents understand their children, have a desire to hear their problems, take care of their feelings and emotions, treat them as important and valuable people (e.g. *certain children have parents which do not have a desire to listen to their children's problems*, but *other children have parents that are willing to listen to their problems*).

Social support of classmates – refers to the degree of interpersonal relationship and acceptance of the child from his or her classmates (e.g. *certain children have friends in a class with whom they can be friends with,* but *other children do not have any friends in the class with whom they can be friends with*).

Social support of teachers – refers to the degree in which teachers help children when they are upset, how they motivate them to give their maximal effort, how they take care of them and treat them as valuable, and equally important people (e.g. *certain children have a teacher that treats them as an individual valuable person,* but *other children do not have a teacher which treats them as an individual valuable person*).

Social support of close friends – refers to the fact whether a child has close friends with whom he or she can have a conversation about his or her problems, which truly understand them, whom they can complain to about things which are bothering them, and which truly listen to what they have to say (e.g. *certain children do not have close friends that truly listen to what they have to say,* but *other children have close friends which listen to what they have to say*).

In addition to the basic indicators of descriptive statistics, a series of regression analyzes were used to obtain data of which specific domains of observed social support pose the greatest influence on different types of physical activity among participants of both genders. All of the data was analyzed with a statistics package Statistical Package for Social Sciences (v.19.0, SPSS Inc., Chicago, IL, USA).

RESULTS

Basic descriptive determinants of the level of social support of children of both genders can be seen in Table 1.

Table 1. Social support of students of both genders
(values of descriptive statistics and t-test for independent sample)

	Boys		Girs			
Support source	M	SD	M	SD	t	p
Parents	3.48	.45	3.66	.33	-2.88	.00
Classmates	3.14	.59	3.27	.50	-1.48	.14
Teachers	2.92	.59	3.12	.51	-2.34	.02
Close friends	3.36	.53	3.55	.50	-2.37	.02

It can be seen from Table 1 that girls show a more favorable observation of the social support in all domains compared to boys. Girls rate social support of parents with the highest scores, after that social support from close friends follow, after which social support from classmates comes, whilst the lowest level of social support which girls remark to as important is the social support of teachers . In boys the most important source of social support comes from their parents, social support from close friends falls into second place, after which social support from classmates and teachers follow. Results of the t-test for independent sample in an observed level of social support from parents, teachers and close friends outside of school show statistically relevant differences between genders in favor of girls.

Results of regression analysis are presented in the next section with an objective to questions to the total and individual influence of system of predictive variables on different physical activity types for boys (Table 2) and girls (Table 3)

Table 2. Influence of different domains of social support
on different types of physical activity among boys

Support source	**Walking**		**Sedentary phsical activity**		**Moderate physical activity**		**Strenuous physical activity**		**Total physical activity**	
	β	p	β	p	β	p	β	p	β	p
Parents	.24	.06	-.05	.66	-.07	.58	.00	.99	.03	.81
Classmates	.11	.35	.08	.52	.12	.31	-.19	.10	-.01	.90
Teachers	.01	.91	.18	.16	-.12	.36	-.32	**.01**	-.26	**.05**
Close friends	-.05	.74	-.05	.70	.24	.09	.27	**.04**	.29	**.04**
	R = .27, R^2 = .07, p = .22		R = .19, R^2 = .04, p = .62		R = .25, R^2 = .06, p = .31		R = .34, R^2 = .11, p = .05		R = .28, R^2 = .08, p = .21	

By measuring the influence of specific domains of observed social support of student as predictors of different activity types, the predictor system has showed as statistically significant in relation to strenuous physical activity (R=.34; p=.05).

By observing the individual influence of each domain of observed social support, the most significant influence among girls on strenuous physical activity the observed social support of close friends had the greatest influence (β = .27, p = .04) and teachers (β = -.32, p = .01), while the observed osical support of teachers has a negative influence on strenous physical activity od boys. By observinng the toatl levleo f physical actiity, teachers (β = -.26 , p = .05) and close friends (β = .29 , p = .04) also have a statistically significant influence. Obtained results point out to the fact that all analyzed domains of social support among boys explain only 7% of variance in walking variable, 4% of variance in variable sedentary physical activity, 6% of variance in moderate physical activity, 11% of variance in strenuous physical activity and 8% of variance in total physical activity.

Table 3. Influence of different domains of social support on different types of physical activity among girls

Social source	Walking		Sedentary physical activity		Moderate physical activity		Strenuous physical activity		Total physical activity	
	β	p	β	p	β	p	β	p	β	p
Parents	.22	.07	.19	.11	.28	**.02**	-.28	.06	.07	.58
Classmates	.01	.89	.11	.38	-.11	.39	.09	.47	.00	.96
Teachers	.00	.97	.02	.82	.15	.21	.18	.14	.19	.14
Close friends	.06	.66	-.23	.10	-.09	.50	.08	.56	.02	.88
	R = .26, R^2 = .07, p = .19		R = .23, R^2 = .05, p = .32		R = .32, R^2 =.10, p = .06		R = .27, R^2 = .07, p = .17		R = .24, R^2 = .06, p = .27	

By observing the influence of specific domains of observed social support of girls on difference types of physical activity (Table 3), it can be seen that the system of predictive variables hasn't showed as statistically significant in any of the physical activity types. Taking into consideration the isolated influence of different domains of observed social support, the observed social support of parents has showed as statistically significant predictor of moderate physical activity levels among girls (β = .28, p =.02). Obtained results point out to the fact that all analyzed domains of social support among girls explain only 7% of variance in walking variable, 5% of variance in variable sedentary physical activity, 10% of variance in moderate physical activity, 7% of variance in strenuous physical activity and 6% of variance in total physical activity

DISCUSSION

Based on previous research studies that have documented the levels of importance that social support plays in total physical activity levels, present study had the goal to examine relations between certain types of physical activity and specific domains of social support in youth population (12 year olds). Specific domains of social support were the following: social support of parents, social support of classmates, social support of teachers, and social support of close friends.

In relation to gender, the results of this research indicate that girls show a better observation of special support in all domains compared to boys, which is in congruence with previous research (Bokhorst, Sumter & Westenberg, 2010). In connection with that, it has been proven that in the initial childhood period, girls show a tendency of developing more intimate peer relationships which are based on trust (Belle, 1989; Maccoby, 1966; Wheeler & Nezlek, 1977), whilst boys show a tendency to base their friendships on mutual interests including physical activity (Ervin, 1985). Researchers also point out that females have a better social support perception in general during all life periods (Demaray & Malecki, 2002; Frey & Rothlisberger, 1996; Jackson & Warren, 2000; Malecki & Demaray, 2003).Obtained data are in congruence with the results of previous research studies which also confirm the presence of gender differences in relationship

with parents during adolescence. Girls generally report higher levels of social support as compared to (Armsden & Greenberg, 1987; Furman & Buhrmester, 1992) boys. Girls have less or less intense contacts, while boys develop an extensive social network, which is in great part based on superficial relationships (Bryant, 1994; Vondra & Garbarino, 1988).

Previous research confirms that females evaluate themselves in an unfavorable fashion when it comes to physical self-concept in comparison to boys, that is, when talking about physical appearance and the competency to play and participate in sports (Ommundsen, & Vaglum, 1991; Weiss, & Chaumeton, 1992). Boys show a more favorable perception of oneself when self-worth is taken into consideration, and especially when they estimate their own physical appearance and competency to play sports. Therefore, it can be concluded that boys show a lower expression of needs in comparison to girls for social support from family, school, teachers, coaches, etc. (Harter, 2001).Among boys, social support stimulates involvement in sports more compared to girls. It is expected from boys to be strong and active, and are therefore directed towards playing sports, in which they form and perfect their motor abilities (Neisen, Braun, & Shepherd, 2007)

Longitudinal studies that were carried out in United States of America also show that a lower level of observed family social support for physical activity participation among elementary school student was connected with a sudden decrease of level of physical activity during high school period of education (Dowda, Dishman, Pfeiffer, Pate, 2007). This points out to a conclusion that boys have a better self-perception and self-estimation of themselves in physical domain, which further leads to their greater participation in physical activity programs.

The answer to a research question on how the analyzed domains of observed social support influence the different types of physical activity of participants was obtained by the application of multiple regression analysis. Obtained results of this research point out to the fact that analyzed domains of observed social support have a statistically significant influence on strenuous physical activity among boys. By observing the isolated influence of each of domains of observed social support, the observed social support of close friends had the greatest influence on strenuous physical activity among boys. Positive influence of close friends on strenuous physical activity of boys can be explained by the fact da boys have a greater tendency to form friendships based on mutual interests, including physical activity, in contrast to girls which form even closer and more intimate friendships that are based on trust (Erwin, 1985). Perhaps during participation in different activities, competitive relationships with peers are more important to boys, while girls tend to develop more intimate relationships, group interaction and communication, and therefore social support and understanding of parents and friends is more important to them (Brajša, Žganec, Raboteg, Šarić, & Franc, 2000).

Observed social support of teachers has a negative effect on strenuous physical activity of boys. This negative effect of observed social support of teachers can be explained by the fact that physical education classes are usually geared toward program standards of achievement and comparison of boys-girls based on achieved results in pedagogical activities, and not on offering positive feedback and creation of everyday environment which will allow the children to feel motivated, to be confident and to enjoy in physical activity participation (Weiss, 2000).

Observing the influence of specific domains of observed social support of girls on different types of physical activity, no statistically significant influence on any of the physical activity types has been observed. Taking into consideration the isolated influence of different domains of observed social support, the observed social support of parents has a positive influence on moderate physical activity participation among girls. Parental support can be especially important for girls because it was shown that parental encouragement and participation in physical activity influence the patterns of activity to a greater degree in girls as compared to boys (Fogelholm, Nuutinen, Pasanen, Myohanen, & Saatela, 1999; Myers, Strikmiller, Webber & Berenson, 1996; Trost, Pate, Saunders, Ward, Dowda, & Felton, 1997). Longitudinal studies carried out in United States of America, also point out that the lower level of observed social support of the family for physical activity participation among girls of elementary school was connected with a sudden and dramatic drop of physical activity participation during their high school education period (Dowda, Dishman, Pfeiffer, & Pate, 2007). Obtained results of this research have refuted the hypothesis that observed domains of social support have a significant influence on different types of physical activity among participants.

As far as the possible limitations of this research paper are concerned, characteristics of the measuring device for physical activity participation could be brought into question. It is possible that with the application of certain more objective parameters, a more authentic evaluation of everyday physical activity, such as pedometers in combination with monitoring, more relevant data could be obtained in relation to different physical activity types, which could further give a different picture of relation of observed social support and physical activity among students. In other words, physiologic scope could portray a slight different image of relations between perceived social support and the level of physical activity of students. Considering that the data obtained for this research was gathered by only examining a single age group, comparing it with results of other research papers which contained a sample of different age groups might present a good direction in future research of similar problems.

Benefits of continuous, regular physical activity participation in its broadest sense represents an underutilized potential of enhancing psycho-social functioning of the youth. Active children become active adolescents and adults, and therefore they represent the target group which should be motivated to participate in physical activity. Identification of factors and special needs that influence participation levels of children in physical activity program present a key factor for developing strategies and interventions with a goal of creating everyday environment which will potentiate motivation, self-confidence and enjoyment in physical activity. It is these positive perceptions and emotions which present the key for resolving problems of children's motivation for physical activity participation.

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APOYO SOCIAL Y LA ACTIVIDAD FÍSICA DE LOS ALUMNOS DE LA ESCUELA PRIMARIA

Resumen
El objetivo del presente trabajo es analizar si existen las diferencias en el nivel de la actividad física de alumnos y alumnas en dependencia de su percepción de distintos alcances del apoyo social. En la investigación participaron en total 165 alumnos del quinto grado de la escuela primaria, y de ellos 88 alumnas y 77 alumnos. Se aplicó la Escala de Apoyo Social para Niños (Social Support Scale for Children, SSSC; Harter, 1985) que contiene cuatro sub-escalas que son: el apoyo social de los padres, apoyo social de los compañeros del aula, apoyo social de los enseñadores y el apoyo social de los amigos cercanos. Los datos sobre la actividad física de los alumnos se obtuvieron aplicando el Cuestionario Internacional de Actividad Física (International Physical Activity Questionnaire, IPAQ; Craig et al., 2003), basado en autoevaluación de la actividad física. Los resultados del análisis de regresión múltiple indican que el sistema de variables predictoras de dominios específicos del apoyo social notado tiene estadísticamente una influencia importante sobre la actividad física intensa de los alumnos varones. El apoyo social de los amigos cercanos se ha mostrado como el factor que influye más en su actividad física intensa y total. En las alumnas no se ha notado una influencia estadísticamente importante del sistema de variables predictoras sobre ninguno de los tipos de actividad física. Observando la influencia de algunos variables de apoyo social, el apoyo social de los padres tiene la mayor influencia en una actividad física moderada de las alumnas. El presente trabajo representa una contribución a la identificación de los factores que influyen en la participación de los niños en la actividad física con el fin de desarrollar unas estrategias e intervenciones efectivas que posibilitarán la motivación y disfrute en la actividad física.

Palabras claves: INFLUENCIA SOCIAL / PERCEPCIÓN SOCIAL / TIPOS DE ACTIVIDAD FÍSICA

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RELIABILITY OF MEASURING VARIOUS CONTRACTILE FUNCTIONS OF FINGER FLEXORS OF MEN OF VARIOUS AGES

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ABSTRACT
The aim of the research is to determine the reliability of testing various contractile functions of a male hand based on motoric and functional dominance and age. The examinee takes a seat with their arm extended or mildly flexed in a mildly abducted position. For the measuring purposes, dynamometric probe with isometric straining conditions fixed to a special construction was used. The "*Isometrics*" (ver. 3.1.1) was used and frequency of data selection was realized on the level of 500 Hz. The sample includes 269 male examinees aged from 14.0 to 69.9. The results of descriptive statistics have shown that in relation to the tested sample for the non-dominant hand, values for maximum force (F_{max}) range from 462.8 to 529.0 N, for explosive force (RFD_{max}) the range is from 1621.6 to 1972.8 N/s and for muscular force impulse ($I_{mp}F_{50\%max}$) from 8203.9 to 15552.3 Ns, while F_{max} values the dominant hand ranges from 478.1 to 566.2 N, for RFD_{max} it ranges from 1742.6 to 2119.0 N/s and for $I_{mp}F_{50\%max}$ 9516.7 to 16845.1 Ns. The results have shown that it is reliable to measure all three examined contractile hand characteristics where by ICC ranges from 0.938 to 0.977 for F_{max}, from 0.903 to 0.971 for RFD_{max} and from 0.747 to 0.943 for $I_{mp}F_{50\%max}$. The second try as the better result should be considered the representational value for $F_{max}$and RFD_{max} variables, regardless of the hand dominance or age group. While for the variable $I_{mp}F_{50\%max}$, in the age groups from 35.0 to 49.9 and from 50.0 to 69.9, the first tested try for both hands should be considered, in 14.0 to 19.9 years group the second try should be taken into consideration, and in 20.0 to 34.9 age range, the better result of the non-dominant hand is the first try, and of the dominant is the second try.

Key words: HAND GRIP / MAXIMUM FORCE / EXPLOSIVE FORCE / CRITERION ENDURANCE / FORCE IMPULSE

INTRODUCTION

The complex anatomical and functional structure of the hand is mostly directed for the assignment of catching and holding as the dominant motoric function of this part of the hand (Fernandes et al., 2014).

Former research have dealt with various functional and motoric characteristics of the hand as a segment of the arm, as well as the attempt of identifying different biomechanical aspects of the production of the hand grip force characteristics (Bohannon, 2001; Nicolay and Walker, 2005; Допсај et al., 2011; Fernandes et al., 2014). It has been determined that the dominant hand is around 10% stronger than the non-dominant hand (Hager-Ros and Rosblad, 2002; Кљајић et al., 2012), and that men reach the absolute maximum force values in the forth decade of life, those values decrease afterwards (Massy-Westropp et al., 2011). It has been confirmed that the children's and adolescent's maximum hand grip force can be useful for tracking biological development as well as for function of total muscular development evaluation (Bohannon, 2001; Sartorio et al., 2002; Wind et al., 2010). In the fields of epidemiology and gerontology it is used for examining the effect of older generation aging (Kerr et al., 2006), and it is also a significant indicator of health parameters of the grown-ups, such as density of the bone mass or the protein loss (Foo et al., 2007).

By analyzing the data from the available literature, it can be concluded that the examined phenomena of the hand contractility are mostly linked to the

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maximum force (Müller et al., 2000; Dopsaj et al., 2007; Aadahl et al., 2011), and the small number of research were realized in accordance with the explosive force (Demura et al., 2003; Dopsaj et al., 2009a), as well as in accordance with the endurance characteristics when producing force (Кљајић et al., 2012). The lack of scientific information about the metrological characteristics of different contractile abilities of thehand muscles which are obtained through the mentioned "Hand Grip" test, compared to the age of the examinees, is noticeable, especially when taking into consideration the fact that during the process of growing up (preadolescent, adolescent and post-adolescent period) and during the aging process, the contractile abilities of the muscles are changing (Aadahl et al., 2011).

No matter which scientific discipline it is being applied in, the fact is that the "Hand grip" test is extremely applicable, simple and informative when applying the standardized measuring procedure. It is necessary to define both the new innovative values of the very test as well as the contractile characteristics which are measured by its application, all in order to improve the technological procedures of obtaining the valid and reliable information that indicate the physical health and specialized muscular function of the upper part of the body, i.e. the general indication about the muscular functions of the entire body of the population of interest. For the needs of defining such expert system, it is necessary to form a huge data base with referential values, where the methodological procedure of forming data base requires initial definition of the healthy population conditions of both genders in every age category (Hager-Ros and Rosblad, 2002; Dopsaj et al., 2009b). Such piece of information is essential when it comes to criterion and normative values and it is used for the needs of deciding algorithms, as well as more precise interpretations of the testing results, in the sense of comparison of both top athletes and recreationists, but also of the rest of the population, no matter whether they are healthy, injured or ill people that don't do sports (Desrosiers et al., 1995; Müller et al., 2000; Bohannon, 2001; Kerr et al., 2006; Gallup et al., 2007; Dopsaj et al., 2007; Dopsaj et al., 2009a; Ivanovic et al., 2009; Dhara et al., 2009; Beloosesky et al., 2010; Carrasco et al., 2010).

The subject of this research is to examine different contractile characteristics of a hand. The aim of the research was to determine the reliability and quantitative descriptive indicators of different contractile functions of the male hand in relation to the maximum and explosive force, as well as criterion endurance of producing force in the function of motoric and functional dominance and age. Considering the already tested space of contractile characteristics realiability of both lower muscles and upper extremities from the aspect of force and explosive force where the results showed the high level of reliability (Blazevich et al., 2002; Demura et al., 2003; Ivanovic and Dopsaj, 2013; Jenkins et al., 2014), similar results can be expected in the space of hand muscles force and explosive force, and positive results in the space of hand muscle force impulse can be assumed.

METHODS

In case of this research, for the purpose of measuring the contractile characteristics of the muscular force, the quantitative approach of sampling the information has been applied, by the dynamometry method and by testing in isometric conditions of straining (Допсај, 2010). As a primary research method, the laboratory testing with the usage of the "Hand Grip" standardized test has been used (Dopsaj et al., 2007; Ivanovic et al., 2009; Допсај et al., 2011). The analytical and statistical methods would be applied as a basic cognitive method, as well as the method of induction,i.e. total induction.

The research sample

The sample included 269 male examinees ranging from 14.0 to 69.9 years old, out of which 59 examinees aging from 14.0 to 19.9 years old - group I (BH = 181.9±6.1 cm, BW = 77.9±10.57 kg, BMI = 23.5±2.7 kg/m^2), 123 examinees aging from 20.0 to 34.9 years old - group II (BH = 182.8±6.9 cm, BW = 86.1±14.4 kg, BMI = 25.7±3.4 kg/m^2), 47 examinees aging from 35.0 to 49.9 years old - group III (BH = 181.7±7.2 cm, BW = 87.5±12.4 kg, BMI = 26.5±3.41 kg/m^2) and 40 examinees aging from 50.0 to 69.9 years old - group IV (BH = 180.3±4.77 cm, BW = 86.7±11.8 kg, BMI = 26.6±3.16 kg/m^2). Twenty examinees reported their left hand as their dominant one. The examinees were chosen by a simple random sample from the sports and general population. They all were familiar with the methods of testing and they voluntarily took part in the examination. The examination was carried out according to the terms of Helsinki declaration and

with the approval of Ethic Committee of the Faculty of Sport and Physical Education University of Belgrade.

Measurament procedure

The examinees were tested by the application of the standardized measurement procedure which was previously described as follows: in a sitting position, with the arm either outstretched mildly flexed which is placed in the easily abducted position (Допсај et al., 2011; Кљајић et al., 2012). The procedure was as follows - after the singly basic 3-minute warm-up (shaping and stretching exercises) each of the examinees was explained the testing procedure. After that, they were introduced to the test by realizing 3 to 4 initial tryouts of the hand grip on lower force intensities, i.e. they tried to realize the endurance of each hand alternately in duration of 10 seconds with the arbitrarily selected force ranging from 150 to 200 N. After that, each examinee performed one try of the maximum hand grip (both with dominant and non-dominant hand) for the sake of getting familiar with the testing procedure and in the function of the final and specific warming up phase as well.

After the 2 to 3-minute break, the examinees did the test following the protocol - firstly, they realized two alternate measurements of maximum muscular hand grip force of both hands, on the mark of the measurer (the examinee was free to choose which hand he would do the test with first) in order to define the level which is 100% of the given contractile ability (maximum contraction duration is 2 seconds). The break between every testing tryout was at least 1 minute long.

After that, in the latter part of the procedure, after 2 to 3-minute break, the measuring of the production of the given force capacity ensued (durability of the isometric muscle force production), i.e. the time interval during which the examinees could maintain the given force level at 50% of the maximum was measured, according to the before mentioned procedure (Markovic et al., 2016). The assignment of the examinees was to keep the defined level of the force in the longest time interval as possible up until willing to quit by looking at the monitor which showed the level of force. The realization time of the given force was measured by a software, and the task of the measurer was to watch the screen with the examinee and to correct the examinee according to the force realization level, as well as to verbally motivate the examinee to endure the given task in as longer time interval as possible. Once the examinee couldn't realize the defined level of force anymore, i.e. when his performance fell below 45% of the maximum, the attempt was stopped, and the software recorded the total time of the endurance in the given range. After the 5-minute break, the same test was realized with the other hand, and after the break of at least 10 minutes, the endurance test for both hands was repeated, following the same procedure.

The dynamometric probe which is fixed to the construction and specially intended for the realization of the "Hand Grip" testing was used (Markovic et al., 2016), while the frequency of the selection i.e. information sampling was realized on the level of 500Hz, and with the help of the software used for analyzing data, called "*Isometrics*" (ver. 3.1.1).

Variables

The tested space was defined in accordance with the three variables muscular hand force as follows: the aspect of maximum force (shown in N), maximum explosive force (shown in N/s), and the endurance in muscular force production, i.e. the temporal aspect of detecting the given force percentage (shown in Ns).

For the purpose of this examination, the following variables were used:

1. Maximum muscular hand grip force - F_{max}: of the dominant hand ($F_{max}D$) and the non-dominant hand ($F_{max}ND$), through the first (1) and the second (2) attempt, shown in Newtons (N);
2. Maximum value of the explosive force - RFD_{max}: absolute value of the dominant hand ($RFD_{max}D$) and non-dominant hand ($RFD_{max}ND$), through the first (1) and second (2) attempt, shown in Newton per second (N/s).
3. The muscular force impulse, endurance of the hand grip force, achieved on the level of 50% of F_{max} - $I_{mp}F_{50\%max}$ (calculated as a product of the force level $F_{50\%max}$ and the performed time during endurance on the mentioned force level): of the dominant hand ($I_{mp}F_{50\%max}D$) and the non-dominant hand ($I_{mp}F_{50\%max}ND$), through first (1) and the second (2) attempt, which is shown in Newton-seconds (Ns).

Statistical analysis

All results were firstly analyzed by the application of the basic descriptive statistical method where the following was calculated: central tendencies measures (arithmetic mean) and the dispersion measures (standard deviation) and the variation coefficient (C_V%). The data was processed by the Student's t test for the dependent samples. After that, the linear regressive analyses, as well as the analyses of the similarities of the variable pairs, were calculated, i.e. the parameters of the reliability were calculated- *Intraclass Correlation Coefficient* (ICC) (Hair et al., 1998). All statistical analyses were carried out with the help of software package "SPSS 19.0", while for the level of the statistical significance, the value $p < 0.05$ was used.

RESULTS

The average values of muscular hand grip characteristics for the dominant and non-dominant hand of the whole sample were 501.8±97.1 N and 534.4±100.2 N for F_{max}, 1837.0±446.2 N/s and 1984.8±494.7 N/s for RFD_{max}, and 13537.4±5511.4 Ns and 14458.6±6600.8 Ns for $I_{mp}F_{50\%max}$.

The Table 1. shows the results of the both attempts of the tested variables of both the dominant and non-dominant hand in the function of age groups of the examinees. It was noticed that the highest measured F_{max} of the hand grip of the non-dominant hand which was obtained from the II group for variable F_{max}ND2, while the lowest level of force was measured in the I group for the variable F_{max}ND1. In accordance with the F_{max} indicators of the dominant hand, it can be noticed that the highest measured hand grip force which was determined in the II group for the variable F_{max}D2, while the lowest force measured in the I group for the variable F_{max}D1.

When it comes to the RFD_{max} variable, the results have shown that the highest explosive hand grip force of the non-dominant hand was measured in II group for variable RFD_{max}ND2, while the lowest level was measured in the IV group for the variable RFD_{max}ND2. In relation to the obtained RFD_{max} values of the dominant hand one can point out that the highest level of the explosive hand grip force was measured in the II group for the variable RFD_{max}D2, while the lowest measured results were found in IV group for the RFD_{max}D1 variable.

In accordance with the $I_{mp}F_{50\%max}$ variables, the results have shown that the greatest impulse of the hand grip force of the non-dominant hand of the 50% below maximum was measured in group III for the variable $I_{mp}F_{50\%max}$ND1, and the lowest level was measured in the I group for the variable $I_{mp}F_{50\%max}$ND1. The highest measured impulse of the hand grip force of the dominant hand was pointed out in III group for the variable $I_{mp}F_{50\%max}$D1, while the lowest one was measured in I group for the variables $I_{mp}F_{50\%max}$D1.

In relation to the established variations of the results, as well as their homogeneity measures, the results of the variation coefficient of the reached levels of the maximum force are within the 16.8% to 20.7% range, while the explosive level ranges from 19.4% to 29.8% which shows that the measured results F_{max} and RFD_{max} belong to the homogenous group of examinees, no matter the age. However in relation to the variation of measured results of the endurance testing while producing the muscular force, the Cv% value ranges from 30.6 for $I_{mp}F_{50\%max}$D2 in the group IV, to the value of Cv% 58.0 for $I_{mp}F_{50\%max}$ND1 in the group I (Table 1). Although the determined level of the variation is about 30% above the optimal value, which means that it belongs to the non-homogenous category, it is placed below the value of 60%, which satisfies the conditions for the usage of the statistical analysis in further phase of parametric statistics.

Table 1. Descriptive statistics of the tested variables

Age groups:	I			II			III			IV		
Variables	Mean	Std. Dev.	Cv%	Mean	Std. Dev.	Cv%	Mean	Std. Dev.	Cv%	Mean	Std. Dev.	Cv%
F_{max}ND1 (N)	462.8	87.6	18.9	519.6	98.0	18.9	507.9	105.3	20.7	481.2	87.1	18.1
F_{max}ND2 (N)	474.2	87.9	18.5	529.0	105.8	20.0	520.5	107.4	20.6	483.5	87.3	18.1
RFD_{max}ND1 (N/s)	1813.2	493.0	27.2	1960.8	585.0	29.8	1822.5	428.6	23.5	1627.9	315.7	19.4
RFD_{max}ND2 (N/s)	1859.7	441.0	23.7	1972.8	581.0	29.4	1893.7	446.2	23.6	1621.6	316.6	19.5
$I_{mp}F_{50\%max}$ND1 (Ns)	8203.9	4757.2	58.0	13970.3	6562.2	47.0	15552.3	7751.3	49.8	15317.7	6431.1	42.0
$I_{mp}F_{50\%max}$ND2 (Ns)	10555.6	4369.5	41.4	13685.9	5537.4	40.5	14770.2	7001.3	47.4	15137.8	5137.2	33.9
F_{max}D1 (N)	478.1	80.5	16.8	554.6	106.1	19.1	534.7	107.9	20.2	503.0	92.4	18.4
F_{max}D2 (N)	497.5	87.0	17.5	566.2	105.9	18.7	557.6	112.0	20.1	516.1	95.9	18.6
RFD_{max}D1 (N/s)	1937.8	471.6	24.3	2087.7	565.5	27.1	1970.3	456.7	23.2	1742.6	385.3	22.1
RFD_{max}D2 (N/s)	2011.0	487.4	24.2	2119.0	614.1	29.0	2015.4	470.0	23.3	1794.0	407.4	22.7
$I_{mp}F_{50\%max}$D1 (Ns)	9516.7	4940.1	51.9	15101.5	7109.4	47.1	16845.1	7717.4	45.8	16371.2	6636.4	40.5
$I_{mp}F_{50\%max}$D2 (Ns)	11685.4	4960.8	42.5	15351.7	6150.9	40.1	15845.5	6273.8	39.6	14798.1	4529.9	30.6

In relation to the results of the differences in average values of the tested variables in the function of the tested tryouts (Table 2), it is established that the differences in results of the first and the second measurement of ten couples of the variables is highly statistically significant no matter the age group, ranging from t = -2.015 and p = 0.049 for F_{max}ND for the III age group, to t = -4.115 and p =0.000 for F_{max}D for group I. The statistical significance wasn't established with thirteen variables i.e. their results range from t = -1.919 and p = 0.061 for RFD_{max}ND in III age group to t = -0.050 and p = 0.961 for $I_{mp}F_{50\%max}$ND in IV age group.

Table 2. The results of the differences analysis (t test)

Age group:	I		II		III		IV	
Variables:	t	p	t	p	t	p	t	p
F_{max}ND1 (N) & F_{max}ND2 (N)	-3.172	**0.002**	-2.266	**0.025**	-2.015	**0.049**	-0.553	0.583
RFD_{max}ND1 (N/s) & RFD_{max}ND2 (N/s)	-2.374	**0.021**	-0.482	0.631	-1.919	0.061	0.305	0.762
$I_{mp}F_{50\%max}$ND1 (Ns) & $I_{mp}F_{50\%max}$ND2 (Ns)	-1.848	0.074	0.300	0.765	-0.857	0.402	-0.050	0.961
F_{max}D1 (N) & F_{max}D2 (N)	-4.115	**0.000**	-3.267	**0.001**	-3.837	**0.000**	-2.788	**0.008**
RFD_{max}D1 (N/s) & RFD_{max}D2 (N/s)	-2.917	**0.005**	-1.409	0.161	-1.820	0.075	-1.903	0.064
$I_{mp}F_{50\%max}$D1 (Ns) & $I_{mp}F_{50\%max}$D2 (Ns)	-2.229	**0.033**	-1.351	0.183	-0.471	0.643	2.510	**0.018**

Table 3. shows the results of the reliability in accordance to the questioned variables and age groups. It has been determined that the reliability level of the each questioned contractive characteristic of the hand in the function of the age group is highly statistically significant (p = 0.000 for every variable pair tested). The ICC value of F_{max} ranges from 0.938 to 0.977, for RFD_{max} from 0.903 to 0.971, and for $I_{mp}F_{50\%max}$ from 0.747 to 0.943.

Table 3. Results of the reliability (Intraclass Correlation Coefficient)

Variables:	Age group:	Intraclass Correlation Coefficient	95% Conf. Inte.		F Test with True Value 0			
			Lower Bound	Upper Bound	Value	df1	df2	p
F_{max}ND1 (N) & F_{max}ND2 (N)	I	0.971	0.944	0.984	39.599	58	58	**0.000**
	II	0.944	0.920	0.961	18.545	122	122	**0.000**
	III	0.956	0.918	0.976	23.884	46	46	**0.000**
	IV	0.977	0.957	0.988	43.581	39	39	**0.000**
RFD_{max}ND1 (N/s) & RFD_{max}ND2 (N/s)	I	0.971	0.950	0.983	37.513	58	58	**0.000**
	II	0.941	0.915	0.959	16.798	122	122	**0.000**
	III	0.903	0.824	0.946	10.854	46	46	**0.000**
	IV	0.956	0.917	0.977	22.411	39	39	**0.000**
$I_{mp}F_{50\%max}$ND1 (Ns) & $I_{mp}F_{50\%max}$ND2 (Ns)	I	0.761	0.509	0.884	4.430	30	30	**0.000**
	II	0.875	0.780	0.929	7.892	49	49	**0.000**
	III	0.943	0.858	0.977	17.313	19	19	**0.000**
	IV	0.771	0.514	0.891	4.251	29	29	**0.000**
F_{max}D1 (N) & F_{max}D2 (N)	I	0.938	0.858	0.969	20.340	58	58	**0.000**
	II	0.961	0.941	0.974	27.667	122	122	**0.000**
	III	0.954	0.884	0.978	27.937	46	46	**0.000**
	IV	0.970	0.935	0.985	38.865	39	39	**0.000**
RFD_{max}D1 (N/s) & RFD_{max}D2 (N/s)	I	0.953	0.912	0.973	23.732	58	58	**0.000**
	II	0.954	0.934	0.968	21.963	122	122	**0.000**
	III	0.964	0.934	0.980	28.735	46	46	**0.000**
	IV	0.948	0.901	0.973	20.566	39	39	**0.000**
$I_{mp}F_{50\%max}$D1 (Ns) & $I_{mp}F_{50\%max}$D2 (Ns)	I	0.769	0.515	0.889	4.753	30	30	**0.000**
	II	0.747	0.557	0.856	4.002	49	49	**0.000**
	III	0.894	0.732	0.958	9.104	19	19	**0.000**
	IV	0.836	0.632	0.925	7.017	29	29	**0.000**

By linear regressive analysis (Table 4, Charts 1 to 6), regressive models of the testing reliability are defined i.e. models of the linear regressive equations of all the tested variables for all ages. Graphs show the results of the linear regressive analysis in relation to the testing (Test 1 and 2) for the F_{max} variable in the function of the non-dominant (Chart 1) and dominant hand (Chart 2), for the variable RFD_{max} in the function of the non-dominant (Chart 3) and dominant hand (Chart 4), and the $I_{mp}F_{50\%max}$ variable in the function of the non-dominant (Chart 5) and dominant hand (Chart 6). For the F_{max} variable the range of the determination coefficient (R^2) for dominant hand is 0.826-0.903, and for non-dominant hand 0.811-0.912. The second variable RFD_{max} ranges from 0.826-0.871 for dominant hand and 0.692-0.910 for non-dominant hand, while the $I_{mp}F_{50\%max}$ variable of the determination coefficient R^2 ranges from 0.360-0.674 for dominant hand, and 0.401-0.808 for non-dominant hand (Table 4). All regressive models of reliability showed the high level of significance on the level of p = 0.000.

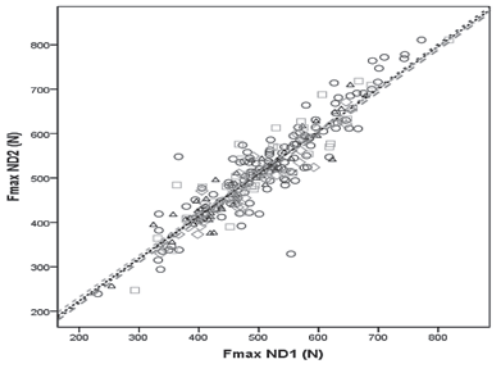


Chart 1

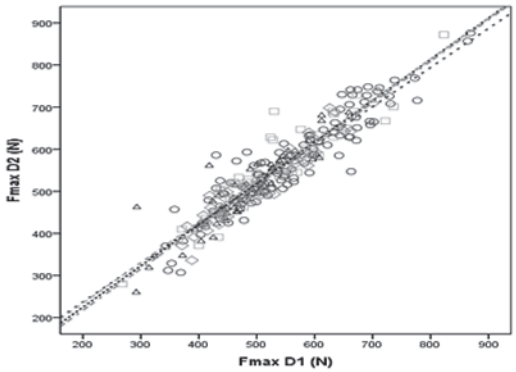
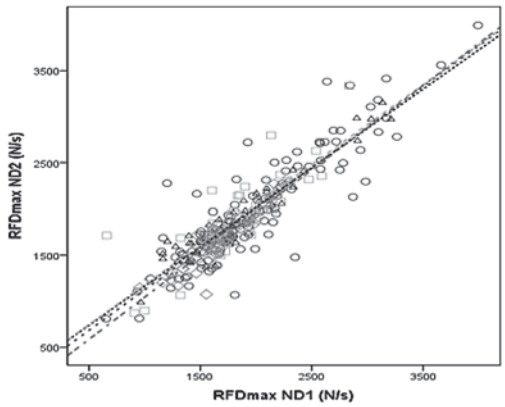


Chart 2

Linear regression F_{max} for 1 and 2 attempt of non-dominant (Chart 1) and dominant hand (Chart 2)



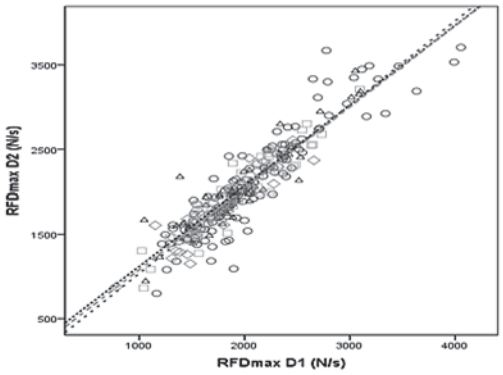
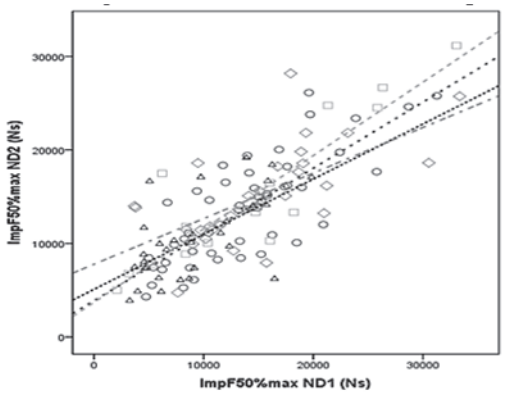
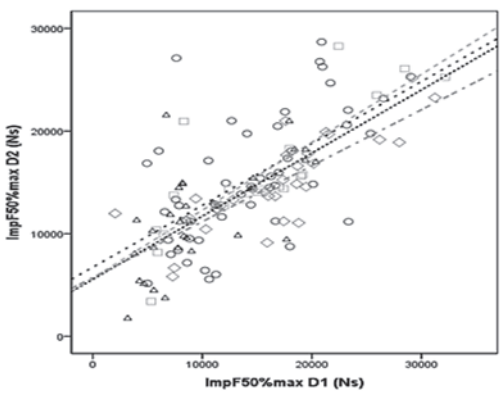


Chart 3 **Chart 4**

Linear regression RFD_{max} for 1 and 2 attempt of non-dominant (Chart 3) and dominant hand (Chart 4)





Charts 5 **Chart 6**

Linear regression $I_{mp}F_{50\%max}$ for 1 and 2 attempt of non-dominant (Chart 5) and dominant hand (Chart 6)

***Legend of the single result positions by age**: **Δ** - age group from 14.0 to 19.9 – I age group; ○ - age group from 20.0 to 34.9 – II age group; □ - age group from 35.0 to 49.9 - III age group; ◊ - age group from 50.0 to 69.9 година - IV age group, and the same color points out the regressive lines also, i.e. blue for age group I; red for age group II; yellow for age group III; green for age group IV.*

Table 4. The results of the defined models of the linear regressive equations

Variables:	Age groups:			
	I	II	III	IV
F_{max}ND1 (N) & F_{max}ND2 (N)	y=0.955•x+32.237 R^2=0.904	y=0.972•x+24.147 R^2=0.811	y=0.938•x+43.905 R^2=0.846	y=0.958•x+22.537 R^2=0.912
RFD_{max}ND1 (N/s) & RFD_{max}ND2 (N/s)	y=0.853•x+312.324 R^2=0.910	y=0.882•x+244.349 R^2=0.788	y=0.866•x+315.077 R^2=0.692	y=0.917•x+128.561 R^2=0.836
$I_{mp}F_{50\%max}$ND1 (Ns) & $I_{mp}F_{50\%max}$ND2 (Ns)	y=0.589•x+5095.834 R^2=0.401	y=0.708•x+3881.749 R^2=0.606	y=0.785•x+3710.923 R^2=0.808	y=0.488•x+7780.499 R^2=0.413
F_{max}D1 (N) & F_{max}D2 (N)	y=0.981•x+28.355 R^2=0.826	y=0.928•x+51.338 R^2=0.865	y=0.967•x+40.519 R^2=0.868	y=0.986•x+20.174 R^2=0.903
RFD_{max}D1 (N/s) & RFD_{max}D2 (N/s)	y=0.950•x+169.398 R^2=0.846	y=0.995•x+42.115 R^2=0.839	y=0.960•x+123.024 R^2=0.871	y=0.961•x+119.489 R^2=0.826
$I_{mp}F_{50\%max}$D1 (Ns) & $I_{mp}F_{50\%max}$D2 (Ns)	y=0.615•x+5548.499 R^2=0.427	y=0.603•x+6729.400 R^2=0.360	y=0.661•x+5679.263 R^2=0.674	y=0.545•x+5721.218 R^2=0.657

DISCUSSION

The examinations of the contractile characteristics of the hand muscles are of great importance in predicting the functional limitations and diagnosis of the neural disorders, and have a significant role in the evaluation of the general level of the contractile physical abilities development of both professional athletes and recreationists (Desrosiers et al., 1995; Rantanen et al., 1998; Bohannon, 2001; Wind et al., 2010; Koley et al., 2011). Research of this type present the permanently current field of interest of the scientific research in order to increase the fundus of the knowledge, and to perfect the testing procedures in diagnostics, therapeutic and professional means as well.

Besides higher statistically significant correlation when it comes to repetitive action of the testing, the statistically significant difference of the average values of the F_{max} variables of the first and the second attempt of the dominant hand of all the age categories, and for the non-dominant hand as well in the first three tested groups (I, II, III age group)(Table 2). Other statistical analyses used to examine the reliability of measuring, showed the extremely high level of given characteristics of detection of maximum force (F_{max}), of the hand grip of all the questioned groups on the ICC level from 0.944 to 0.977 for non-dominant hand, i.e. from 0.938 to 0.970 for the dominant hand (Table 3). The given results are in total confirmation with the previously determined standards in relation to the reliability of the standard tests of the hand grip force of 0.961 for the right hand and 0.950 for the left hand (Hamilton et al., 1994), and respectably in accordance with the higher reliability of the standard tests of force of other muscular groups ranging from ICC 0.97-1.00 for isometric squat position and leg pushing from the standing position (Blazevich et al., 2002), as well as for the standard leg thrust on the Cronbach's Alpha level of 0.989 (Ivanovic and Dopsaj, 2013). This way, the results showed that the usage of the isometric testing, in relation to the maximum hand grip force measurement is also reliable in the function among the male sex examinees of different age. It ought to be mentioned that because of the estimated statistically significant difference of the second measurement compared to the first measurement, the result of the second attempt, i.e. the result of the stronger attempt should be considered as a final result.

In the case of second tested variable, which measured the maximum level of explosive hand grip force - RFD_{max}, the statistically significant difference between attempts was estimated only in age group I, both in cases of dominant and non-dominant hand (Table 2). This can be explained by the omition of the previous experience of performing the same strainings and their initial unpreparedness for the task during their first attempt i.e. the higher acute neuro-motoric adaptability during their second attempt. Further statistical analysis have shown extremely high level of reliability of the given contractile characteristic RFD_{max} of hand grip in all of the tested age groups on ICC level from 0.903 to 0.971 for non-dominant hand, and from 0.948 to 0.964 for dominant hand (Table 3). As in the case of F_{max} these results are in confirmation with the early established standards in relation to the reliability of methods for testing the explosive hand grip force where the ICC levels from 0.870 to 0.930 (Demura et al., 2003; Jenkins et al., 2014) i.e. in accordance with the high reliability of the standard tests of force of the other muscular groups leveled from 0.808 to 0.945 Cronbach's Alpha for the standard leg thrist (Ivanovic and Dopsaj, 2013). Based on former research and the given results of these tests it is obvious that the usage of the isometric testing, in relation to the measures of the maximum explosive force of the hand grip test, is valid in the function of the various groups and ages of men. One should mention that the statistically significant difference of the second measurement compared to the first is detected only in age group I for both hands. However, absolute differences in the average results obtain are seen in favor of the second attempt, and they are based on the descriptive statistics in all age groups, except for group IV for non-dominant hand, where the first attempt was better (Table 1). With all this in mind, one can propose the measurement of the final attempt of the explosive force, i.e. the result of the second attempt as the final result.

While in the third tested variable which measured the impulse of the maintaining of the force on the 50% from maximum - $I_{mp}F_{50\%max}$ the significant difference between the first and the second attempt oftesting can be seen in I age group, but also in the IV age group for dominant hand only (Table 2). The important factor of this testis the usage of the sensory information i.e. the visual monitoring of maintenance of the assigned level of the force which is at 50% of maximum, and their compatibility (motoric

control) with the muscular characteristic (muscular endurance), where in the disputed age categories one may come across the process of accelerated developmentor the degradation of the same, this being the cause of obtained results (Nicolay and Walker, 2005). Based on these results the statistically significant level of reliability of the detection of the $I_{mp}F_{50\%max}$ hand grip can be seen in all tested age groups on the ICC level from 0.761 to 0.943 for non-dominant hand, and from 0.747 to 0.894 for dominant hand (Table 3). Functional muscular ability for manifestation of the assigned level of the force as a measure of endurance, expressed as a force impulse has not been much examined phenomena in the sports area (Nicolay and Walker, 2005; Кљајић et al., 2012). Besides statistically significant difference between the testing attempts $I_{mp}F_{50\%max}$ only in the I and IV age group for dominant hand (Table 2), the differences in average accomplished results can be distinguished based on the results of the descriptive statistics (Table 1). Based on that, it can be recommended that the value which presents the higher endurance should be taken as a final result, but that in the III and IV age group the first testing attempt mainly presents the better result for both hands, while in the I age group it is the second one, and in the II aging group the mark of the better result of the non-dominant hand is the first, and of the dominant hand is the second attempt.

The high level of significance of the regressive models of testing reliability of the variables of all age groups has been established. One can say that the great amount of variety of the second measurement is explained through the first one and that is for F_{max} ranging from 81% to 91%, for RFD_{max} ranging from 69% to 91% and for $I_{mp}F_{50\%max}$ ranging from 36% to 80%. There by it is notice able that the obtained results of the linear regressive analysis for F_{max} and RFD_{max} are for a bit lower than the values informer research which range from 96 % to 99 % for both variables (Giampaoli et al., 1999; Dopsaj et al.,2009b). Regressive models of reliability $I_{mp}F_{50\%max}$ were not noticed as a matter of former interest, so the possibility of comparison is omitted. This way the possibility of the prediction of the optimal result of the measured contractile characteristics of the hand is enabled, as well as positioning of the actual examinee in the function of the defined population standards.

CONCLUSION

The hand grip presents the important method which can be used to diagnose the level of the functional ability of tested contractile properties of the hand as a basic manipulative segment which shows the basic condition of the muscular functions of the whole organism.

In accordance with the aim of the research, quantitative descriptive indicators which can serve as a means of comparing and determining the levels of development of the stated abilities of people of various level of training, various functional and health condition as well as of people with different stadiums of motoric or some other disorders, and therefore can gain the vast practice from many cognitive and practical aspects. One can state that the "Hand Grip" test can measure all of the three contractive characteristics of the hand - maximum and explosive force, endurance of the force of males from the age of 14.0 to 69.9 years.

Of course, as a final indicator of the contractive muscle characteristics, the value which shows the better score is taken into consideration. By omitting the previous experience of performing the similar straining and their initial motor in adaptability for the task, it is established that the representative value of the F_{max} and RFD_{max} variables is best shown by taking the second attempt into consideration, no matter the hand dominance or age group. For the variable $I_{mp}F_{50\%max}$, after the 35th year of age, it is common to take the first attempt for both hands, while for the youngest tested group, the second attempt should be taken as a definite means of testing. In the age of 20.0 to 34.9, the indicator of the better result of the non-dominant hand is the first, and of the dominant hand is the second attempt.

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FIABILIDAD DE MEDICIÓN DE DISTINTAS FUNCIONES CONTRÁCTILES DEL FLEXOR DE LOS DEDOS DE MANO EN HOMBRES DE DISTINTA EDAD

Resumen
El objetivo de la investigación es establecer la fiabilidad de las pruebas de distintas funciones contráctiles de la mano de varón en dependencia de la dominación motriz-funcional y de la edad. La persona examinada toma la posición sedentaria con el brazo extendido o suavemente flexible, puesto en una ligera posición de abducción. Para las necesidades de medición se ha utilizado una sonda dinamométrica con las condiciones isométricas de tensión, fijada a una construcción especial. Se ha utilizado el software "Isometrics" (ver. 3.1.1), y la frecuencia de selección de datos se ha realizado en nivel de 500 Hz. La muestra abarcó 269 personas examinadas del sexo masculino de 14.0 a 69,9 años de edad. Los resultados de la estadística descriptiva demostraron que en relación con la muestra examinada, los valores de la fuerza máxima demostrada (Fmax) para el brazo no dominante están en el rango de 462.8 до 529.0 N, para la fuerza explosiva (RFDmax) en el rango de 1621.6 до 1972.8 N/s y para el impulso de la fuerza muscular (ImpF50%max) de 8203.9 a 15552.3 Ns, mientras que los valores Fmax para el brazo dominante en el rango de 478.1 a 566.2 N, para RFDmax en el rango de 1742.6 a 2119.0 N/s y para ImpF50%max de 9516.7 a 16845.1 Ns. Se estableció que se pueden medir fiablemente todas las tres características contráctiles examinadas de la mano, con lo que ICC está en el rango de 0.938 a 0.977 para Fmax, de 0.903 a 0.971 para RFDmax, y de 0.747 a 0.943 para ImpF50%max. Como un valor representativo para las variables Fmax y RFDmax, sin tener en cuenta la dominación de un brazo o grupo de edad, debe tomarse la segunda prueba como mejor resultado, mientras que para la variable ImpF50%max, en los grupos de edad de 35.0 a 49.9 y de 50.0 a 69.9, debe tomarse en general la primera prueba para ambos brazos, en el grupo de 14.0 a 19.9 años la segunda prueba y en la edad de 20.0 a 34.9 años el mejor resultado del brazo no dominante es la primera y del brazo dominante la segunda prueba.

Palabras claves: PRESIÓN DE MANO / FUERZA MÁXIMA / FUERZA EXPLOSIVA / RESISTENCIA DE CRITERIO / IMPULSO DE POTENCIA

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MOTOR SKILLS AS PREDICTORS OF COMPETITORS` SELECTION IN KARATE

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Abstract
The goal of the research, which encompassed a wide range of indicators, was to examine the predictive value of motor abilities of karatekas in competitive selections, regarding their competitive orientation towards a certain discipline: kata or kumite. Related to set object and goal of research, a hypothesis was set up: motor skills are significant predictors for competitive selection of karatekas. The sample of respondents was made of male karatekas, aged 12 to 14, who are in regular training process and who compete in current competitive system. The research encompassed 79 karatekas, of which 37 compete in kumite, 23 compete in kata, and 19 in both disciplines. To evaluate general motor skills of karatekas, 15 tests were applied, 3 tests for each of the following set: repetitive strenght, explosive strenght, speed, coordination and flexibility. Descriptive statistical parameters were applied, Multivariate analysis of covariance (MANCOVA) and analysis of covariance (ANCOVA). Statistical significance was analyzed at ($p<0.05$) level. Results obtained confirmed the set up hypothesis of predictive value of motor abilities of competitive selections karatekas.

Key words: *KARATE / KATA / KUMITE / MOTOR SKILLS.*

INTRODUCTION

Different moving activities show certain qualitative characteristics of change it. These characteristics of the movable abilities of man are called different terms, but most often they are motor skils (Zivanovic, Stanković, Randjelovic, and Pavlović, 2010). They represent the basis for every learning of moving tasks and can be considered as fundamental values in the total space of the human motor system (Kurelić, Momirović, Stojanović, Šturm, Radojevic, and Viskić-Štalec, 1975).

Defining one of the youngest martial arts disciplines that experienced real expansion in the second half of the last century(Savić, Nićin, Horvat and Kopas, 1994; Cirkovic Jovanović, 2002. Bratic,2006) represents a delicate theoretical and methodological problem. In literature we are faced with numerous attempts to define karate. At the same time, as a rule, polemic, mystique and overall complexity of research karate as a sort of phenomenonis emphasised (Savić et al.,1994; Bratic, 2006; Cirkovic, Jovanović, Kasum, 2010). In this regard, it seems helpful to claim that, instead of the usual question: "when and where it originated", it is more important to answer the question "what is karate" or "what can be defined as karate" (Jovanović, 1992).

Since competitions in karate, according to special rules, take place in two competing disciplines (kata and kumite), the subject of interest in this research is the motor ability that contributes to this differentiation for one of these two disciplines. Therefore, we conducted a study to determine the predictive values of relevant motor skills.

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In relation to the subject and goal set, as well as on the basis of previous researches (show research), we presume that the motor abilities are important predictors of competitive selection in karate.

METHODS

The sample consisted of male karatekas aged 12 to 14 who were in regular training and competed in the existing system of competition in the Karate Federation of Serbia. This research included a total of 79 karatekas, of which 37 were competitors in the kumite, 23 kata competitors and 19 respondents who competed in both disciplines (Table 1).

Table 1. Caracteristics of the sample

THE YEAR	Fighters	Kata competitors	Kata + fighters	Total
2000	17	6	10	33
2001	13	5	4	22
2002	7	12	5	24
IN TOTAL	37	23	19	79

Significant motorical dimensions were examined using the following measuring instruments: standing long jump (MSLJ), throwing a medicine ball from a lying position (MTFLP), standing triple jump(MSTJ), 20 meters of sprint from the high start in seconds (M20SS), hand tapping (MHT15), leg tapping (MLT15), forward bend on a bench (MFBB), twist witha stick (MTWS), forward bend from discrepant position (MFBFD), polygon exercise backwards (MPEB), steps to a side in seconds (MSUS), 5x10 meters (MR5X10M), push-ups (MPU), sit-ups (MSU), chin-ups (MCU).

The results of measurement of motor skills are statistically processed by application of descriptive statistical parameters: aritmetic mean (MEAN), standard deviation (SD), with 95% reliability interval.

To examine potential differences between groups (‘’kumite”, ‘’kata”, ‘’kumite + kata”), Multivariate analysis of covariance (MANCOVA) was applied, while for the group of tests (for excluding the potential influence of body height on differences in motor skills tests) analysis of covariance (ANCOVA) was applied. Statistical significance was analyzed at ($p<0.05$) level.

RESULTS

The results of descriptive statistics of the sample variables are shown in Table 2.The fighters had a bit more value than kata competitors,or those who are both kata competitorsand fighters, although these differences are not significant (see the table for details) (Table 3).

Table 2. Descriptive Statistics [Mean mean (standard deviation), interval reliability]for motor variables (whole sample)

VARIABLE	Kumite competitors		Kata competitors		Kumite + kata competitors	
	AS (SD)	95% IP	AS (SD)	95% IP	AS (SD)	95% IP
MSLJ	185.3 (22.4)	178.1 ÷ 192.4	168.0 (18.3)	160.5 ÷ 175.5	178.8 (21.4)	169.4 ÷ 188.2
MTFLP	8.3 (2.0)	7.7 ÷ 8.9	6.5 (1.5)	5.8 ÷ 7.1	7.1 (1.8)	6.3 ÷ 7.9
MSTJ	540.9 (61.7)	521.3 ÷ 560.5	490.7 (47.0)	471.4 ÷ 509.9	523.5 (79.6)	488.6 ÷ 558.4
M20SS	3.8 (0.3)	3.7 ÷ 3.9	4.2 (0.4)	4.1 ÷ 4.4	3.8 (0.3)	3.7 ÷ 4.0
MHT15	30.5 (3.8)	29.3 ÷ 31.7	28.7 (3.4)	27.3 ÷ 30.1	30.2 (1.8)	29.4 ÷ 31.0
MLT15	25.9 (2.3)	25.2 ÷ 26.6	24.1 (2.2)	23.2 ÷ 25.0	24.9 (1.7)	24.1 ÷ 25.6
MPEB	12.8 (2.2)	12.1 ÷ 13.5	15.3 (3.1)	14.1 ÷ 16.6	13.5 (3.2)	12.1 ÷ 14.9
MSUS	10.1 (0.9)	9.8 ÷ 10.4	11.9 (1.5)	11.3 ÷ 12.5	10.9 (0.8)	10.5 ÷ 11.2
MR5X10M	13.7 (0.9)	13.4 ÷ 14.0	14.8 (1.1)	14.4 ÷ 15.2	14.1 (1.0)	13.7 ÷ 14.6
MFBB	43.8 (5.9)	41.9 ÷ 45.6	41.7 (7.9)	38.4 ÷ 44.9	43.5 (5.8)	40.9 ÷ 46.0
MTWS	50.8 (12.3)	46.9 ÷ 54.7	46.2 (11.8)	41.3 ÷ 51.0	48.4 (13.1)	42.6 ÷ 54.2
MFBFD	47.7 (7.4)	45.3 ÷ 50.0	42.6 (9.0)	38.9 ÷ 46.3	44.3 (8.2)	40.7 ÷ 47.8
MPU	26 (13)	2 ÷ 51	18 (10)	-1 ÷ 38	24 (11)	3 ÷ 45
MSU	70.2 (20.8)	63.6 ÷ 76.8	47.5 (21.8)	38.6 ÷ 56.4	67.0 (24.6)	56.2 ÷ 77.7
MCU	5.6 (3.3)	4.5 ÷ 6.6	3.1 (3.2)	1.8 ÷ 4.4	5.8 (4.6)	3.7 ÷ 7.8

AS - arithmetic mean; SD - Standard deviation; 95% CI - Reliabilityinterval

Table 3. Results of multivariate analysis covariance (MANCOVA) motor variables (Factors: age and competitive direction)

F values			
Covariance	FACTORS		
Body height	Age	Orientation	Age x orientation
1.71 **	1.05	0.00 *	0.00

**** - p <0.05; ** - p <0.01***

Multivariate covariance analysis (Table 3) showed that the influence of body height on the results of motor tests is significant.When the results of a motor test compare relative to the body height,there were no significant differences in the motor between the respondents of different ages, but orientation factor was significant in this case.

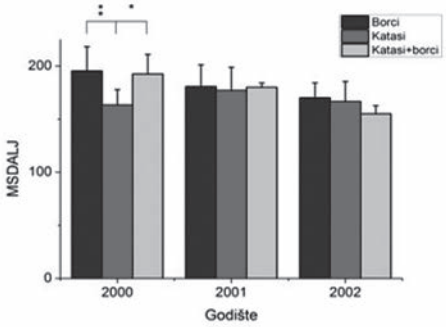
Subsequent analysis (Table 4) showed that body height had significant influence on variables MSLJ, MTFLP, MSTJ, M20SS.Relative to body height, the factor of age was significant in the case MTFLP, MCU, while the "competition orientation" factor was significant in the case of the largest number of variables(MTFLP, M20SS, MHT15, MSUS, MR5X10M, MSU).The differences between age and competition (cross factors) were consistent for all motor variables.

Table 4. Results of covariance analysis (ANCOVA) for motor variables (factors: age and competition orientation)

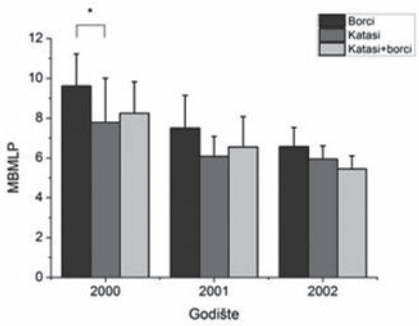
Variables	Age	Year	Orientation	Year x orientation
	F (1; 79)	F (2; 79)	F (2; 79)	F (4; 79)
MSLJ	6.22 *	2.42	2.31	2.16
MTFLP	48.91 **	3.69 *	5.99 **	0.13
MSTJ	13.12 **	2.15	1.83	1.77
M20SS	5.75 *	0.74	10.29 **	0.98
MHT15	2.18	1.95	0.48	1.38
MLT15	1.36	0.93	3.37 *	2.11
MPEB	0.01	2.95	3.61 *	0.59
MSUS	0.00	2.63	11.68 **	0.28
MR5X10M	1.25	0.89	7.81 **	1.48
MFBB	2.38	1.19	0.37	0.08
MTWS	0.11	1.49	0.59	1.20
MFBFD	8.54 **	0.11	1.36	0.55
MPU	0.87	6.25 **	2.00	0.49
MSU	0.29	0.81	4.89 *	0.44
MCU	0.61	3.81 *	1.43	2.08

** - p <0.05; ** - p <0.01*

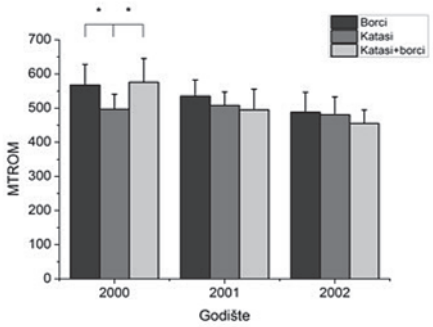
The descriptive statistics of motor variables results of the whole sample, [arithmetic mean (standard deviation)] according to age or competition orientation, are shown in the following pictures (Picture 1 to Picture 9).



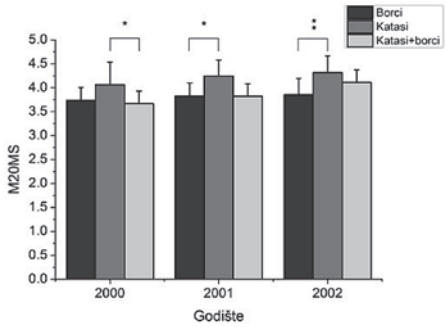
Picture 1. Standing long jump



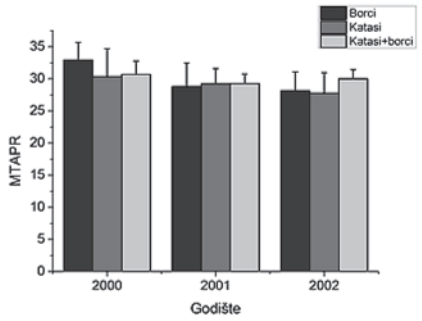
Picture 2. Throwing a medicine ball from a lying position



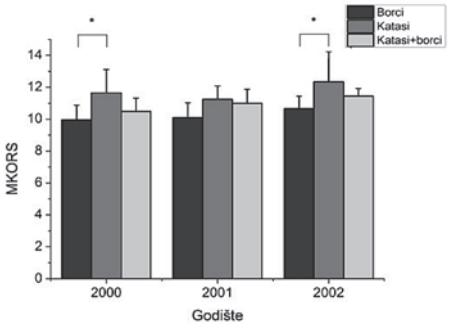
Picture 3. Standing triple jump



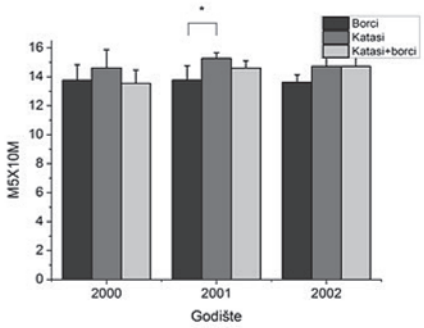
Picture 4. 20 meters of sprint from the high start in seconds



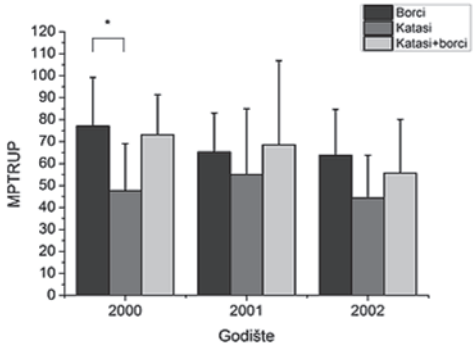
Picture 5. Hand tapping for 15 seconds



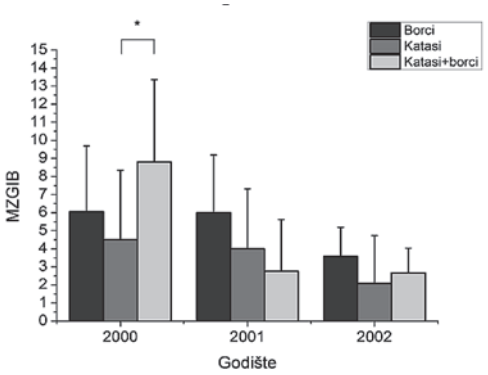
Picture 6. Steps to a side in seconds



Picture 7. Running 5x10 m



Picture 8. Sit-ups



Picture 9. Chin-ups

DISCUSSION

On the basis of previous research (Dodera and Doder, 2006; Blazevic, Katic Popović, 2006; Doder and Babiak, 2007; Blazevic, Zaja & Katic, 2008; Bozanic & Bešlija, 2010; Gužvica, 2011), we can say that karate skills are positively correlated with basic motor skills. Most significant abilities, those that affect movement and selection techniques that are most often used in combat, are explosive power, speed, coordination and flexibility. As a result of specific motor demands, required in a particular discipline competition, it was expected that some differences between the groups will appear.

Based on the results and descriptive statistics of motor variables in the entire sample,[Mean (standard deviation)] according to the age or discipline, as shown in the pictures (Pictures 1 to 9), we conclude that it is the kumite competitors who have slightly higher values than kata competitors and kata competitors + kumite competitors. In the evaluation variables of explosive strength (MSLJ, MTFLP, MSTJ), the results of kumite competitors

compared to the results of kata competitors were significantly better only in the oldest respondents (2000), and this difference is reduced when analyzing the results of younger karatekas. The situation is similar at the maximum speed, where in M20SS variable, kumite competitors have significantly better results in relation to the kata competitors, which is particularly manifested in the youngest participants. At speed of frequency movements there are no significant differences between groups except for the oldest competitors (2000), where the results of the kumite competitors are better in comparison to the other two groups of respondents. In coordination, kumite competitors also have better results, though these values are not significantly higher, except in one variable (MSUS), among the oldest (2000) and the youngest (2002) Throw out respondents. Kumite competitors were also significantly better than kata competitors in the variable MR5X10M among the oldest respondents. There was no significant difference in the domain of flexibilitybetween the groups, although the results of the kumite competitors were better, while in the repetitive power, kata competitors' group was significantly weaker than the other two groups of respondents. In only one variable (repetitive force (MCU)), groups which competes in both fields, is significantly better than in the other two groups, and that at the oldest (2000) competitor.

By comparing the results obtained in our study with recent similar studies (Koropanovski et al., 2011; Koropanovski, 2012), we can say that there are no major differences. As in our study, kumite competitors had better results in speed and explosive power, but the results of flexibility are different. In this domain competitors in kata, in contrast to our study, had better results, slightly below the level of significance. This can be attributed to the fact that in this research respondents are top-level kumite competitors, while kata competitors in modern karate are performing techniques from relatively low poses. For this reason, the training of kata competitors focuses on increasing mobility, especially in lower extremities. In a more recent study, Korapanovski(2012), examined the characteristics of the best competitors in kata and fighting, and applied tests of general and specific motor abilities in different regimesof muscle strain.

Multivariate analysis of covariates indicated that the influence of body height on motor test results is significant. When the results of motor tests compare relative to body height, there are no significant differences in motor skills between respondents of different ages, but the factor of competitive orientation in this case was significant. Subsequent analysis showed that body height had a significant impact on the MSLJ, MTFLP, MSTJ, M20SS, variables. Relative to body height, the age factor was significant in the case of MTFLP, MCU, while the factor "competitive orientation" was significant in the case of most variables (MTFLP, M20SS, MHT15, MSUS, MR5X10M, MSU). Differences by age or competition orientation (crossed factors) were consistent for all motor variables. Subsequent analysis showed that the largest number of significant differences were obtained in the oldest age group (2000) in favor of fighters or fighters + kata competitors, compared to kata competitors.

CONCLUSION

The aim of the study, which covered a wide range of indicators, was to examine the predictive value of motor skills in karate competition selection, and in their competitive orientation toward specific disciplines of kata or fighting. Therefore, we explored the differences between respondents of different competitive orientations.In this research we tried to determine the eventual impact of motor abilities on the preference of the respondents to the competitive discipline, by testing their differences. To assess general motor skills of karatekas, we applied three tests for most significant motor skills that affect movement and the techniques which are commonly used in sports fight. As a result of specific motor demands in a specific discipline, it was expected that there would be some differences between the groups of examined karatekas, and it was confirmed by the obtained results. This confirmed the established hypothesis on the predictive values of motor skills in the competitive selection of karatekas. This confirmed the established hypothesis on the predictive values of motor skills in competitive selection of karatekas, but it should be noted that the research was carried out on a population of karatekas who are in a period of intensive growth and development, and similar studies should be done with a population of older adults in order to collect even more reliable results. The study is a

major contribution to karate because of the very small number of studies devoted to study the differences between the different competition orientation of karatekas. The results of this research can serve as the basis and impetus for future research in karate.

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CAPACIDADES MOTRICES COMO PREDICTORES DE LA SELECCIÓN COMPETITIVA EN KARATE

Resumen
El objetivo del presente estudio es investigar el valor predictivo de las capacidades motrices de los jóvenes karatekas en su orientación competitiva hacia la disciplina concreto: para katas o para luchas. En relación con el objeto y objetivo fijados, se estableció la hipótesis que las capacidades motrices son un predictor importante de la selección competitiva en karate. La muestra de los examinados eran los karatekas varones, de edades cronológicas de 12 a 14 años quienes están en un proceso de entrenamiento regular y compiten en marco del sistema actual de competencias. La investigación abarcó 79 karatekas en total, de los que los 37 competidores en luchas, 23 competidores en katas y los 19 examinados que computen en las dos disciplinas. Para evaluar la motricidad general de los examinados se han aplicado 15 pruebas como sigue: tres pruebas para la fuerza repetitiva, fuerza explosiva, rapidez, coordinación y flexibilidad respectivamente. Se han establecido los parámetros estadísticos descriptivos, se ha hecho el análisis extendida de covarianza (MANCOVA) y análisis de covarianza (ANCOVA). La importancia estadística se ha analizado en el nivel ($p<0.05$). Los resultados obtenidos confirman la hipótesis establecida de valores predictivos de las capacidades motrices escogidas en la selección competitiva de karatekas.

Palabras claves: KARATE / CAPACIDADES MOTRICES / NIÑOS

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EXPLOSIVE ISOMETRIC MUSCLE FORCE OF DIFFERENT MUSCLE GROUPS OF CADET JUDO ATHLETES IN FUNCTION OF GENDER

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ABSTRACT

The aim of this paper is to determine the differences in general and specific explosive isometric muscle force in male and female cadet judo athletes. The results of the measured contractile characteristics were obtained by application of a standardized test battery using the isometric dynamometry method for the following five muscle groups: flexor muscles of the left (ŠL) and the right hand (ŠD), back (MRT) and leg extensor muscles (NOGE) and the ankle joint plantar flexor muscles (LIST). The testing included a sample of 14 participants who were competing in the system of individual national championship of the Republic of Serbia for the given age category. On the basis of the obtained results, it can be argued that a general, statistically significant, difference exists between tested judo athletes in the function of gender, both for the absolute values of the variables of basic and specific explosive isometric muscle force (Wilks' Lambda Value 0.000, F=898.61, p=0.000), as well as between the partialized (relative) values of the measured variables (Wilks' Lambda Value 0.001, F=325.71, p=0.000). The highest level of difference between male and female athletes in relation to the absolute values of the obtained results was determined for the variables of the specific explosive isometric muscle force of the left hand flexor muscles (RFD_{max}_ŠL, p=0.001), leg extensor muscles (RFD_{max}_NOGE, p=0.003) and right hand flexor muscles (RFD_{max}_ŠD, p=0.005). In relation to the relative values obtained by partialization of absolute values in relation to skeletal muscle mass (SMM) the highest level of difference was determined for variables of specific isometric explosive muscle force for the left and the right hand, respectively (RFD_{max}_$ŠL_{SMM}$, p=0.000; $RFD_{max}ŠD_{SMM}$, p=0.003). The summarized value of the gender dimorphism index (IPD) is at the level of 71.55 and 53.09% for both absolute basic ($RFDF_{max}$) and specific (RFD_{max}) explosive isometric muscle force, respectively. This indicates that the tested girls reached 71.55% and 53.09% of the given contractile characteristics compared to the tested boys. However, when the measured variables are partialized relative to the skeletal muscle mass (SMM), the fore mentioned differences are lowered to 101.98% and 71.58%, respectively. On general level, the obtained results have shown that there are methodological indications of scientific justification in relation to the partialization of the results of explosive isometric muscle force as a measure of development of contractile muscle potential directly responsible for the intensive manifestation of muscle force in the unit of time, in relation to skeletal muscle mass.

Key words: JUDO/ CADETS/ ISOMETRIC DYNAMOMETRY/ EXPLOSIVE ISOMETRIC MUSCLE FORCE

INTRODUCTION

Judo is an Olympic martial sport in which the performance is determined by the optimal integration of various components of the athlete's preparation that are jointly manifested in the changing conditions of the competition. It can be described as a high-intensity sport, in which athlete attempts to throw his opponent on the back or control him during groundwork combat (Franchini et al., 2007). According to the applicable Judo rules we can distinguish several age categories where in the system of long-term athletes development, and in the system of the selection of perspective athletes, the cadet and junior age categories are distinguished in their importance, while the significance of the senior age category is primarily in the materialization of the maximal competitive performance through

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the achievement of results in competitions of international significance. In each of the age categories, competitors are further divided into clearly defined weight categories, which is common in martial sports disciplines. Within the overall development of their competitive capacities, in order to be successful at international competitions, judo athletes during their training must achieve an exceptional level of physical preparedness (Franchini et al., 2011) where, from a physiological point of view, anaerobic power and capacity, aerobic power and muscle strength/power are considered the main abilities to be developed in judo competitors (Thomas et al., 1989). Consequently, these characteristics were in the primary focus of previous research.

An analysis of judo fighting points to the differences in the manifestation of muscle force and power among judo athletes of different weight categories (Franchini & Sterkowicz, 2000). This specificity further influences tactical setting of the match and the dominance of use of particular techniques, or groups of techniques specific to each of the weight categories. However, the undeniable fact is that the optimal level of development of the dimensions of isometric muscle force largely determines the competition performance, whereby explosive isometric muscle force (RFD – rate of force development) can be singled out as one of the important predictors of competition performance (Monteiro, 2016; Monteiro et al., 2011). Although modalities of muscle force and power have been in focus of a large number of papers (Detanico et al., 2012; Franchini et al., 2011), regardless of the age category, there is a lack of available data considering basic and specific explosive isometric muscle force. Considering the fact that a sports career is a multi-year process aimed at achieving maximum results, within which three main stages with the corresponding sub stages can be distinguished (Koprivica, 2013), and considering the fact that cadet age is consistent with the first stage of the development of a sports career – basic preparation stage, it can be concluded that at this age it is necessary to provide all conditions for the unobstructed and multidimensional development of the psycho-physical potential of the athlete as a precondition for later specialization. Cadet age is also characteristic because of the phenomenon of accelerated biological development which, due to the specificity of the growth of each individual, causes the heterochronism of biological development in general, as well as the heterochronism of the development of different abilities, from both the aspect of the age and the gender aspect. In the modern concept of the technology of development of a top athlete, along with the course of the selection process, the process of testing and evaluation of the obtained results in relation to the standards established for each individual age and competitive level should start and run (Koprivica, 2013; Dopsaj, 2015). It is also necessary to point out the fact that the positive impact of systematic training on the morphological characteristics and motor skills of children involved in judo sport is documented even in younger age categories (Ilić et al., 2012), so in this respect early involvement of children in systematic judo training can be considered justified and even desirable.

In accordance with the previous, this paper presents one of the initial quantitative research aimed at defining the descriptive characteristics as well as the parameters of the differences in the explosive isometric muscle force in systematically trained and selected cadet age category judo athletes, both from the aspect of absolute and from the aspect of values partialized in relation to skeletal muscle mass (SMM). Partialization of the results was enabled by the application of a new methodology for measuring the body composition of the participants using the InBody 720 system, which operates on the measurement principle of multichannel multisegmental bioelectric impedance (Dopsaj et al., 2015).

The secondary aim of this research consists in obtaining the initial values of the measured contractile characteristics, which can serve as initial standard values in the function of evaluation and defining qualitative assessments of a given level of preparedness of tested athletes. This will significantly contribute to the increase of the knowledge base in the system of long-term sport preparation of young judo athletes, i.e. it will improve the existing technology of sports preparation in judo sport.

METHODS

The method used in this research was laboratory testing. All data sampling was performed by dynamometry method, using tensiometric probes.

The research sample

The research sample in this study consisted of 14 cadet age judo athletes, of which 10 boys and 4 girls. The basic descriptive characteristics of the sample are shown in Table 1.

Table 1. Basic descriptive characteristics of examined subsamples in relation to gender

	Boys	Girls
Age (years)	15.5 ± 0.7	16.4 ± 0.1
BH (cm)	174.6 ± 4.6	159.7 ± 7.8
BW (kg)	65.9 ± 7.0	55.7 ± 11.9
BMI ($kg \cdot m^{-2}$)	21.68 ± 2.70	21.7 ± 3.56
PBF (%)	3.32 ± 0.92	11.14 ± 7.55
PSMM (%)	54.66 ± 1.42	49.99 ± 3.81
Training experience (years)	3.9 ± 2.7	3.17 ± 0.62
Training frequency (training sessions per week)	4.0 ± 0.5	4.0 ± 0.5
Weekly training volume (min)	420 ± 30	420 ± 30

All subjects were members of Judo team "Vinča" and were competing in Republic of Serbia system of national championship for cadet age category. Of the overall sample, two participants were members of Republic of Serbia cadet national team.

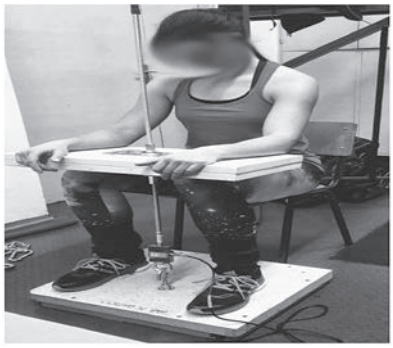
Measurement methods

Testing of muscle force characteristics was performed using dynamometry method, by application of isometric tensiometry, by means of tensiometric probes (Isometrics SMS All4Gym, Belgrade). All tests were performed on University of Belgrade Faculty of sport and physical education in Methodological research laboratory (MIL).

All tests were carried out in the morning (between 09:00 and 11.30 AM) by application of standardized testing procedure and standardized test battery described in previously published literature (Dopsaj et al., 2000; Dopsaj et al., 2001; Dopsaj et al., 2004; Dopsaj et al., 2007).

According to the testing procedure requirements, all participants performed 10 minute individual warm-up and stretching. After that the testing was carried out according to the following procedure: The testing procedure was thoroughly explained to the participants. Each subject had two trial attempts performed in high and sub-maximal intensity for the purpose of familiarization with the testing procedure. After having at least 5 min pause, the testing was carried out using trial-to-trial method, where the break between testing attempts was 3 minutes (Tanner & Gore, 2013).

Better test result was taken for statistical processing. Pictures 1 to 4 show the measurement procedures for the applied test battery.



Picture 1. Sitting plantar flexion test (LIST)

Picture 2. Dead lift test (MRT)

Picture 3. Leg extension test (NOGE)

Picture 4. Handgrip test (ŠD/ŠL)

Variables

For the purposes of this research contractile characteristics of isometric muscle force were examined from the aspect of intensity of its manifestation. In other words characteristics of explosive muscle force were examined. Explosive muscle force was analyzed in relation to basic ($RFDF_{max}$) and specific (RFD_{max}) value. All tests were performed on the following muscle groups: flexor muscles of the left (ŠL) and the right hand (ŠD), back extensor muscles (MRT), leg extensor muscles (NOGE) and ankle joint plantar flexors (LIST), by application of following variables:

Following variables were used for the assessment of basic explosive isometric muscle force (basic explosiveness):

- $RFDF_{max}$_ŠL – basic explosive isometric muscle force of flexor muscles of the left hand expressed in N/s^{-1}
- $RFDF_{max}$_ŠD – basic explosive isometric muscle force of flexor muscles of the right hand expressed in N/s^{-1}
- $RFDF_{max}$_MRT – basic explosive isometric muscle force of back extensor muscles expressed in N/s^{-1}
- $RFDF_{max}$_NOGE – basic explosive isometric muscle force of leg extensor muscles expressed in N/s^{-1}
- $RFDF_{max}$_LIST – basic explosive isometric muscle force of ankle joint plantar flexors expressed in N/s^{-1}

Following variables were used for the assessment of specific explosive isometric muscle force (specific explosiveness):

- RFD_{max}_ŠL – specific explosive isometric muscle force of flexor muscles of the left hand expressed in N/s^{-1}
- RFD_{max}_ŠD – specific explosive isometric muscle force of flexor muscles of the right hand expressed in N/s^{-1}
- RFD_{max}_MRT – specific explosive isometric muscle force of back extensor muscles expressed in N/s^{-1}
- RFD_{max}_NOGE – specific explosive isometric muscle force of leg extensor muscles expressed in N/s^{-1}
- RFD_{max}_LIST – specific explosive isometric muscle force of ankle joint plantar flexors expressed in N/s^{-1}

All absolute values of the examined variables were partialized relative to the pure skeletal muscle mass (SMM) in order to obtain relevant data in relation to the used component of the body composition, which is directly responsible for the manifestation of the contractile potential of skeletal muscles. All calculations were performed using the standard calculation formula as follows: VAR_CCrel = VAR_CCmax / SMM, where VAR_CCmax represents the measured value of the isometric explosive muscle force characteristic for the given muscle group, SMM represents skeletal muscle mass expressed in kg, while VAR_CCrel represents the value of the variable derived.

Both absolute and partialized results of muscle explosiveness, i.e. explosive isometric muscle force, are also shown in the function of gender, that is, they are represented in terms of gender dimorphism, where the gender dimorphism index (IPD) is calculated as a ratio of the given result of the girls relative to the given result of the boys, multiplied by 100 (Dopsaj et al., 2015).

Statistical analysis

For the purposes of this paper, in the first step of the analysis all raw data obtained by laboratory testing were subjected to descriptive statistical analysis in

order to define the basic measure of central tendency (MEAN), indicators of data dispersion - standard deviation and coefficient of variation (SD, cV%) and results span indicators – minimum and maximum (MIN, MAX). For the purposes of determining the differences between the tested variables in the function of gender, the methods of multivariate (MANOVA) and univariate (ANOVA) statistical analyses were used. All analyses were carried out using Microsoft Office Excel 2007 and IBM SPSS Statistics v23.0 software packages, while the statistical significance level was defined based on the 95.0% probability criterion for $p \leq 0.05$.

RESULTS

Table 2 shows the descriptive statistics in relation to the tested variables by gender of the participants

Table 2. Basic descriptive indicators of the tested sample in relation to gender

Variable	Boys					Girls				
	Mean	SD	cV%	Min	Max	Mean	SD	cV%	Min	Max
RFD_{max}–ŠL (N/s^{-1})	2253.9	558.50	2.48	1776	3298	990.67	51.16	5.16	953	1063
$RFDF_{max}$–ŠL (N/s^{-1})	425.7	186.21	4.37	246.80	832.28	272.69	134.11	49.18	136.17	454.98
RFD_{max}–ŠD (N/s^{-1})	2369.2	679.56	2.87	1779	3999	1177.33	69.21	5.88	1123	1275
$RFDF_{max}$–ŠD (N/s^{-1})	458.5	172.20	3.76	232.5	807.69	378.34	180.21	47.63	212.85	628.93
RFD_{max}–MRT (N/s^{-1})	6231.0	3036.07	4.87	3673	13679	3322.33	386.92	11.65	2829	3774
$RFDF_{max}$–MRT (N/s^{-1})	935.5	292.12	3.12	554.70	1364.71	585.78	162.61	27.76	446.13	813.83
RFD_{max}–NOGE (N/s^{-1})	4919.67	1390.14	2.83	3329	7425	2298	272.99	11.88	1999	2659
$RFDF_{max}$–NOGE (N/s^{-1})	1059.57	550.35	5.19	466.4	2183.98	724.21	43.81	6.05	668.75	775.86
RFD_{max}–LIST (N/s^{-1})	12314.4	1821.38	1.48	9819	15997	8840.33	2627.62	29.72	5738	12163
$RFDF_{max}$–LIST (N/s^{-1})	2839.53	890.41	3.14	1834.9	5048.1	2277.07	421.51	18.51	1856.82	2853.32
RFD_{max}–$ŠL_{–SMM}$ ($N/s^{-1kgSMM}$)	61.85	9.55	15.44	52.67	77.38	36.9	6.04	16.36	29.50	44.29
$RFDF_{max}$–$ŠL_{SMM}$ ($N/s^{-1kgSMM}$)	11.60	4.47	38.5	7.03	22.02	10.65	6.16	57.9	4.22	18.96
RFD_{max}–$ŠD_{SMM}$ ($N/s^{-1kgSMM}$)	64.8	11.39	17.57	53.08	88.67	43.36	3.17	7.32	39.47	47.25
$RFDF_{max}$–$ŠD_{SMM}$ ($N/s^{-1kgSMM}$)	12.73	4.60	36.15	6.62	21.89	13.22	4.53	34.28	8.87	19.47
RFD_{max}–MRT_{SMM} ($N/s^{-1kgSMM}$)	167.75	60.73	36.2	97.17	303.30	124.91	28.66	22.94	87.59	157.25
$RFDF_{max}$–MRT_{SMM} ($N/s^{-1kgSMM}$)	25.93	7.78	30.01	16.71	40.81	22.31	8.49	38.07	13.81	33.91
RFD_{max}–$NOGE_{SMM}$ ($N/s^{-1kgSMM}$)	136.42	35.25	25.84	88.07	201.22	86.34	19.96	23.12	61.89	110.79
$RFDF_{max}$–$NOGE_{SMM}$ ($N/s^{-1kgSMM}$)	28.68	12.36	43.1	14.05	49.76	27.05	4.80	17.76	20.70	32.33
RFD_{max}–$LIST_{SMM}$ ($N/s^{-1kgSMM}$)	341.04	25.51	7.48	295.66	375.81	319.09	69.34	21.73	221.54	376.56
$RFDF_{max}$–$LIST_{SMM}$ ($N/s^{-1kgSMM}$)	61.85	9.55	15.44	52.67	77.38	82.8	7.86	9.49	71.69	88.38

Table 3 shows the results of analyses of differences (MANOVA & ANOVA) between the tested groups in the function of gender. Based on the presented results of MANOVA, it can be argued that there is a statistically significant difference between the absolute values of basic and specific explosive isometric muscle force variables (Wilks' Lambda Value 0.000, F = 898.61, p = 0.000), as well as between the partialized values of the basic and specific explosive isometric muscle force (Wilks' Lambda Value 0.001, F = 325.71, p = 0.000), for the tested cadet age judo athletes in the function of gender.

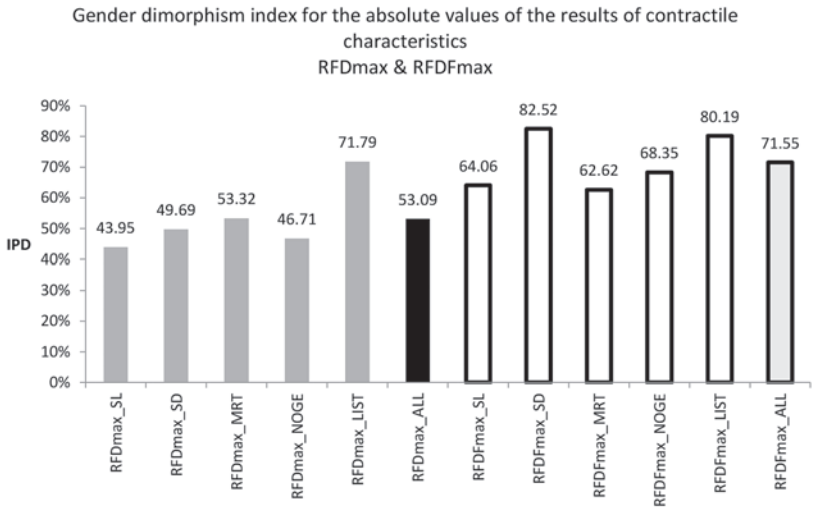
The highest level of difference between the male and female athletes in relation to the absolute values was determined for the variables of the specific explosive isometric muscle force of the left hand flexor muscles (RFD_{max}–ŠL, p = 0.001, Eta^2 = 0.618, i.e. 61.8%), for the leg extensor muscles (RFDmaxNOGE, p = 0.003, Eta^2 = 0.527, i.e. 52.7%), and for the right hand flexor muscles (RFD_{max}ŠD, p = 0.005, Eta^2 = 0.493, i.e., 49.7%).

In relation to the values of the variables partialized based on the pure contractile tissue, i.e. skeletal muscle mass, the highest level of difference was determined for the variables of the specific explosive isometric muscle force for the left hand (RFD_{max}–$ŠL_{SMM}$, p = 0.000, Eta^2 = 0.657, i.e. 65.7%), for the right hand (RFD_{max}–$ŠD_{SMM}$, p = 0.003, Eta^2 = 0.523, i.e. 52.3%), and for leg extensor muscles (RFD_{max}–$NOGE_{SMM}$, p = 0.022, Eta^2 = 0.367, i.e. 36.7%), while other variables did not show statistically significant differences.

Table 3. Results of MANOVA and ANOVA for the tested variables in relation to gender

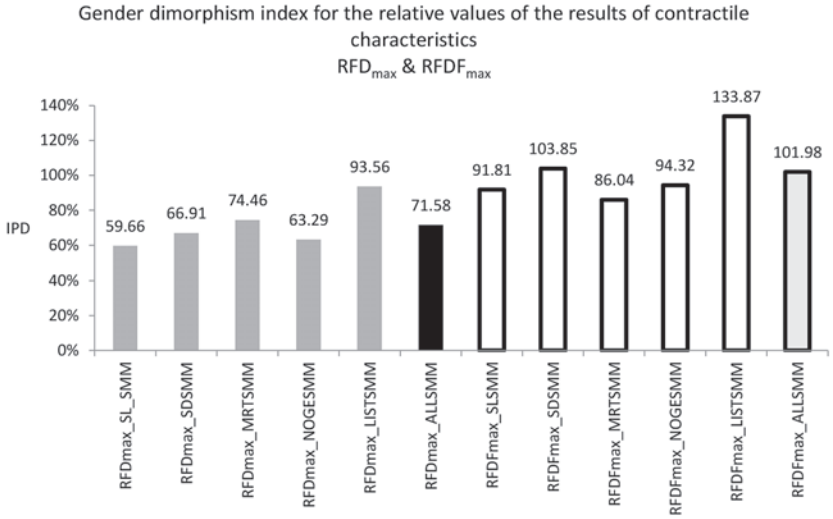
MANOVA – multivariate test						
	Effect	Value	F	p	Partial Eta^2	Observed Power
Gender – absolute values	Wilks' Lambda	0.000	898.61	0.000	1.000	1.000
Gender – relative values (SMM)	Wilks' Lambda	0.001	325.71	0.000	0.999	1.000
ANOVA – Test of Between – subjects Effects						
	Variable	Mean Square	F value	p	Partial Eta^2	Observed Power
Gender – absolute values	RFD_{max}–ŠL	4559229.6	19.44	0.001	0.618	0.981
	$RFDF_{max}$–ŠL	66886.0	2.19	0.164	0.154	0.276
	RFD_{max}–ŠD	4058854.6	11.68	0.005	0.493	0.880
	$RFDF_{max}$–ŠD	18365.1	0.61	0.452	0.048	0.111
	RFD_{max}–MRT	24172405.1	3.48	0.087	0.225	0.404
	$RFDF_{max}$–MRT	349422.4	4.95	0.046	0.292	0.534
	RFD_{max}–NOGE	19637531.8	13.38	0.003	0.527	0.918
	$RFDF_{max}$–NOGE	321320.5	1.41	0.258	0.105	0.195
	RFD_{max}–LIST	34484137.2	8.18	0.014	0.405	0.747
	$RFDF_{max}$–LIST	903885.1	1.41	0.257	0.105	0.195
Gender – relative values (SMM)	RFD_{max}–$ŠL_{SMM}$	1778.5	22.95	0.000	0.657	0.992
	$RFDF_{max}$–$ŠL_{SMM}$	2.6	0.11	0.750	0.009	0.060
	RFD_{max}–$ŠD_{SMM}$	1313.8	13.17	0.003	0.523	0.914
	$RFDF_{max}$–$ŠD_{SMM}$	0.7	0.03	0.858	0.003	0.053
	RFD_{max}–MRT_{SMM}	5244.4	1.77	0.209	0.128	0.232
	$RFDF_{max}$–MRT_{SMM}	37.4	0.59	0.457	0.047	0.109
	RFD_{max}–$NOGE_{SMM}$	7166.8	6.95	0.022	0.367	0.678
	$RFDF_{max}$–$NOGE_{SMM}$	7.6	0.06	0.806	0.005	0.056
	RFD_{max}–$LIST_{SMM}$	1376.9	0.82	0.384	0.064	0.132
	$RFDF_{max}$–$LIST_{SMM}$	64.8	0.26	0.620	0.021	0.076

The results of the obtained gender dimorphism index (IPD) values in relation to the absolute and partialized (relative) values of the measured explosiveness (basic and specific) for the applied tests are shown in Chart 1 and Chart 2. Based on the obtained absolute values, it can be argued that a greater difference in specific explosiveness between males and females (IPD RFD_{max}_ALL = 53.09%) was determined, compared to the level of basic explosiveness (IPD $RFDF_{max}$_ALL = 71.55%).



Graph 1. IPD in relation to the absolute values of the explosive isometric muscle force (explosiveness)

As in the case of absolute IPD values (Graph 1), based on the obtained results of the partialized (relative) values of the explosive isometric muscle force (explosiveness) (Graph 2), it can be argued that a greater difference in specific explosiveness between males and females was determined (IPD RFD_{max}–ALL_{SMM} = 71.58%) comparing to the basic explosiveness differences (IPD $RFDF_{max}$–ALL_{SMM} = 101.98%).



Graph 2. IPD in relation to the partialized (relative) values of the explosive isometric muscle force (explosiveness)

DISCUSSION

Based on the results of descriptive statistical analysis, it can be concluded that all the measured values of the tested variables are in the acceptable range of variation of results because the coefficient of variation (cV%) for the absolute values is in the range of 1.48% (RFD_{max}_LIST) up to 5.19% ($RFDF_{max}$_NOGE) for boys, while in girls it the ranges from 5.16% (RFD_{max}–ŠL) up to 49.18% ($RFDF_{max}$_ŠL) (Table 1). Since most

variables, that is 75.0% of the variables, have extremely low level of variation, i.e. an extremely high level of homogeneity (15 variables have a variation below 10% or below 30%, for both males and females), while the other 25.0% have a coefficient of variation below 60.0%, at the general level it can be concluded that the measured results are homogeneous and representative in terms of valid scientific interpretation.

In relation to the achieved levels of development of the basic explosive isometric muscle force, i.e. $RFDF_{max}$ variable, it can be argued that for the boys subsample a maximum average value of 425.70 and 458.51 N/s^{-1} has been measured for the left and right hand, respectively. For the girls subsample basic explosive isometric muscle force of the left and right hand at the level of 272.69 and 378.34 N/s^{-1} respectively, has been measured (Table 2).

ANOVA has shown that in the case of these results there was no statistically significant difference between the absolute characteristics of the basic explosive isometric muscle force in relation to gender (Table 3, $RFDF_{max}$_ŠL - F value = 2.19, p=0.164; $RFDF_{max}$_ŠD - F value = 0.61, p=0.452).

If the obtained average value is analyzed in the context of gender dimorphism, it can be argued that the ratio of girls and boys results of the measured variable for the left and right hand is at the level of 64.05 and 82.52%, respectively (Chart 1), i.e. the value of the gender dimorphism index (IPD) is at an average level of 73.63%. In other words, the general level of muscle explosiveness of the hand flexor muscles in girls is at about 3/4 of the score achieved by boys.

For the back extensor muscles (Dead lift test), as one of the very important muscle groups from the aspect of judo sport, average $RFDF_{max}$ value of 935.49 N/s^{-1} in boys subsample and 585.78 N/s^{-1} in girls subsample was measured (Table 2). The results of ANOVA have shown that there is a statistically significant difference between the aforementioned absolute characteristics of explosiveness in relation to gender (Table 3, $RFDF_{max}$_MRT - F value = 4.95, p=0.046). The girls achieved a lower level of basic explosiveness by as much as 349.71 N/s^{-1}, with the achieved IPD level of 62.62% (Graph 1). In other words, the basic level of muscle explosiveness of the back extensor muscles in girls is at about 2/3 of the results achieved by boys.

The average value of the basic explosive isometric muscle force of the leg extensor muscles was at the level of 1059.57 N/s^{-1} in boys and 724.21 N/s^{-1} in girls (Table 2). The results of ANOVA have shown that there was no statistically significant difference between the measured explosiveness in relation to gender (Table 3, $RFDF_{max}$_NOGE - F value = 1.41, p = 0.258). As with the back extensor muscles, for the leg extensor muscles it was found that girls achieved a lower score for as much as 335.36 N/s^{-1}, with IPD level of 68.35% (Chart 1). For this muscle group, the basic explosiveness of the leg extensor muscles in girls was at the level of about 2/3 in relation to the boys.

For the ankle joint plantar flexor muscles the mean value of basic explosive isometric muscle force at the level of 2839.53 N/s^{-1} in boys and 2277.07 N/s^{-1} in girls was measured (Table 2). The results of ANOVA have shown that there was no statistically significant difference between the above mentioned absolute characteristics of explosiveness in relation to gender (Table 3, $RFDF_{max}$_LIST - F value = 1.41, p = 0.257). For the ankle joint plantar flexor muscles it was found that girls achieved a lower score for 562.46 N/s^{-1}, with the achieved IPD level of 80.19% (Chart 1). In case of this muscle group, the result achieved by girls is at the level of about 4/5 in relation to the results found in boys.

In relation to the achieved levels of development of the basic explosive isometric muscle force, but from the aspect of values partialized in relation to the skeletal muscle mass, for the handgrip test the results at the level of 11.60 and 12.73 $N/s^{-1kgSMM}$ for the boys subsample, and 10.65 and 13.2 $N/s^{-1kgSMM}$ for the girls subsample were measured, for left and right hand, respectively (Table 2). The results of ANOVA have shown that there is no statistically significant difference between the mentioned relative characteristics of explosiveness in relation to gender (Table 3, RFDFmax_ŠLSMM - F value = 0.10, p = 0.750; RFDFmax_ŠDSMM - F value = 0.03, p = 0.858). It was found that female subjects for the left hand achieved 0.95 $N/s^{-1kgSMM}$ lower partialized value of basic explosive isometric muscle force compared to boys, reaching the IPD level of 91.81%, while the partialized values achieved for the right hand grip were 0.49 $N/s^{-1kgSMM}$ higher than those found in boys, with an IPD level of 103.69% (Chart 2). These results indicate that after partialization in relation to the pure skeletal muscle mass, i.e. SMM, the gender difference in relation to the basic explosive isometric muscle force of the flexor muscles of the left and right hand is lost, that is, they are in the IPD summarized interval of 97.75%.

For the back extensor muscles (Dead lift test) the measured mean value of $RFDF_{max}$_MRT_{SMM} in boys was at the level of 25.93 $N/s^{-1kgSMM}$ while in girls it was

at the level of 22.31 $N/s^{-1kgSMM}$. When it comes to leg extensor muscles (Leg extension test), the measured relative value of the basic explosive isometric muscle force was at the level of 28.68 $N/s^{-1kgSMM}$ in boys and 27.05 $N/s^{-1kgSMM}$ in girls (Table 2). The results of ANOVA have shown that in both tests there was no statistically significant difference between the aforementioned relative characteristics of explosiveness in relation to gender (Table 3, $RFDF_{max}$–MRT_{SMM} - F value = 0.59, p=0.457; $RFDF_{max}$–$NOGE_{SMM}$ - F value = 0.6, p=0.806). In this test, the tested girls achieved 3.62 $N/s^{-1kgSMM}$ lower relative values of the basic explosive isometric muscle force, with the IPD reaching a level of 86.04 %, that is, the tested boys in the given test achieved 1.63 $N/s^{-1kgSMM}$ better result compared to girls, with the IPD of 94.32%, respectively (Chart 2). In this respect, it can be said that for the back extensor muscles, from the aspect of relative values, boys achieved about 1/6 better results than girls, while partialized results for the leg extensor muscles were very similar.

The results of partialized values of the basic explosive isometric muscle force for the ankle joint plantar flexor muscles (Sitting plantar flexion test) showed that this characteristic is at the level of 61.85 $N/s^{-1kgSMM}$ for the boys subsample and 82.80 $N/s^{-1kgSMM}$ for the girls subsample (Table 2). The results of ANOVA have shown that there is no statistically significant difference between the aforementioned relative characteristics of explosiveness in relation to gender (Table 3, $RFDF_{max}$–$LIST_{SMM}$ - F value = 0.259, p=0.620). Nevertheless, on this test girls achieved, on average 20.95 $N/s^{-1kgSMM}$ higher results, with the IPD at the level of 133.82%. In other words, when observed from the aspect of partialized values relative to the skeletal muscle mass (SMM), girls achieved about 1/3 better results than boys on the sitting plantar flexion test.

The achieved level of development of specific explosive isometric muscle force, i.e. variables (RFD_{max}), for the flexor muscles of the hand (Handgrip test) was at the average level of 2253.89 and 2369.22 N/s^{-1} in boys and 990.67 and 1177.33 N/s^{-1} in girls, for the left and right hand, respectively (Table 2). In relation to the partialized values the achieved results were at the level of 61.85 and 64.80 N/s^{-1} in boys and 36.90 and 43.36 N/s^{-1} in girls, for the left and right hand, respectively (Table 2). The results of ANOVA have shown that a statistically significant difference exists between the aforementioned characteristics of explosiveness in relation to gender for the absolute as well as for the partialized values of the obtained results (Table 3, RFD_{max}–ŠL - F value = 19.44, p=0.001; RFD_{max}–ŠD - F value = 11.68, p=0.005; RFD_{max}–$ŠL_{SMM}$ - F value = 22.949, p=0.000; RFD_{max}–$ŠD_{SMM}$ - F value = 13.17, p=0.003). Based on the presented results, it was found that the boys achieved 1263.22 N/s^{-1} better results for the left hand, i.e. 1191.89 N/s^{-1} for the right hand, and that the IPD value was 43.95% and 49.69%, respectively. In this respect, it can be said that the results achieved by boys are more than twice higher than the results achieved by girls.

For the back extensor muscles (Dead lift test) specific explosive isometric muscle force mean value at the level of 6231.00 N/s^{-1} and 3322.33 N/s^{-1} was measured for the boys and girls subsample, respectively (Table 2). The results of ANOVA have shown that there was no statistically significant difference between the absolute characteristics of explosiveness in relation to gender (Table 3, RFD_{max}–MRT - F value = 3.48, p=0.087), that is, the difference is at the boundary level for the 90.0% probability. The absolute mathematical difference of the measured results of the given variable of 2908.67 N/s^{-1} in favor of the boys, and the IPD value of 53.31% indicates that in the case of this muscle group, boys achieved approximately double the results compared to girls.

For the leg extensor muscles (Leg extension test) the measured mean value of specific explosive isometric muscle force is at the level of 4919.67 N/s^{-1} and 2298.00 N/s^{-1} for boys and girls, respectively (Table 2). The results of ANOVA have shown that there is a statistically significant difference between the aforementioned absolute characteristics of explosiveness in relation to gender (Table 3, RFD_{max}–NOGE - F value = 13.38, p=0.003). From the aspect of absolute indicators, the boys on average achieved 2621.67 N/s^{-1} better results, with the IPD at the level of 46.71%. In other words, in this case, the difference achieved indicates about twice the better results in boys.

For the ankle joint plantar flexor muscles (Sitting plantar flexion test) the measured mean value of specific explosive isometric muscle force was at the level of 12314.40 N/s^{-1} in boys and 8840.33 N/s^{-1} in girls (Table 2). The results of ANOVA have shown that there is a statistically significant difference between these results (Table 3, RFD_{max}–LIST - F value = 8.183, p=0.014). Girls achieved a lower level of absolute value of specific explosive isometric muscle force for

3474.07 N/s^{-1}, with the achieved IPD level of 71.78% (Graph 1). In other words, the achieved RFD_{max} values for the girls subsample were 2/3 of the values achieved by boys.

For the back extensor muscles (Dead lift test) the mean partialized value of specific explosiveness at the level of 167.75 $N/s^{-1kgSMM}$ was measured in boys, while for the girls measured mean value was at the level of 124.91 $N/s^{-1kgSMM}$ (Table 2). The results of ANOVA have shown that there was no statistically significant difference in relation to gender (Табела 3, RFD_{max}–MRT_{SMM} - F value = 1.765, p=0.209), although girls of a given age achieved a lower level of specific explosiveness for 42.84 $N/s^{-1kgSMM}$, with the achieved IPD level of 74.45% (Chart 2). The specific level of explosiveness of the back extensor muscles partialized in relation to the skeletal muscle mass (SMM) found in girls was at about 3/4 of the results measured in boys.

For the leg extensor muscles (Leg extension test) partialized value of specific explosiveness in boys was at the level of 136.42 $N/s^{-1kgSMM}$, while for the girls it was at the level of 136.42 $N/s^{-1kgSMM}$ (Table 2). A statistically significant difference was found between these results (Table 3, RFD_{max}–$NOGE_{SMM}$ - F value = 6.95, p=0.022). As in the case of back extensor muscles, for the leg extensor muscles girls achieved lower relative value of a given variable for 50.08 $N/s^{-1kgSMM}$ with the achieved IPD value of 63.29% (Chart 2). In the case of this muscle group, the relative value of specific explosiveness in girls was approximately 2/3 relative to the results measured in boys.

The average value of the specific explosive isometric muscle force of the ankle joint plantar flexor muscles (Sitting plantar flexion test) was 341.04 $N/s^{-1kgSMM}$ in boys, and 319.09 $N/s^{-1kgSMM}$ in girls (Table 2). There was no statistically significant difference between these relative explosiveness characteristics in relation to gender (Table 3, RFD_{max}–$LIST_{SMM}$ - F value = 0.815, p=0.384). The girls achieved a 21.95 $N/s^{-1kgSMM}$ lower value, with the achieved IPD level of 93.56% (Graph 2). However, in the case of this muscle group, the average value of the relative level of specific explosiveness of the ankle joint plantar flexor muscles in girls was very similar to the values found in boys.

On the basis of all of the fore mentioned, it can be concluded that, in all tested muscle groups, boys have significantly higher absolute values of basic explosive isometric muscle force than girls. The results of this study have shown that IPD values range from 62.62% for the back extensor muscles up to 82.52% for the finger flexor muscles of the right (dominant) hand. On a general level girls on average achieved 71.55% of basic explosiveness in realtion to boys (Graph 1). These results are very similar to the results of previously published research that dealt with inter gender power differences of different muscle groups (Chen et al., 2012), where it has been found that girls at the general level account for 37-68% of the muscle power achieved by men, with lower results achieved for all of the tested muscle groups. In the context of the results obtained by this study, it is important to point out the fact that smaller inter gender differences in exerted power have been found in the extensor muscle groups of the lower extremities, where girls achieve results at the level of 65% of the value of the results achieved by men (Chen et al., 2012) which, although concerning different properties, somewhat correlates with the findings of our study.

However, when the results are considered from the aspect of values partialized relative to the skeletal muscle mass (SMM), the observed differences between the tested boys and girls are drastically reduced, indicating a relatively equal contractile potential in the function of pure muscle mass, regardless of the gender of the participants. In this respect, the absolute values total IPD of 71.55% (IPD $RFDF_{max}$–ALL), and relative IPD value of 101.98% (IPD $RFDF_{max}$–ALL_{SMM}) can be indicative (Graph 2). This can be explained by the higher percentage of muscle mass in the body composition of boys (PSMM% = 54.66±1.42) compared to girls (PSMM% = 49.99±3.81), and by the fact that girls have lower total body mass, and hence, lower absolute muscle mass. Also, these results correlate with the previously determined fact that men and women have relatively small differences in RFD in conditions of maximal voluntary contraction (Kent-Braun & Alexander, 1999), i.e. explosive isometric muscle force exerted without involving the external muscle electro stimulation in terms of increasing the level of achieved activation.

It is necessary to considering that even with relative indicators of the basic explosive isometric muscle force of the ankle joint extensor muscles (plantar flexors), it has been established that the IPD is at the level of 133.82%, indicating that the tested girls on average achieved 1/3 better results than boys in the given test.

Also, one of the possible explanations for the determined differences in the parameters of basic and specific explosive isometric muscle force, regardless of the muscle group observed, relates to the previ-

ously established differences in the percentage of different type muscle fibers and the differences in the overlapping area of myofilaments in muscle fibers in favor of men (Staron et al., 2000; Kent-Braun & Alexander, 1999), which could have caused an absolute higher potential for expressing explosiveness in boys. Second potential cause of the inter gender differences can be the established difference in the distribution of contractile tissue between the upper and lower part of the body. A higher percentage share of contractile tissue in the lower part of the body in women (Janssen et al., 2000) was determined, but also a higher percentage of muscle mass in the male body composition and an absolute higher skeletal muscle mass in boys.

Possible reason for the determined values of the specific explosive isometric muscle force of the fingers flexor muscles of the left and right hand, both from the aspect of absolute and relative values, in addition to the greater distribution of muscle mass in the cranial part of the body in men (Janssen et al., 2000), most likely indicate the presence of a specific adaptation as a consequence of judo training, given the fact that the absolute values of RFD_{max} at the level of 4623.1 N/s^{-1} for both left and right hand have been found. The average absolute values of specific explosive isometric muscle force at the level of 5197.6 N/s^{-1} and 4040.4 N/s^{-1} for both hands have been determined by previous study which examined adult trained wrestlers and moderately active subjects (Marković et al., 2016). Based on the comparison of the previous results with the results of this research, it can be argued that cadet judo athletes on the handgrip test achieve results at the level of 88.94% compared to adult wrestlers and 114.42% compared to adult moderately active participants. This can be interpreted as the direct influence of judo training.

CONCLUSION

The aim of this paper is to define descriptive characteristics as well as the parameters of the difference in explosive isometric muscle force in systemically trained and selected cadet age judo athletes, both from the aspect of the absolute values and from the aspect of the values partialized relative to the skeletal muscle mass (SMM). The basic method used in this research was the laboratory testing method using tensiometric probes. The research sample in this study consisted of 14 cadet age judo athletes, of which 10 boys and 4 girls. Explosive isometric muscle force was analyzed in relation to its basic ($RFDF_{max}$) and specific (RFD_{max}) dimension, while the following five muscle groups were tested: flexor muscles of the left (ŠL) and the right hand (ŠD), back (MRT) and leg extensor muscles (NOGE) and the ankle joint plantar flexor muscles (LIST).

On the basis of the obtained results, it can be argued that a general, statistically significant, difference exists in the tested cadet age judo athletes in the function of gender, both considering the absolute values of the variables of general and specific explosive isometric muscle force (Wilks' Lambda Value 0.000, F = 898.61, p = 0.000), as well as between the partialized (relative) values of basic and specific explosive isometric muscle force (Wilks' Lambda Value 0.001, F = 325.71, p = 0.000).

The highest level of inter gender difference considering the absolute values of the measured explosiveness was determined for the variables of the specific explosive isometric muscle force for the left hand (RFD_{max}–ŠL, p=0.001, Eta^2=0.618, i.e. 61.8%), followed by leg extensor muscles (RFD_{max}NOGE, p=0.003, Eta^2=0.527, i.e. 52.7%) and the right hand flexor muscles (RFD_{max}ŠD, p=0.005, Eta^2=0.493, i.e. 49.7%). Considering the values of the variables partialized in relation to skeletal muscle mass (SMM), the highest level of difference was determined for variables of specific explosive isometric muscle force of the left hand (RFD_{max}–$ŠL_{SMM}$, p=0.000, Eta^2=0.657, i.e. 65.7%), right hand ($RFD_{max}ŠD_{SMM}$, p=0.003, Eta^2=0.523, i.e.. 52.3%) and the leg extensor muscles (RFD_{max}–$NOGE_{SMM}$, p=0.022, Eta^2=0.367, i.e. 36.7%).

The total value of the gender dimorphism index (IPD) for absolute basic ($RFDF_{max}$) and specific (RFD_{max}) explosive isometric muscle force was at the level of 71.55 and 53.09%, respectively, which means that the tested girls reached 71.55% and 53.09% of the given contractile characteristic relative to the tested boys. However, when the measured variables are partialized relative to the SMM, the differences in the function of the gender are reduced to 101.98 and 71.58%.

These results have shown that there are methodological indications of scientific justification in relation to the partialization of the results of explosive isometric muscle force, as a measure of development of the contractile muscle potential responsible

for the most intensive expression of muscle force in the unit of time, in relation to skeletal muscle mass i.e. the mass of pure contractile tissue in the organism. In this way, the level of sensitivity of the variable itself is increased in terms of determining the real functional differences between the genders. The assumption is that this method of partialization of the results could be more sensitive in relation to determining the differences in contractile abilities and in relation to other criteria such as age, competitive efficiency, training period, etc.

Generally speaking, the results of this research present the initial quantitative values of the measured contractile characteristics, which can serve as initial standards in the function of evaluation and in function of defining qualitative assessments for assessing the level of fitness of athletes, which will increase the knowledge base in the system of preparation of young judo athletes, i.e. it will contribute the improvement of the existing technology of sports preparation in judo sport.

Limitations

This study was conducted on a relatively small sample of participants consisting of 10 male and 4 female judo athletes who were all members of the cadet selection of the same judo team. This somewhat diminishes the possibility of generalization of the findings and points to the need for further systematic investigation of the characteristics of explosive isometric muscle force, and muscle force in general, with the inclusion of a larger number of subjects in the sample.

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FUERZA (POTENCIA) EXPLOSIVA DE DISTINTOS GRUPOS MUSCULARES DE LOS JUDOCAS DE EDAD DE CADETE EN LA FUNCIÓN DEL SEXO

Resumen
El objetivo del presente trabajo es establecer la diferencia entre la fuerza (potencia) explosiva en judocas varones y judocas hombres de la edad de cadete. Los resultados de las capacidades contráctiles medidas se obtuvieron aplicando las baterías de pruebas estándar, utilizando el método de dinamometría isométrica, para los cinco grupos musculares como sigue: el músculo flexor de dedos de las manos izquierda y derecha, el extensor de la musculatura dorsal-lumbar, el extensor de piernas y extensor de tobillo. La medición abarcó una muestra de 14 examinados y examinadas en total que compitieron en el sistema del campeonato nacional individual de la República de Serbia para la determinada edad. Sobre la base de los resultados obtenidos se puede afirmar que existe una diferencia general estadísticamente considerable de los judocas examinados en función del sexo, tanto entre los valores absolutos de las variables de fuerza (potencia) explosiva general y específica, en el nivel Wilks' Lambda Value 0.000, F=898.61, p=0.000, como también entre los valores parcializados (relativos) de las variables medidas en el nivel Wilks' Lambda Value 0.001, F=325.71, p=0.000. El mayor nivel de diferencia entre los sexos y en relación con los valores absolutos, se estableció en las variables de la fuerza (potencia) explosiva específica en la mano izquierda (RFDmax_MI, p=0.001), para los músculos extensores de piernas (RFDmax_PIERNAS, p=0.003), así como también para la mano derecha (RFDmax_MD, p=0.005). En relación con los valores parcializados de las variables sobre la base de la masa muscular de esqueleto (MME), el mayor nivel de diferencia se estableció en las variables de la fuerza (potencia) explosiva específica para las manos izquierda y derecha, respectivamente (RFDmax_MIMME, p=0.000; RFDmax MDMME, p=0.003). El valor sumado del índex de dimorfismo sexual (IDS) para la fuerza (potencia) explosiva absoluta general (RFDFmax) y específica (RFDmax) está en nivel de 71.55 y 53.09%, lo que significa que las muchachas examinadas alcanzaron 71.55% y 53.09% de las características contráctiles dadas en relación con los muchachos examinados. Sin embargo, parcializando las variables medidas en relación con la MME, las diferencias mencionadas en función del sexo disminuyen al nivel de 101.98 y 71.58%. Observando generalmente, los resultados obtenidos demostraron que existen las indicaciones metodológicas de justificación científica en relación con la parcialización de los resultados de la fuerza explosiva, como medida del desarrollo de la potencialidad muscular contráctil para la expresión más intensa de la potencia muscular por unidad de tiempo en relación con la masa muscular de esqueleto.

Palabras claves: JUDO/ CADETES / DINAMOMETRÍA ISOMÉTRICA / FUERZA (POTENCIA) EXPLOSIVA

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EFFECTS OF PROPRIOCEPTIVE TRAINING ON EXPLOSIVE STRENGHT, AGLILITY AND COORDINATION OF YOUNG RHYTHMIC GYMNASTS

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Abstract

The aim of this study was to examine the influence of proprioceptive training on explosive strength, agility and coordination in young rhythmic gymnasts. The study was conducted on a sample of 74 healthy girls, aged 7 to 9 years of age who train rhythmic gymnastics. The whole sample was divided into two groups: experimental (43 girls) and control (31 girls). The experimental group had the proprioception training before their regular trainings for 12 weeks (24 trainings), while the control group had only rhythmic gymnastics trainings. Effects of proprioceptive trainings on the examined motor abilities were estimated by two explosive strength tests, three coordination tests and two agility tests. All respondents were tested before the application of the experimental treatment (pre-test) and after its completion (post-test). To examine differences in the achieved results between the initial and final measurement for each group, t-test for dependent samples was used. To determine differences between groups at the initial and final measurement, t-test for independent samples was used. By comparing results from the initial and final measurement, improvement in all tests for the observed abilities was perceived in the experimental group, while improvement in coordination tests and one agility test was noticed in the control group. Testing differences in results between groups in the final measurement showed that there are differed only in agility tests, and in favour of the experimental group. Based on the obtained results, the conclusion was that the application of proprioceptive training in rhythmic gymnasts can contribute to improvement of agility, while in other observed abilities we cannot conclusively claim that improvement was the direct product of proprioceptive training.

Key words: PROPRIOCEPTIVENESS/ RHYTHMIC GYMNASTIC/ GIRLS

INTRODUCTION

Motor abilities are in the basis of every physical activity, from usual, everyday movements to performance of various sport techniques. They significantly contribute to biological but also to psychological and social aspects of life, and care of their development multiplies the invested effort through health improvement and building of emotionally stable personality with an adequate social status.

Given the importance of motor abilities, they are often subject for research. Professionals constantly search for different training methods and types of training that can contribute to their improvement, especially in the period of growth and development. Proprioceptive training is the type of training whose influence on different motor abilities has not been fully investigated. It is directed towards the stimulation of proprioceptors with the aim to provoke adequate motor response, which primarily contributes to stability of joints and balance of the whole body, and then also more precise and more efficient performance of all kinds of movements. This improves proprioception itself as well as a series of other motor abilities, which, thanks to the timely reception of stimuli from proprioceptors, can be expressed more efficiently. The most important for the efficiency of expressing motor abilities are stimuli emerging from intrafusal muscle fibres, the so called "muscle spindles", Golgi tendon organs and Pacinian corpuscles.

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These receptors react to the changes in tension and length of muscles and tendons, at speed of these changes, as well as changes in posture of the body and parts of the body (Harris & Dudley 2000; Lephart & Fu 2000). Excitation of these receptors are transferred along afferent pathways to lower or higher level of the central nervous system, so that the timely activation of the adequate motor units enables sustaining stability of the body during static and dynamic activities (Laskowski, Newcomer-Aney, & Smith, 1997).

Proprioceptive training was first used in rehabilitation, most often in ankle and knee injuries. It was found that its application improved the functional stability of joints, that it contributed to improvement of the clinical picture in disturbed postural status and significantly reduces the frequency of repeated injuries (Irrgang et al., 1994; Weste et al., 1996; Bernier & Perrin, 1998; Elis & Rosenbaum, 2001; Vad et al., 2002; Liu Ambrose et al., 2003). It was very quickly accepted in elite sports primarily as a prevention of injuries. A large number of authors emphasizes that the improvement of neuro-muscle response to excitation of kinaesthetic receptors can be a key factor in the effective reduction of the risk from injuries (Gauffin, Tropp & Odenrick, 1988; Sheth et al., 1997; Robbins & Waked, 1998; Eils, Schröter et al., 2010). Conscious movements initiated in the cerebral cortex are too slow to prevent an injury in urgent situations, and it is estimated that the spinal reflexes are those that contribute to quicker and timely activation of the stabiliser muscles (Laskowski et al., 1997).

In healthy persons positive effects of this training are primarily reflected in the improvement of the ability to keep the balance i.e., in reduction of postural oscillations (Hoffman & Payne, 1995), while its influence on different motor abilities is not completely researched. Most authors examined the influence of proprioceptive training on the ability to balance and they all emphasize its positive influence on this ability, both in adults (Gioftsidou et al., 2006; Yaggie & Campbell, 2006; Granacher, Gollhofer & Kriemler, 2010; Romero-Franco et al., 2012), and in children (Dobrijević, Moskovljević and Dabović, 2016). When it comes to strength, various authors agree that the application of proprioceptive training has no influence on this motor ability, but that it positively affect the rate of force development (Gruber & Gollhofer, 2004; Granacher et al., 2010).

Findings of different authors considering influence of proprioceptive training on the explosive strength and agility are different, often even opposed (Yaggie & Campbell, 2006; Cressey et al., 2007; Šimek, Milanović & Jukić. 2008; Granacher et al., 2010). There are insufficient data on influence of proprioceptive training on coordination (Lukić, 2010), and the existing ones do not offer clear answer to this question.

There are few data on the influence of proprioceptive training on the development of motor abilities in athletes, i.e. its place in the fitness preparation of athletes. Dobrijević et al. (2016) point out that the application of proprioceptive training in young rhythmic gymnasts can significantly contribute to the development of balance as one of crucial motor abilities for success in this sports branch. Some authors who investigated the influence of proprioceptive training on the specific sports technique (Wolf-Cvitak et al., 2002; Šebić-Zuhrić, Rađo and Bonacin, 2007), noted that, relying on the kinaesthetic feeling, learning certain movements in sports, such as rhythmic gymnastics, can significantly be sped up and that proprioceptive training represents a significant means for improvement of specific technique in rhythmic gymnastics.

Given that the influence of proprioceptive training on the explosive strength, agility and coordination is not completely examined, that the previous studies dealt with the sample of adults, and that there are data on the influence of this training on the specific technique, but not on the motor abilities in rhythmic gymnastics, there came the idea on realisation of this study. The aim of this study was to examine the influence of proprioceptive training on agility, coordination and explosive strength of leg muscles in young rhythmic gymnasts.

METHOD

This research represents a longitudinal study conducted on a sample of girls who train rhythmic gymnastics to examine the effects of proprioceptive training on agility, coordination and explosive strength of legs.

Samples

The sample of respondents was comprised of 74 healthy girls (aged 8±0.8) who have been training rhythmic amateur gymnastics in the "In" Gymnastic Club in Belgrade. All girls have been involved in this type of training for 1-2 years, and their training sessions are 60 minutes twice a week. Using the random sample method, they were divided into two groups, experimental (E) – 43 girls and control (K) – 31 girls. Girls and their parents were informed about all details of the study, and the parents provided the written consent for participation of girls in the study.

Experimental protocol

All respondents were tested before the commencement of the experiment (initial measurement-T1) and after 12 weeks of the application of the experimental treatment (final measurement – T2). The sample of variables encompassed two variables for agility assessment, three for coordination and two for explosive leg strength assessment. All variables were measured with standardized tests whose validity and reliability had already been confirmed:

- Agility – *20 yards test* (20Y) (Milanović, 2003) and *Lateral agility test* – change of direction lateral test (LAT) (Metikoš et al., 1989),
- Coordination – *Twisting/agility in the air* (OuV) (Kurelić et al. 1975), *Figure eight with bending and jumping* (OsS) (Eurofit, 1988), *Jumping over and pulling under* (PiP) - (Metikoš et al., 1989),
- Explosive strength of leg muscles – *Countermovement jump* (CMJ) (Enoksen, Tonnessen & Shalfawi, 2009) and *Standing long jump* test (LJ) (Eurofit, 1988).

Testing

The respondents were familiar with the test protocol before the beginning of measurement. Each respondent had one trial, followed by two measurements, and a better result was used for the analysis. Breaks between trials were 3-5 minutes, which was enough for the respondent recovery and to avoid a potential influence of fatigue in the subsequent performance (Spencer et al., 2008). Before each test, the respondents were instructed to finish the given task as quickly as possible in agility and coordination tests, while in explosive strength tests they were given instructions to jump as high as possible (CMJ), or as long as possible (LJ). All tests were completed in the morning hours in the sport centre hall "Novi Beograd". During testing the respondents wore sports outfit.

20 yards test (20Y) is done by 20-yard-run at maximum speed with one 90^0 turn and two 180^0 turns. In the initial position, the respondent is turned laterally in the direction of movement. The respondent starts from the middle; she runs to the right marker cone (5y=4.55m), then to the left marker cone (10y=9.1m), and at the end to the one in the middle (5y=4.55m). *Lateral agility test (LAT)* is done by moving sideways (sideway steps) with maximum speed along the 4-meter drawn path. The respondent stands behind the start line, turned laterally in the direction of movement. She starts at the sign made by the person who measures time and moves along the path for 6 times (6x4m), without changing the orientation in space (only the direction of movement is changed).

Jumping over and pulling under (PiP) is done in the space 7.5m long, where at each 1.5m there is one segment of vertical vaulting box placed, the total of four, and 1.5m behind the last segment there is the line for turning back. The respondent stands behind the start line and at the sign made by the person who measures time, she starts moving. She jumps over the first and crawls under the second to get through in both directions.

Twisting/agility in the air (OuV) is done when the respondent starts moving from the position sitting on 4 medicine balls, facing the opposite direction to the direction of movement. At the sign of the person who is measuring, the respondent has to do backward roll as quickly as possible, stands up, and performs a forward roll over the medicine balls without touching them. After the forward roll, the respondent turns round for 180^0 and touches all 4 medicine balls with her palms.

Figure eight with bending and jumping (OsS) is performed by moving between three posts placed in a line at the distance of 2.5m. The elastic tape is stretched between them, at hip height of the respondent between the first and the second, and at the knee height between the second and the third. The respondent should go round the post for as short time as possible bending down under the

elastic tape placed at hip height and jumping over the elastic tape placed at knee height.

Long jump (LJ) is done on a flat, non-slippery surface marked with a place for jumping and for take-off. The task for the respondent is to jump as long as possible, and the distance is measured from the jump line from the place where the respondent touches the ground with her heels. *Countermovement jump, CMJ* is done on a contact surface (Newtest Powertimer, 300-series). The respondent stands upright on the surface with her feet as wide apart as hips. Then she performs countermovement jump with arm swing.

Experimental program of proprioceptive training model

In the period of 12 weeks (24 trainings), the experimental group had proprioceptive training before their regular rhythmic gymnastics trainings, while the control group had only regular trainings for that time. The proprioceptive training started 15 minutes before regular rhythmic gymnastics trainings, and partially continued during the regular training. This type of organization was applied because of the scope of work in the experimental and the control group, which was achieved because the time of active exercises and rest alternated in equal time intervals in proprioceptive training. The program of proprioceptive training was realized using various boards for this kind of training, such as T-board, wobble board, balance board, then with Pilates balls, low balance beam, soft mat. The participants were asked to maintain the balanced position for as long as possible on proprioceptive boards in unstable conditions, participants used the beam to perform exercise on the small surface of support, and the mat was used to stimulate the proprioceptrs by changing the quality of surface (performing exercise on hard and subsequently on soft surface). Different tasks were done with eyes open and closed, on one or both legs, and in later phases specific technique of rhythmic gymnastics was introduced (for example, balancing with a ball, rotating hoop or rope, throwing and catching...) all with the aim of making tasks more complex and increasing stimulation of proprioceptors. Proprioceptive training included warming up for 5 to 7 minutes and the main phase of the training organized by the method of stations. During each training session the respondents had 3 tasks done in 3 series with equal time of exercising and recovery between series (Jukić et al., 2003). The girls were most often organized in pairs, so that one was doing the exercise while the other had a rest. The contents of this program were realized at the beginning of the training, and the total duration of the active phase of proprioceptive training per respondent was not longer than 10 minutes, so that there would be no nervousness and muscular fatigue. A special attention was directed towards concentration of respondents at doing tasks, because it increased efficiency of flow of stimuli in central nervous system (Voight and Cook, 1996), which contributes to a greater efficiency of exercising.

Statistical data processing

Data collected in this study were arranged and processed in statistical procedures of Microsoft excel program, version 15 and SPSS 22.0. From the field of descriptive statistics, the arithmetic mean (Mean), standard deviation (SD) and standard error of the measurement (SEM) were calculated for each variable. Shapiro-Wilks test was used for testing normal distribution. From the field of comparative statistics, t-test for independent samples was used to determine differences in results between the control and experimental group separately for initial and final measurement, as well as the t-test for dependent samples to determine differences in results between the initial and final measurement.

RESULTS

Testing differences between groups at the initial measurement (Table 1) showed that they do not differ in any of the applied tests.

Table 1. Testing differences between groups at the initial and final measurement *(t-test for independent samples)*

	Initial measurement				Final measurement			
	E	K			E	K		
Tests	Mean ± SD	Mean ± SD	t	*p*	Mean ± SD	Mean ± SD	t	*p*
20Y (sec)	7.94 ± 0.64	8.16 ± 0.52	-1.496	0.14	7.62 ± 0.66	8.30 ± 1.04	-2.922	**0.01**
LAT (sec)	16.26 ± 1.45	16.88 ± 1.60	-1.647	0.10	14.93 ± 1.37	15.77 ± 1.86	-2.041	**0.05**
PiP (sec)	19.36 ± 4.45	18.75 ± 4.03	0.562	0.58	18.07 ± 4.08	16.91 ± 3.28	1.153	0.25
OuV(sec)	7.38 ± 1.55	7.69 ± 1.61	-0.771	0.44	6.22 ± 1.21	6.72 ± 1.22	-1.564	0.12
OsS (sec)	8.83 ± 1.32	8.21 ± 1.09	1.923	0.06	7.27 ± 0.91	7.52 ± 1.20	-0.934	0.35
CMJ (cm)	24.71 ± 4.49	25.34 ± 4.32	-0.526	0.60	26.57 ± 4.49	24.68 ± 8.28	0.987	0.33
L J (cm)	114.95 ± 13.97	117.10 ±16.32	-0.585	0.56	122.62 ± 15.36	117.18 ± 20.44	1.187	0.24

Legend: E – experimental group; K- control group; SD-standard deviation; t – result of t-test; *p*- significance of difference

Table 2 shows differences in the achieved results between the initial and final measurement in both groups. These results show that the experimental group showed improvement in all tests, while the control group showed improvement in all coordination tests and in one agility test (LAT).

Table 2. Testing differences between the initial and final measurement *(t-test for dependent samples)*

Tests	**Experimental group**					**Control group**				
	MeanD ± SD	SEM	t	*p*	ES	MeanD ± SD	SEM	t	*p*	ES
20Y (sec)	0.33 ± 0.53	0.09	3.683	**0.001**	-0.50	0.04 ± 0.83	0.18	0.212	0.834	0.26
LAT (sec)	1.29 ± 0.91	0.16	8.277	**0.000**	-0.92	1.24 ± 1.61	0.32	3.854	**0.001**	-0.69
PiP (sec)	1.18 ± 2.74	0.52	2.274	**0.031**	-0.29	1.75 ± 2.72	0.57	3.083	**0.005**	-0.46
OuV (sec)	1.20 ± 1.08	0.19	6.32	**0.000**	-0.75	1.06 ± 1.29	0.27	3.956	**0.001**	-0.60
OsS (sec)	1.52 ± 0.90	0.16	9.586	**0.000**	-1.18	0.67 ± 0.81	0.17	3.877	**0.001**	-0.63
CMJ (cm)	-2.17 ± 2.82	0.67	-3.264	**0.005**	0.41	2.03 ± 6.51	1.45	1.395	0.179	-0.15
L J (cm)	-8.26 ± 11.80	1.91	-4.319	**0.000**	0.55	-1.00 ± 17.86	3.44	-0.291	0.773	0.00

Legend: MeanD – arithmetic mean of the difference between the initial and final measurement; SD-standard deviation; SEM- standard error; t – result of t-test; *p*- significance of difference; ES-effect size

By comparing the results between the experimental and the control group in the final measurement (Table 1), it was determined that there are differences between results only in agility tests.

DISCUSSION

Test results from the initial measurement show that the control and the experimental group do not differ in any of the observed abilities, and that the differences obtained at the final measurement can be attributed to the influence of the experimental factor.

By observing results between the initial and the final measurement, it can be noted that the experimental group achieved improvement in all tests, while the control group made improvement in coordination tests and one agility test. Based on such results, it can be concluded that the rhythmic gymnastics training itself was sufficient as a stimulus for coordination improvement, as expected, given that rhythmic gymnastics belongs to sports in which results depend largely on the development of this ability. By comparing the results between experimental and control group at the final measurement, there are no differences between them at the final meas-

urement, so that the improvement in coordination cannot be attributed to influence of proprioceptive training. According to results of an earlier study, in some coordination tests the authors found the improvement under the influence of proprioceptive training, but not in all tests; and the study was done on the sample of respondents of both genders, from 15 to 19 years of age (Lukić, 2010).

Agility, i.e., a segment of this ability which relates to the speed of movement direction change (Sheppard & Young, 2006), showed the tendency of improvement under the influence of proprioceptive training. Such findings are in accordance with the results of Yaggie and Campbell (2006), and partially with the results of Šalaj et al. (2007), who found significant improvement in this ability under the influence of proprioceptive training in 20-yard test. Cressey et al. (2007) did not find a significant agility improvement under the influence of this training, and the reason for it may be the specific sample of soccer players, who are well known for a highly developed agility. A possible future study should assess the influence of proprioceptive training on this ability in children of both genders and in different periods of development.

In explosive strength tests, the experimental group showed improvement, while progress was not recorded in the control group. The comparison of the results from the final measurement points to the fact that the proprioceptive training had no positive influence on development of this ability. On the other hand, it should be understood that the experimental group had slightly weaker results on the initial measurement, but also slightly better results at the final measurement. This leads to the conclusion that the rhythmic gymnastics training in combination with proprioceptive explosive strength training may significantly improve the explosive strength of legs in girls aged 7-9. Previous studies, conducted on adults and with the use of the same tests, are in favour of positive influence of proprioceptive training on the explosive leg strength (Cressey et al., 2007; Granacher et al., 2010). Besides, a sensitive period for the explosive strength development is the period between the age of 10 and 12 (Гужаловский, 1984, Drabik, 1996), when a greater reaction of the child's organism to these stimuli can be expected. All the above should be taken into account and investigate the influence of this training on the explosive strength of legs in children of different age, including the sample of children of both genders, in some future studies.

CONCLUSION

Based on the presented results and the discussion it can be clearly concluded that the proprioceptive training has a positive impact on the development of agility in girls aged 7-9, while this type of training proved to be an insufficient stimulus for development of coordination. In combination with the rhythmic gymnastics training, proprioceptive trainings have positive effects on the explosive strength of legs in girls of this age. The development of the observed motor abilities under the influence of proprioceptive training in children should be additionally examined, by including into the study children of both genders and different age.

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EFECTOS DE LA APLICACIÓN DE ENTRENAMIENTO PROPIOCEPTIVO SOBRE LA FUERZA, AGILIDAD Y COORDINACIÓN DE JÓVENES GIMNASTAS RÍTMICAS

Resumen
El objetivo de la presente investigación era examinar la influencia del entrenamiento sobre la fuerza explosiva, agilidad y coordinación de las niñas de 7-9 años de edad que se entrenan en gimnasia rítmica. Las mediciones se realizaron en una muestra de 74 niñas sanas. La muestra se ha dividido en dos grupos: el grupo experimental (43 niñas) y el grupo de control (31 niña). El grupo experimental aplicaba el entrenamiento propioceptivo en marco de sus entrenamientos regulares RG, en período de 12 semanas (24 entrenamientos). El grupo de control asistía solo a los entrenamientos de gimnasia rítmica. Para establecer los efectos del factor experimental sobre las capacidades motrices seguidas se utilizaron los test estandarizadas para valorar la fuerza, coordinación y agilidad. Todas las niñas examinadas fueron medidas antes de la aplicación del factor experimental (preprueba) y después de su terminación (postprueba). Para establecer la diferencia en los resultados alcanzados entre la medición inicial y final para cada grupo, se utilizó prueba-t para las muestras dependientes. Para establecer la diferencia entre grupos en la medición inicial y final se utilizó prueba-t para las muestras independientes. Por análisis de los resultados de la medición inicial y final se constató progreso en todos los atributos de las capacidades motrices seguidas en el grupo experimental. En las niñas examinadas en el grupo de control se notó progreso en el espacio de coordinación y agilidad. La prueba estadística de las diferencias de los resultados entre los grupos en la medición final demostró que la diferencia entre los grupos existe solo en el espacio de agilidad a favor del grupo experimental. Sobre la base de los resultados obtenidos se llegó a conclusión que la aplicación de entrenamiento propioceptivo en las niñas incluidas en el programa de gimnasia rítmica puede contribuir al aumento de los atributos motrices que tienen influencia en la agilidad, mientras que en el espacio de las demás capacidades motrices seguidas no se puede confirmar con seguridad que se ha notado progreso como resultado de la aplicación de entrenamiento propioceptivo.

Palabras claves: PROPIOCEPCION/ CAPACIDADES MOTRICES / GIMNASIA RÍTMICA / NIÑAS

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ANALYSIS OF ICE CLIMBER SPORT PERFORMANCE DURING COMPETITION

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Abstract
Sport discipline ice climbing was built on the reputation of climbing frozen waterfalls and can be defined as a unique discipline under the International Climbing and Mountaineering Federation (UIAA) in artificial, prescribed conditions, and according to certain rules. Due to the lack of articles about the motor activities of top ice climbers, the aim of this study is to determine sport performance of ice climbers, both genders, in discipline "lead climbing". Both genders are analysed, because in this sport discipline there is positive discrimination, due to the weaker characteristics of the female climbers. The propositions define that women and men have different climbing routes. Therefore, the sample were UIAA World Cup finalists in Beijing (2017) in lead climbing discipline, 8 men and 8 women. The method of work is the analysis of sport performance using the notation analysis. It was found that the average time of the race for men was 224.52 ± 98.81 seconds, of which the active climbing time was 103.88 ± 48.97 seconds, while the passive climbing time – pauses was 119.66 ± 50.40 seconds. The average time of the race of women was 219.09 ± 62.11 seconds, of which the active climbing time was 108.52 ± 31.37 seconds, while the passive climbing time-pause was 110.58 ± 41.42 seconds. Although men and women climbed in a different direction, this analysis did not find the difference in sport performance between the gender, as well as in terms of the climbing pace and the type of technique used. The results of this analysis can be of great importance to trainers for practical work, for the immediate preparation of competitors for participation in UIAA ice climbing competitions.

Key words: ICE CLIMBING/ SPORT PERFOMANCE ANALISYS/ PACE/ UIAA

INTRODUCTION

Ice climbing is an extreme sport that has been part of traditional mountaineering. It means climbing frozen waterfalls or ice-covered walls - traditional ice climbing (Mashkovskiy et al., 2016). Ice climbing competitions (sports ice climbing) have developed from the climbing of frozen waterfalls, one of the discipline of alpinism.

Sports ice climbing, consisting of two disciplines –"lead" and „speed" climbing, can be defined as an extreme competitive climbing activity that takes place under the International Climbing and Mountaineering Federation (UIAA) in artificial, prescribed conditions, and according to certain rules (PractICEclimbing, UIAA). The competition polygon is very similar to the rock that is used for sport climbing competitions. In the „lead climbing" discipline, climbers hold their tools in the hands, which look like a mountaineering ice axes, and they are hooked on specially constructed climbing grips. On the legs, the competitors have sharply-pointed shoes, which look likea mountaineering crampon, and stab the metal peaks in the construction of the wall. Using various techniques that dictate the position of the grips and the construction of the wall, by clamping the tools and drilling the crampons into the wall, they compete vertically upwards with the aim of reaching the highest possible point. Each competitor has only one attempt to reach the top in a timeframe that is fixed and is the same for all competitors. The result of each competitor is based on the achieved height, except in

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cases when the competitor successfully reaches the top of the route, then the time is taken as a result. In the event that more competitors successfully complete the climb before the end of the scheduled time, the faster competitor will be better placed. In order to ensure a fair fight for everyone, competitors stay in an isolation zone prior to their appearance in which they have no opportunity to follow the sport performance of their opponents.

It is obvious that even in this discipline, as in other sports, the level of athlete's performance is measured at the competition. Technically-tactical, but also physical elements displayed at different levels of the competition are considered as an integral preparation of athletes (Viner et al., 2012). Integral preparation is the result of the process of combining, harmonizing and realizing various types of preparation (physical, technical, tactical, psychological, theoretical, affective in training and competition). The optimal level of integral preparation of athletes, which shows itself at the most appropriate moment is the basis for the achieving top results (Koprivica, 2013). The basis for rational approach to the problems of planning, programming, realization and evaluation of the effects of the systematic training process is in the analysis of sport performance. (Važni, 1978; Boženko, 1997; Nešić, 2002; Majstorović, 2015). Scientific research in sports should disclose information that sets knowledge in sports. Knowledge is necessary for better understanding of sports performance. Understanding sports allows the purpose of sport to be discovered (Nešić, 2006). So far there has been no research on the sport performance of sports ice climbers. Therefore, as the goal of this study is the analysis of quantitative characteristics of the structure of sport performance in ice climbing, in both genders, in climbing discipline - lead. The thesis is that the sport performance of ice climbers will have acceptable and reliable characteristics of central and dispersive statistical parameters; and that a difference will be noted between the structure of the sport performance in ice climbers in the function of the gender. For methodological reasons, and for the purpose of describing the sport performance, it is necessary to define information on the technical-tactical activities of top ice climbers, in both categories (men and women) that are being gathered in the competition. In this sport, as well as at other top competitions (world championships, Olympic Games ...), the success of the competitors is expressed through the achievement of an individual who is able to perform technique of respective sport at extremely high levels in a dynamic and unpredictable environment (Seifert et al., 2014).

METHOD

Sample of subjects

The sample of subjects consisted of the UIAA World Cup competitors in Beijing (2017) in both categories (men and women) who took part in the final round of ice climbing competition. The total number of analyzed competitors was 16, of which 8 men and 8 women.

Sample of variables

Notation technique analysis of competitive activities was used to collect data. The data from the official video clip UIAA are registered with the spread sheet. The results of the measurement were transmitted and processed in Microsoft Office EXCEL, version 2007. For each competitor, a notation sheet was filled in with noted techniques, time frame of the duration of movement and type of movement (active or passive). The following variables were observed:

- Total Climbing Time (TCT) - time elapsed since the start to the end of the competitor's performance, during one race. TCT was determined for each competitor individually, the average TCT of all competitors was calculated. The result is expressed in seconds (s).
- Active climbing time (ACT) - time spent for performing active movements (movements involving segment / body position change) within a single race. The ACT was determined for each competitor individually, the average active climbing time of all competitors was calculated. The result is expressed in seconds (s).
- Pauses (TP) - total pause time on the wall (no segment / body position change) within a single race. The TP of each competitor was determined individually, the average of the passive climbing time of all competitors was calculated. The result is expressed in seconds (s).
- Individual active movement (IAM) - the duration of the realization of a climbing technique, the active movement. The IAM was determined for each competitor individually, the average duration of the individual active movement for all competitors was calculated. The result is ex-

pressed in seconds (s). The IAM variable is also expressed by the number of repetitions (n) - the frequency of applying the active movement during a single race.
- Single pause (SP) - duration of each pause. SP was determined for each competitor individually, the average duration of each break for each competitor was calculated. The result is expressed in seconds (s). The variable SP is also expressed by the number of repetitions (n), the frequency of applying the break during a single race.
- Climbing technique - a variable that talks about the type of climbing technique that competitors perform during a single race. The types of techniques were recorded individually for each competitor, the average of climbing techniques for all competitors were calculated during a single race. The result is expressed by the number of repetitions (n).

For the easier documentation of the climbing characteristics, all movements were classified: *individual elements of climbing techniques* and *complex elements of climbing technique.*

Individual elements of the climbing technique are simple to perform, they involve the stretching of one hand with the participation of the activity of legs, and the following elements of the climbing technique belong to them:
- Stretching right / left hand up, right (right hand right up, left arm up right)
- Stretching right / left hand up, left (right hand up left, left hand up left)
- Stretching right / left hand up, right (right hand right, left hand up right)
- Stretching right / left hand down, right (right hand down right, left hand down right)
- Stretching right hand down, right (right hand down right)
- Stretching right hand horizontally, right (right hand horizontal right)
- Stretching left hand down, left (left hand down left)
- Stretching left hand horizontally, left (left hand horizontally left)

The complex elements of the climbing technique have more complex mechanic pattern and require the active involvement of the whole body. The following climbing techniques are analysed as complex:
- Hand change (left tool, right hand; right tool, left hand)
- Figure four - the opposite leg goes over the opposite hand, for example, the right leg crosses the left hand and the left leg above the right hand
- Figure nine- right hand above the right leg or left hand above the left leg
- Attaching tool picks to the same grip (connection)
- Clipping

In addition to the absolute values of the variables, in terms of methodology, the relative values expressed in percent (%) are calculated. All variables with relative values are calculated according to the standard mathematical principle: relative variable = (selected variable / original variable) x 100; Eg: Active climbing time (%) = (Active climbing time (s) / Total climbing time (s)) x 100.

Data analysis

Data processing is performed in the Microsoft Office EXCEL statistical sub-program, version 2007. Descriptive and comparative statistics are used for data processing. Descriptive statistical parameters determined for all variables were:
- Arithmetic Mean (Mean)
- Standard deviation (SD)
- Coefficient of variation (cV%)
- Minimum value of the variables (Min)
- Maximum value of the variables (Max)

For the determination of the differences in arithmetic meanings in the function of a gender for the same variables, Student's t-test for non-contiguous samples was used. For the purposes of determining the differences between multiple pairs of variables of applied climbing technique, the variance analysis was used - ANOVA. Statistical significance was defined at 95% probability for $p < 0.05$.

RESULTS

Time parameters of the race in the function of gender

Table 1 shows the results of the Student t-test and coefficient of variation for all time climbing indicators during a single race in both categories, men and women.

Table 1. Results of Student t-test for time climbing parameters and coefficient of variation for men and women

Variable	M – MEAN	W – MEAN	t relation	p value	cV%-M	cV%-W
TCT (s)	224.52	219.09	0.13	0.45	44.01	28.22
ACT (s)	103.88	108.52	0.23	0.41	47.14	28.91
TP-pauses (s)	119.66	110.58	0.39	0.35	42.12	41.14
ACT-relative (%)	45.20	50.34	1.37	0.10	12.54	18.94
TP-relative (%)	54.52	49.66	1.31	0.11	9.87	20.14
IAM-duration (s)	6.98	6.77	0.21	0.42	53.33	31.04
SP-duration(s)	10.16	8.60	1.17	0.13	52.40	36.74

Leged: TCT- total climbing time, ACT- active climbing time, TP-total pause, IAM- individual active movement, SP-single pause, cV%-coefficient of variation

Based on the results of the Student t-test, it can be concluded that there was no statistically significant difference between the observed individual pairs of variables of the time indicators of the race in the function of the gender.

Technique elements in the function of gender

Table 2 shows the results of ANOVA analysis in the function of the applied elements of the techniques for men and women.

Table 2. Results of ANOVA in function of applied elements of the techniques for men and women

Individual elements of climbing technique						
Source of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between groups	66.62	15	4.441	0.927	0.536	1.719
Withingroup	920.15	192	4.792			
Total	986.77	207				
Complex elements of climbing technique						
Source of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between groups	48.59	15	3.239	0.598	0.866	1.826
Within group	346.80	64	5.419			
Total	395.39	79				

Based on ANOVA results, it can be concluded that there was no statistically significant difference between the observed pairs of variables of the analysed groups of technical elements in the function of gender.

The structure of competitive activities in ice climbers, lead climbing discipline, categories men and women had the following attributes and values (Table 3).

Table 3. Structure of sport perfomance in both categories

Structure of sport perfomance	Men	Woman
Total climbing time	224.5±98.81s	219.09±62.11s
Active climbing time	103.88±48.97 s (45.20±5.67% relative to total climbing time)	108.52±31.37 s; (50.34±8.99%relative to total climbing time)
Pauses	119.66±50.40 s (54.52±5.38%relative to total climbing time)	110.58±41.42 s; (49.66±8.99% relative to total climbing time)
Individual active movement-duration	6.98±3.69 s	6.77±2.10 s
Number of active movements in one race	14.38 repetiton (54.96% relative to number of total movements)	16.75 repetition (55.75%relative to number of total movements)
Single pause	10.16±5.68 s	8.60±3.16 s
Number of single pause in one race	11.63 repetitions; (45.04% relative to number of total movements)	13.5 repetitions (44.25%relative to number of total movements)
The most used technique	Technique connection with 7.38±2.77 repetitions.	Technique clipping with 4.63±2.45 repetitions.

By analysing the notation sheet, it was found that men did not use the following climbing techniques: the left hand upward on the right, and vice versa, figure nine, left hand down right and left hand down to the left. In the sample of women, it is not determined using the left hand climbing techniques to the right and vice versa, figure nine, left hand down right, right hand down right, right hand down to the right.

DISCUSSION

The aim of this study was to determine the quantitative characteristics of the basic parameters of competitive ice climbers in both categories (men and women), in discipline lead climbing. Based on the results of descriptive indicators of average time during a single race in men and women (Table 1), it can be claimed that the value of the coefficient of variation in total, active and passive climbing-pause times in men exceeds 30% in absolute times. In women, the value of the total and active climbing time is below 30%, while the passive climbing time is above 30%.

The results found in men can be caused by the discrepancy of the duration of the movement - the climbing pace of all competitors. It is assumed that competitors who are more experienced and successful, simpler and easier elements of the technique perform faster in order to save energy for heavier parts. On the contrary, competitors who are less experienced choose a slower climb pace, ie, perform the given elements of a technique with a lower level of efficiency, and possibly with a lower level of economy.

The results indicate the equality of the duration of active movements, as well as the total climbing time in women. Possible cause of large differences from average results in passive climbing time(total pause) can be the result of competitive preparation, but also competitive experience. Practice has shown that weaker placed competitors spend more time in pause, thinking about next move, while more successful competitors solve this with shorter or even without unnecessary retention.

Results obtained in Table 3. show the basic descriptive indicators of the average duration of individual climbing (motion-movement) techniques in men and women during a single race. It can be concluded that in men the total number of active movements during one race was 14.38 reps (54.96% compared to the total race time), while the pauses on average had 11.63 reps (45.04%) compared to the total number of moves. Such results show that there are more active movements, in one climbing race than passive movements. Women, on average, use 16.75 active movements (55.75%), and pauses 13.5 times (44.25%) during one race. Women, unlike men, spend more time

in active movement, and spend less time in pause (passive movements).

When analysing the relative indicators of the results, it was found that the active climbing time in men was 45.20%, while at women was 50.34% compared to the duration of the race. This result is part of the difference in the pace that originates in the order, efficiency, and economy of movement, but is probably the consequence of gender and on it's better training and competitive preparation that is fact of a higher speed of movement. The active climbing time for women is longer, most likely due to a greater number of attempts to set up the tool, or put the legs in the right position. If an athlete fails on the first try to find the best handgrip, then the movement can be repeated without a break to the desired outcome. Future research should take into account also the type of active movement, whether it is worthwhile or not. This means that the realized elements of the technique should be analysed through the aspect of the applied climbing tactics. In addition, the total climbing time is around 224 seconds, which implies complex metabolic process that occur due to the overall involvement of the muscular system not comparable with other sports. We must not ignore the constant influence of the gravity force that requires more energy in opposing its intensity.

When analysing the relative duration of the pause, it is observed that during a single race in men it was54.52% relative to the total climbing time, while in women, the passive climbing time was 49.66%. The origin of this difference in result may be that men need a longer rest period because of the higher muscle mass they have comparing to women. Also, women may spend less time resting because of the rationality and prevalence of fat metabolism in the process for obtaining energy comparing to men (metabolic criteria) or climbing without much unnecessary retention (technical criteria). A pause on the rock is not a complete break, but it is also the period of fatigue; even its specific static component. Fatigue in sports has a complex nature and is still insufficiently studied. At the root of this fatigue is the temporarily disturbed internal balance of the organism, defined as allostasis-homeostasis, which main consequence is decreased working capacity (Fratric, 2015). Reduced competitive ability, if long lasting, can lead to a complete loss of competitiveness which finally lead to the end of an athlete's performance. Therefore, it is necessary for the competitors to carefully balance between recovery and fatigue during their performance. Reducing the competitive potential of an athlete in a short time is primarily conditioned by metabolic changes as response of the organism to highly intensive activities (Veljović et al., 2012). Both genders come to the competition results firstly by the technique. In the second and third steps, they differ in way that women dominantly based their result on endurance and then on strength, while the strength takes second and endurance third place in men.

Highly intensive activities are not only caused by physical fatigue, but by intellectual, sensory and emotional ones. For gender analysis, an interesting and significant analysis of the neuroendocrine origin of fatigue, in particular the participation of anabolic hormones (sympathetic origin) in relation to catabolic hormones (parasympathetic origin), would be interesting. Common to all of these types of fatigue is the impact on decision-making ability, choosing the best routes of climbing and applying the most appropriate technique ... Certainly, even the feeling of pace with a high degree of fatigue is „compromised".

Table 3 shows basic descriptive indicators of the frequency of realization of elements of climbing techniques in men and women during the analysed competition-climbing race. The notation analysis of the competition activities indicated that certain techniques were not used at the Beijing competition (right hand left, left hand to the right, left hand down right, right hand down right, left hand to the left, figure nine). The thesisi s that the crossing movements (right hand to the left, left hand to the right) do not appear in ice climbing competitions due to the technical complexity of performance and physical difficulty, or the configuration of the wall and route set-up did not require the use of these techniques. Further research on this sport discipline that would be extended to other UIAA ice climbing competitions could verify those theses.

Based on the results of the coefficient of variation for all elements of the technique of over 30% in men implies a multiple way of solving the problem in climbing of each competitor (individual approach to a competitive result). The competitors used different techniques for overcoming the same problems on the competition route. In women, the value of the coefficient of variation is less than 30%, only in the technique right-hand side is 14.24%. This result can mean that most competitors have solved the problem in the same way, ie the route was set so that it was the easiest

and most effective way to overcome it with this technique. Based on the results of the Student t-test, the difference in time indicators of the race between men and women found that there are no statistically significant differences in any of the analysed variables. On the basis of the obtained results, it was concluded that the total climbing time, on average, was 224.52 seconds in men, while in women it was 219.09s. These results indicate a similar structure of the time parameters of the sport performance in men and women, although they compete on different competitive paths (routes) on the wall of the same configuration. Based on the results of the analysis of the variance - ANOVA of the observed pairs of variables of the analysed groups of technical elements in the function of gender, there is no statistically significant difference for any variable (Table 2). This result suggests that the structure of the techniques applied by men and women in the competition does not differ, although they go in different directions, on the same construction, ie, wall. Thus, the whole problem returns to the time parameters, namely the pace of movement which, as the results show, significantly influence the order of the competitors. Choosing the right and most efficient pace of movement depends on the rhythm, the cognitive side of the competitor, but also the characteristics of the general and specific training before the competition. What is important to point out is, from a theoretical point of view, which may be useful in the application of this young sport, the fact that the pace belongs to the time parameters of the movement. That means that they originate from the parts of the motor cortex where there are no parameters for spatial side of the locomotion. In other words, the spatial and time parameters of movement are remembered in different parts of the motor cortex, which means that, learning and adopting them are determined by age. Time coordinating parameters are conditioned by early learning and specialization, while spatial parameters are determined by the muscular force as well as the morphological characteristics of athletes (Jevtić, 2011). Therefore, for the development of ice climbing, one of the first tasks is the setting of quality theory, methodology and training technology. On this path, it would also be important to create a multi-year program and an athlete's development program in the function of specializing in the challenges of this extreme sports discipline.

CONCLUSION

The subject of this study was to determine the structure of the sport performance in the discipline of lead climbing in the function of gender and pace.

The structure of the analysed ice-climbing performance has acceptable and reliable characteristics of central and dispersive statistical parameters. Although the men and women in the competition are climbing in different directions and have a different, predetermined time for this, there is no difference between the profile of the sport performance in the function of the gender; neither in terms of time parameters (pace), nor in terms of the type of applied technique.

Further research should have the aim, based on the consideration of specific characteristics of athletes, to acquire **Know-how knowledge and / or technical skills** related to procedures, processes, programs, standards ... in the context of specialization, as well as in the area of knowledge and philosophy of ice climbing itself.

The results obtained by this study can serve to model the training of competitors who will take part in UIAA World Cups in ice climbing with the ultimate goal of improving efficiency and achieving success in the competition.

Knowledge and information on the average duration of the competition race, the pace of movement, the duration of the pause and active movement, the type and frequency of the techniques applied will enable coaches and athletes to understand this relatively new competitive discipline.

The results of this study can help to further improvement the sport performance in ice climbing discipline. Future research, in order to obtain a more complete picture of the structure of sport performance of ice climbers and to confirm or deny the thesis of this study, should include all competitions that are held within the UIAA World Cup in ice climbing.

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ANÁLISIS DE LAS ACTIVIDADES COMPETITIVAS DE LOS ESCALADORES EN HIELO

Resumen

La disciplina competitiva de escalada en hielo, surgió respondiendo a la escalada en cataratas congeladas y se puede definir como una disciplina deportiva particular que se desarrolla bajo el auspicio y proposiciones de la Federación Internacional de Asociaciones de Alpinismo (UIAA). Se desarrolla en las condiciones artificiales prescritas y bajo determinadas reglas. Por falta de trabajos sobre la actividad motriz de escaladores en hielo de alto rendimiento, el objetivo del presente trabajo es establecer la estructura de la actividad competitiva de los escaladores en hielo en las dos competencias (hombres y mujeres), en la disciplina escalada de plomo. Se analizan las dos competencias porque en esta disciplina deportiva por la discriminación positiva y por los atributos más débiles del organismo femenino para la escalada, las proposiciones prescriben que mujeres y hombres tienen distintas direcciones de escalada. Por esto, la muestra de los examinados se hizo de los finalistas de la copa mundial de UIAA en Pekín (2017) en la disciplina escalada de plomo y fueron 8 hombres y 8 mujeres. El método de trabajo es análisis de la actividad competitiva aplicando la técnica de análisis de notación. Se estableció que el tiempo promedio de duración de la carrera competitiva en los hombres ascendió a 224,52±98,81 segundos, de lo que el tiempo activo de escalada ascendía a 103.88±48.9 segundos y el tiempo pasivo de escalada - pausa ascendió a 110.58±41.42 segundos. Aunque los hombres y mujeres en la competencia escalan por distintas direcciones, este análisis no estableció la diferencia entre la estructura de la actividad competitiva en función del sexo, como tampoco en cuanto al ritmo de escalada y tipo de técnica aplicada. Los resultados de este análisis pueden tener importancia excepcional para los entrenadores en su trabajo práctico para la preparación directa de los competidores para la participación en las competencias de UIAA.

Palabras claves; ESCALADA EN HIELO / ANÁLISIS DE ACTIVIDAD COMPETITIVA / RITMO / UIAA

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INFLUENCE OF DANCE FITNESS-PROGRAMMS ON THE PHYSICAL PREPARATION OF THE STUDENTS IN CONDITIONS OF FACULTY LESSONS

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Abstract

To explore the impact of dance fitness programs on the physical training of the students in conditions of faculty lessons. In the research took part the students of the pedagogical faculty of Pereiaslav-Khmelnytsky Hryhorii Skovoroda State Pedagogical University. (n = 30). It was revealed the interest of scientists in solving the problem of integration of choreography in physical education, but we want to admit the lack of scientific methodological developments in this direction. Using of modern fitness programs in dancing direction (Aero dance, Bodi Balet, Belly Dance) in physical education of students in conditions of faculty lessons is offered. The results of the research showed significant changes in the indicators of physical training, physical health, theoretical preparedness, which had occurred during the pedagogical experiment. It has been found that indicators students' physical state of experimental group substantially changed: ChSS from indicator 82,5 b/m increased to 93,03; AP – from 120/70 to 130/90 mm.r.st., body mass declined from 63,1 to 60,15 kg; tilt of the trunk forward from the sitting position t = 7,77 ($p<0,05$); shuttle running 4x9m t =4,82 ($p<0,05$); lifting the body in one minute t =4,15 ($p<0,05$). It is proved that using of modern fitness programs of the dancing direction (Aero dance, Bodi Balet, Belly Dance) in the context of faculty lessons is an effective way to optimize the physical education of the students in order to solve the problems of their physical and intellectual development in a comprehensive way, satisfaction of motor activity needs, and to form a sustainable motivation to the lessons of physical education.

Key words: CHOREOGRAPHY / AEROBIC DANCE / BODI BALET / BELLY DANCE / PHYSICAL PREPARATION / FITNESS PROGRAMS / STUDENTS.

INTRODUCTION

The most actual problem of modern society is nation's health in general and the rising generation in particular. Especially acute this problem arises among young students – the most critical group of population, which include basis of future health and nation's beauty. The promising step in deciding problem of optimization the process of the student's physical education is using of the popular types of motor activity among students (Garkava, 2016).

About relevance and effectiveness of dancing exercises in the physical education tell native and foreign scientists. The place of dance in physical education, the interaction of choreography and physical education were researched (Angioi, 2009, Mattsson, 2015, Wang Bei, 2016). In particular, (Radaeva, 2015) affirms, that using choreographic exercises cause in the student higher interest to the physical training and further self-improvement. (Zubkov, 2006) made methodology of complex using of choreographic and gymnastic exercises on the faculty lessons of physical education for students of universities in the different degree of physical preparation. The scientist detected, that reliable improvement of indicators of physical features, ability of mood's improvement, higher interest of the students to the physical training, possibility full and consistent to decide tasks of physical education in the students of different degree of physical preparation, improving their emotional mood (Semeniv, 2016). Researches of Kravchuk and Rohanin (2015) show, that using dancing exercises in the process of the student's physical education at the universities promote considerable rising their

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physical health in general and improvement its separate indicators. Cone Stephen made a conclusion, that dance covers psychomotor (includes movements, which we can use during all life) cognitive (critical thinking) and affective (self-expressions) sphere of the people (Stephen, 2015). In this way it helps students to get success in studying and getting useless from life during all life, supporting active way of life (Bajek, 2015). Reseaarchers affirms, that dance can be important part of educational program, which promote studying psychomotor, cognitive and emotional skills, related with either physical activity and can integrates as a part of studying plan of physical education (Column Editor 2015). Problems of interplay and integration of physical education and choreography are showed in works of (Rafferty, 2010). Scientist admits gaps in the structure of the programs of dancer's preparation, which can fill with means of physical education and give recommendations of elimination gasps in the physical education with help of dance (Rafferty, 2010).

Therefore, coming out from above said, we assume, that mix modern fitness programs of dancing direction (Aerobic dance, Bodi Balet, Belly Dance) promote rising physical readiness of the students in conditions of faculty lessons.

Aim of the research – to explore an influence of modern fitness programs of dancing direction (Aaerobic dance, Bodi Balet, Belly Dance) on physical readiness of the students in conditions of faculty lessons.

MATERIAL AND METHODS

The research was based on Pereiaslav-Khmelnytsky Hryhorii Skovoroda State Pedagogical University. In the research took part 30 female students, aged 17-18 years, first year students of Pedagogical faculty. All students were divided for control and experimental groups, in every group for 15 students. Control group did according to the generally accepted technique, experimental group according to the experimental technique, which included different modern fitness programs of dance direction. The experiment lasted 4 months, from September to December 2017 year (First semester). Lessons were conducting twice a week – Tuesday (Aerobic dance) and Thursday (Bodi balet/ Belly Dance). Duration of the lesson 60 minutes. The experimental program, can be defined as training directed towards the development of cardiovascular endurance by using movement structures of aerobics, dance, aesthetically shaped choreography. Additionally, exercises for strength and flexibility development were performed. The training sessions consisted of three parts: the warm up (8 min), main part (45 min) and cool down (7 min). Every part of the training session was performed in accordance with the appropriate music; the music tempo during the warm up was 120-135 beats per minute, while the main part was performed along to 125-155 beats/min music tracks, and cool down to 60-90 beats/min music tracks. General and specific warm ups were followed by the first part of the main part of the training session i.e. low intensity exercise (60-85% of maximal heart rate). This part of the training was reserved for learning dance movements that are part of the choreography, while the second part of the main part of the training session was reserved for practicing the entire choreography at a high intensity (>85 of HRmax).

Methods of the cognition: analyze and generalization of scientific and methodological literature and advanced pedagogical practice. In the process of conducting test guided by the same conditions for all participants, simplicity of measurements and evaluation, principle of accessibility for all students. Evaluation of physical readiness and definition the level of development of physical skills carried out with help of motor tests: tilt of the trunk forward (cm); Sit-Ups in 60 seconds - measures trunk strength (MLESED); 4x9 meter Shuttle Run - measures agility – 4x9m (s), running 30m (s), medical and biological: body weight (kg), BPs and BPd (mmHg), ChSS (Apanasenko, 1995) in a state of rest and the Stange test (Malikov et al, 2006). All the data obtained by the study were processed by the procedures of descriptive and comparative statistical methods. From the area of the descriptive statistics the following parametres were defined: representative central and dispersive parametres: arithmetic average – $\bar{x} \pm m$; standard deviation – δ ; initial and final measuring. Unpaired t-test, applied in copmarative statistics, was perfomed in order to compare the arithmetic means of two independent data sets (experimental and control groups). Statistical analysis was performed by applying SPSS statistical software.

RESULTS AND DISCUSION

Analyze, generalization and systematization educational methodical and special literature about problems of optimization and introduction into the educational process different means and methods of Physical education point to rising interest and active work of scientists in this way. In scientific literature are made assumptions, that for modern students defining condition of choosing form of the lessons in Physical training at the university is attractiveness of a program, its novelty, emotionality and popularity. For the purpose of exploring an influence of dance fitness programs on the student's physical preparation was conducted pedagogical experiment. In this research took part the first year students of Pedagogical faculty with the total number is 30 people. All participants of this experiment previously agreed to participate in experiment and data processing. Students were divided into control and experimental groups, in every group 15 students. Control group work according to the generally accepted technique, experimental group – according to the experimental program of lessons, which include mix of modern fitness programs with dancing direction - Aerobic dance (Viski-Stalec et al, 2007), Bodi balet (Bondarenko, 2006), Belly Dance (Blagoy, 2005). The experiment lasted 4 months, from September to December 2017 year (First semester). Lessons were conducting twice a week – Tuesday (Aerobic dance) and Thursday (Bodi balet, Belly Dance). Duration of the lesson was 60 minutes.

The results of own research confirm information, that corporal culture of dance provides deciding tasks, directed at optimization of motor activity depending on individual (Chuprun, 2018) and age-old features, rising functional possibilities (Pantelic et al, 2013) of a system and correction slight deviations of physical development and give a chance to consider dance exercises in the system of means of physical education different segments of the population .

The results of research's indicators morphed-functional students' state before and after experiment are listed in the table 1 and 2.

Table 1. Indicators morphed-functional students' state before experiment

Group	$\bar{x} \pm m$	δ	*v*	*t*	*p*
Stange test, s					
CG	39,65 ± 2,57	11,49	22,57		
EG	37,25 ± 2,41	10,81	23,82	0,84	0,21
Body mass, kg					
CG	60,5 ± 2,03	7,09	16,26		
EG	63,1 ± 2,54	11,39	19,26	1,04	0,43
BPs, mm.r.st.					
CG	120,10 ± 2,52	11,26	9,97		
EG	120,95 ± 2,22	9,93	8,64	1,33	0,55
BPd, mm r.st.					
CG	70,85 ± 1,77	7,94	11,23		
EG	75,15 ± 1,87	8,38	11,64	0,75	0,18
HB at rest, b./m.					
CG	82,50 ± 2,80	10,54	15,03		
EG	85,01 ± 2,19	9,79	11,91	0,77	0,17

* - probability variance p<0,05.

Table 2. Indicators morphed-functional students' state after experiment

Group	$\bar{x} \pm m$	δ	*v*	*t*	*p*
Stange test, s					
CG	38,25 ± 2,19	9,82	17,57	-	-
EG	45,25 ± 2,40*	9,95	17,85	1,50	0,030
Body mass (kg)					
CG	58,42 ± 1,90	8,50	15,29	-	-
EG	60,15 ± 1,88	8,63	15,34	0,75	0,130
BPs, mm r.st.					
CG	130,90 ± 2,05	9,19	8,07	-	-
EG	120,70 ± 1,55*	6,93	5,99	1,65	0,557
BPd, mm r.st.					
CG	80,05 ± 1,17	5,22	7,58	-	-
EG	73,70 ± 1,18*	5,28	7,49	1,55	0,03
HB at rest, b./m					
CG	93,03 ± 2,08	9,31	11,86	-	-
EG	75,15 ± 2,00*	9,01	10,17	1,71	0,01

Note. Authenticity of difference – * p<0,05, ** - p<0,005

The results of researches' indicators morphed-functional students' state show that indicators timed inspiratory capacity, body mass, blood pressure as control group, as experimental meet age standards and haven't probable differences. Exclusion was heart rate, which exceed normal values and was evaluated as moderate tachycardia. In our opinion, this phenomenon may be related with functional tension in work of students' cardiovascular system. To confirm the effectiveness this program was conducted the second research of indicators students' physical state of control and experimental groups in the end of experiment. From the table is visible that indicators students' physical state of experimental group substantially changed: ChSS from indicator 82,5 b/m increased to 93,03; BP – from 120/75 to 120/73 mm.r.st., body mass declined from 63,1 to 60,15 kg, indicator timed inspiratory capacity significantly hasn't changed.

In experimental group was discovered that great changes got thanks to such tests: tilt of the trunk forward from the sitting position (flexibility) t = 7,77 (p<0,05); shuttle running 4x9m (agility) t =4,82 (p<0,05); lifting the body in one minute (power) t =4,15 (p<0,05). The fourth place according to rating – jump in length from place (high power quality) t =2,75. Indicators of flexibility and agility allowed to show improvement in growth, which was 55,7% (in flexibility) and 49,3% (agility). This explain that in experimental group was used classical choreographic exercises, which carried out at the support and in the middle of the hall, tools for plasticity, rhythmic and dance exercises.

Indicators of testing running of girls for 30 m and 2000 m (table 3) in control and experimental groups didn't change and we can see slight improvement t = 1,79 (p>0,05) t =1,73 (p>0,05).

Table 3. Indicators level of the first year students' physical preparation after experiment

№ p/n		Measurement indicators			
		CG	EG	P	
1	Running 30 m (s)	4,9 ± 0,04	4,8 ± 0,04	1,79	> 0,05
2	Sit-Ups in 60s. (times)	41,1 ± 0,39	43,9 ± 0,55	4,15	< 0,05
3	Jump in length from place (cm)	183,91±2,9	194,58±2,59	2,75	< 0,05
4	Running at 2000m (mn)	10,38 ±0,12	10,12± 0,09	1,73	> 0,05
5	Shuttle Run 4 x 9m (s)	9,92±0,04	9,65±0,04	4,82	< 0,05
6	Lift of the trunk forward from the sitting position (cm)	14,3±0,3	18,0±0,37	7,77	< 0,05

The results of research showed great changes in indicators of physical readiness, physical health, theoretical readiness, which were during pedagogical experiment. The level of the students' physical health has risen, indicators of students' cardiovascular and respiratory systems became better. This coincide with researches of Stojanović-Tošić and associates (2011). Increase in the results occurred in the indicators of motor tests. Mostly changes were in indicators of coordination abilities. The same results got Viskić–Štalec and asoociates (2007) in accordance with their researches. Researches of Sibinović and associates (2011), Zagorc and associates (2000) confirm that aerobic exercises develop nearly all kinds of coordination.

Conclusions

Analyze of educational methodical literature and advanced modern world practice allow to make a conclusion about effectiveness joining different fitness programs of the students' physical education. Dance movement is an effective mean of training human body is proved and can effectively use in the modern efficient technologies of study and education, which decide problems of physical and intellectual student's development, satisfaction needs in movement activity, formation resistant motivation to the Physical training. Accessibility, variety of means, forms, types of choreography improve successful enrichment of motor experience, and high emotional of lessons arise students' interest to systematic lessons of physical exercises.

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INFLUENCIA DE LOS PROGRAMAS DE FITNESS A BASE DE BAILE EN LA PREPARACIÓN FÍSICA DE LOS ESTUDIANTES DE LA FACULTAD DE PEDAGOGÍA

Resumen
El objeto del presente trabajo es la influencia de los programas de fitness a base de baile en el estatus físico-fitness de los estudiantes (N-30) de la Universidad Estatal Jmelnitski Grygor Skovoroda. Los resultados obtenidos son de interés para los enseñadores investigadores en solución del problema de integrar coreografías en la educación física. Sin embargo, es importante destacar que hay una falta en el desarrollo científico-metodológico en esta dirección. Se ha presentado la aplicación de los programas de fitness modernos orientados hacia el baile (danza aeróbica, body ballet, danza del vientre) en la educación física de los estudiantes en las condiciones de conferencias de la facultad. Los resultados de las investigaciones demostraron importantes cambios en los indicadores de entrenamiento físico, salud física, como también en la preparación teórica que sucedieron durante el experimento pedagógico. Se ha establecido que los indicadores de estado físico de los estudiantes en el grupo experimental cambiaron considerablemente como sigue: CxSS indicador aumento de 82,5 b/m a 93,03; tensión arterial se mantuvo inalterado, la masa corporal disminuyó de 63,1 a 60,15 kg; la inclinación hacia adelante en la posición sedentaria en 7,77 cm ($r<0,05$); carrera de lanzadera 4x9m en 4,82sec ($r<0,05$); levantamiento del cuerpo en un minuto en 4,15 subida ($r<0,05$). Se ha establecido que la aplicación de los programas modernos de fitness orientados hacia el baile que se realizan en contexto de la enseñanza universitaria es un modo eficiente de optimizar el programa de la educación física de los estudiantes para que los problemas de su desarrollo físico e intelectual se solucionaran de una manera multifacética, satisfaciendo las necesidades de actividades motrices, pero también para desarrollar una motivación sostenible en las clases de la educación física.

Palabras claves; COREOGRAFÍA / DANZA AERÓBICA / BODY BALLET / DANZA DEL VIENTRE/ PREPARACIÓN FÍSICA / PROGRAMAS DE FITNESS / ESTUDIANTES

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PREDICTION MODEL OF INFLUENCE OF FORCE ON LAND AND PERFORMANCE IN FIN SWIMMING, A PILOT STUDY

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Abstract
The purpose of this research is the determination of a prediction model that could predict 50m and 100m fin swimming results on surface. The sample of this research consisted of 9 fin swimmers of competitive level. All participants swam 50 and 100 meters on the water surface with monofin and a snorkel with maximum intensity. In two next sessions, force of the leg extensors and ankle extensors were measured in the workout gym with a dynamometer. The results of this study concluded in a potential statistical significance of regression analysis for 50m fin swimming with snorkel on the surface of the water. Relative force values of ankle and leg extensors are better predictors of 50m fin swimming. No similar results were found for 100m fin swimming. These findings probably suggest that in shorter distance of 50m fin swimming, force variables of extensor muscles play a greater role in comparison to longer distance of 100m fin swimming. The measurement of force of legs in fin swimming is of particular interest because legs are mostly responsible for the propulsion in fin swimming and should further be studied with other force protocols, different exercises and larger sample.

Keywords: MESURAMENT IN SWIMMING / DYNAMOMETRY / MONOFIN / PREDICTION MODEL

INTRODUCTION

Monofin swimming is a movement of the swimmer's body through water, in a wavy line, in which the movement of legs is maximal, while the movement of the upper body is minimal. To achieve this, the body must be aligned with the arms stretched above his head while hands crosslinked (the inner part of the hands facing the bottom of the pool). Respiration is done by ventilation (snorkel) through the mouth which is fixed to the head. Fin swimming is a sport of speed, and it takes place on the water surface and underwater. In fin swimming speeds of 3,89m / s are achieved (Vogel, 1994). The movement of the swimmer resembles the movement of dolphins and the propulsion needs a movement of the entire body (Videler, 1981). The arms and hands are not used for the propulsion of the body (Gautier et al., 2004).

Different distances and different types of fins and equipment are used in competition. Clearly, improved materials of fins and equipment are generally responsible for the improved performance, despite the fact that the design of monofin is still empirical (Bideau et al., 2002).

The most significant contribution to the development of high speed is derived from the construction of the monofin which was adjusted to competition and training program (Zamparo, Prendergast, Termin & Minetti, 2002).

Researches on fin swimming were intensified after the invention of the monofin and the new method of propulsion in water (Pendergast, Tedesco, Nawrocki & Fisher, 1996). The movement with monofin as a new way to swim forced the researchers to turn their interest in fin swimming as a particular sport.

Scientific studies on the preparation of fin swimming athletes appeared in the decade of 1980 (Popov, 1982; Zammartini, 1986). Few studies exist on the effects of training in the art of swimming.

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Apart from the necessary qualitative execution of technical elements of swimming (Dopsaj, et al 2000b), characteristics of force provide important information and play a decisive role in the competition of 50 and 100 meters fin swimming. Propulsion bears on the vertical displacement of the whole body. The use of the upper body is forbidden for propulsion purposes. The vertical displacement of the body during the stroke cycle has been described as wave-like (Ungerechts, 1982). Since such motion could be characterized by specific amplitudes of oscillations. Such oscillations were also specified by a particular frequency and phase relationship (Sanders et al., 1995).

Another study revealed the effect of the monofin shape on the propulsive forces by analyzing the change in the swimmer's velocity over one cycle of the monofin's motion (Tamura et al., 2002).

Measurement of muscle force is performed using a dynamometer, and in the attempt to obtain the most accurate data, precision electronic devices are applied. In the measurement of force of various muscle groups using a dynamometer, there is a different development trend. The difference of athlete's strength is changing through the years.

Monofin swimming is very interesting concerning the force application. The swimmer and monofin share a mechanical interaction, that is, the swimmer can transmit the force to the monofin to drive it, and the monofin returns the reaction to the swimmer. This interactive relationship determines the total swimming performance (Nakashima, Suzuki & Nakajima, 2010). The present research is an attempt to measure the force out of the water, of muscle groups that play an important role in fin swimming.

The purpose of this research was the determination of force parameters of selected muscle group that, should predict of performance of 50m and 100m fin swimming

METHOD

Sample

The sample consisted of 9 athletes of fin swimming and competitive level, age: 17.0 ± 0 years, height: 176 ± 5cm and weight: 72 ± 5kg. Their training age was 5 years. The study was approved by the Ethical Committee of Athens University.

Procedures

The measurements were performed in an outdoor swimming pool 50m length and 3m depth (Olympic size). The water temperature was 26°. The measurements took place at midday between 12:00 to 14:00, because this was the time of their training session.

All measurements were made 15 days before the main competition of the summer cycle, in random order. Body height (cm) and weight (kg) were measured with minimum athletic attire (swimsuits) in the gym of the swimming pool.

The athletes were informed about the purpose of the investigation, the potential risks and procedures of measurements, and they gave their written consent with their parents. All swimmers involved in daily training lasting two hours and at least five days per week.

In the first session swimmers made the same warm up of 1000m under the guidance of their coach. Ten to fifteen minutes after, they swam with maximum intensity the distance of 50 meters on the surface of the water with a ventilator (snorkel) and the monofin adjusted to their feet. In the next session on a different day, they swam the distance of 100 meters with the same conditions. Before each test, heart rate was measured to reassure that participants have a heart rate of low and equal level.

Both measurements started from the starting block. Immediately after the efforts, heart rate and performance time were recorded with a stopwatch (Seiko Water Resistant 10bar S140).

In the last session, on different day in two subsequent measurements, the force of the ankle extensor (Image 1) and the leg extensors (Image 2) were recorded with a dynamometer (IMADA) in the gym where the dry land workout takes place.

For the measurement of isometric force of ankle extensors, the swimmers were sitting on a chair and were asked to lift their ankles against a thick wooden platform that was fixed on their legs and connected to the dynamometer. The angle of both knees was same for all participants, 90 degrees.

For the second measurement of isometric force of leg extensors, swimmers were standing with their knees slightly bend and with their hands straight next to their hips holding a handle connected to the dynamometer and were asked to straighten their knees.

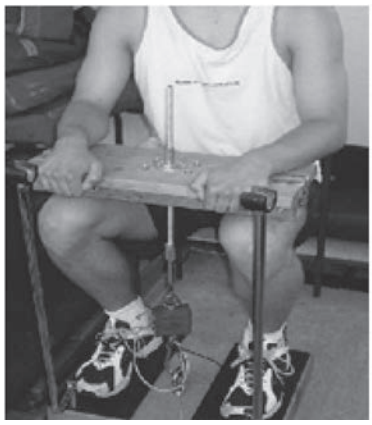

Fig. 1. Ankle extensors measurement with dynamometer.

Fig.2. Leg extensors measurement with dynamometer.

All of the data were automatically stored in the computer memory using the appropriate «Imada software», connected with the dynamometer (Pro-Ing system, Serbia). For the analysis of the results, maximum force of each measurement was used. Furthermore, relative value of isometric force was calculated and used in the prediction model of 50m and 100m fin swimming. Relative force values (Frel) were calculated according to the maximum values obtained in previous Fmax values divided by body weight.

Variables

Variables that accrued of the measurements and calculation were:

- Fmax of leg extensors- average of maximum muscle pulling force (peaks) for leg extensors, given in N.
- Fmax of ankle extensors- average of maximum muscle pulling force (peaks) for ankle extensors, given in N.
- Frel of leg extensors- relative force for ankle extensors.
- Frel of ankle extensors--relative force for ankle extensors.

Statistical analysis

All data went through a descriptive statistical analysis. For the analysis of force and swimming performance multiple regression analysis was applied in order to determine the variables that best describe 50m and 100m fin swimming. Values are expressed in mean values and standard deviations. The significance level for all parameters was set at $p < 0.05$. Data analysis was done with the statistical program SPSS 22.

RESULTS

Descriptive statistics of the variables are shown in Table 1.

Table 1. Means and standard deviation of measured variables.

	Mean ±SD
Time 50m fin swimming (secs)	19.8878±0.92
Time 100m fin swimming (secs)	45.7956±2.56
Fmax Leg Ext (N)	948.0±159.17
Fmax Ankle Ext (N)	2872.87±577.35
Frel Leg Ext (N)	13.31±2.52
Frel Ankle Ext (N)	40.15±7.58

Multiple regression model explained 64.1% of dependent variable (Adj. $R^2 = 0.641$) 'fin swimming time at 50m', (50m fin swimming average results = 19.8878 ± 0.9231secs). Regression model for 50m was not generally statistically significant (Sig. .085). We could say that these results are potentially statistically significant because p is less than 0.100, which means statistical probability is 91.5%. The results of the multiple regression analysis concerning 50m fin swimming on surface are shown in Table 2.

Table 2. Regression analysis for 50m fin swimming results.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	5.593	4	1.398	4.571	.085[a]
	Residual	1.224	4	.306		
	Total	6.817	8			

Furthermore, at partial level all single variables explain statistically significantly 50m fin swimming results at 0.015, 0.019, 0.016 and 0.020 p level, respectively, but as a group of variables no general significant explanation can occur.

The Prediction Model Equation for 50m Fin swimming time is:

50m Fin Swim Time = 25.1023 – (Legs_Ext_Fmax • 0.1130) + (Ancle_Ext_Fmax • 0.0346) + (Legs_Ext_Frel • 7.7764) – (Ancle_Ext_Frel • 2.5149)

As shown by the analysis of the results, relative results (Frel) have greater influence at 50m results than absolute results (Fmax).

Concerning the results of 100m fin swimming with snorkel, no statistical significance occurred. None of the force variables describe sufficiently the dependent variable '100m time in fin swimming' , all four variables were removed with p values .981, .929, .809, .537, respectively for each model. Furthermore, no significant results were presented in partial level.

DISCUSSION

The results of this study concluded in a potential statistical significance of regression analysis for 50m fin swimming with snorkel on the surface of the water. Relative force values of ankle and leg extensors are possible predictors of 50m fin swimming. The prediction model that occurred is:

50m Fin Swim Time = 25.1023 – (Legs_Ext_Fmax • 0.1130) + (Ancle_Ext_Fmax • 0.0346) + (Legs_Ext_Frel • 7.7764) – (Ancle_Ext_Frel • 2.5149)

No similar results were found for 100m fin swimming. These findings probably suggest that in shorter distance of 50m fin swimming, force variables of extensor muscles play a greater role in comparison to longer distance of 100m fin swimming.

Previous study concerning classical swimming (Dopsaj et al., 2004) found that explosiveness of back, feet and ankle extensors can be significant predictors of performance of 50 and 100m swimming.

In the field of monofin swimming, there is not enough bibliography that has to do with dry land measurements of force. Most of the research concerning monofin swimming has to do with kinematic analysis of the movement of the fin and the swimmer (Rejman, 2013; Rejman, Klarowicz & Zaton, 2012).

Further research is needed in order to determine a procedure that will control swimmer's fitness levels on land not only to enable more accurate management of the training process either in water or on land, but also to enhance the effectiveness of training and raise the competitive fitness levels in sprint monofin swimmers.

CONCLUSION

Limitations of this research (sample size) could not permit statistical significance of the regression model for 50m fin swimming, whereas all force parameters resulted in significant predictors in partial level.

Lack of significant results in 100m fin swimming in this study emphasize the need of further research in dry land measurements connected to monofin swimming.

Such a measurement, which can yield high quality information on an athlete's actual level of competitive fitness, is very important both to the trainer and the athlete, as to the control of the effects of the training methods employed in the preparation period, and to the fitness status on land with respect to explosiveness, which is an essential part of training technology.

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MODELO DE PREDICCIÓN DE LA INFLUENCIA DE FUERZA EN LO SECO Y EL RENDIMIENTO EN LA NATACIÓN CON ALETAS – ESTUDIO PILOTO

Resumen
El objetivo de la presente investigación es determinar el modelo de predicción que podría prever los resultados de natación con aletas a 50 m y a 100 m. La muestra de esta investigación han sido los 9 nadadores con aletas a nivel de competencia. Todos los participantes nadaron con la intensidad máxima con aletas monofin con tubo respetador a 50 y a 100 metros en la superficie del agua. En dos siguientes fases la fuerza de los músculos extensores de piernas y de los musculáis extensores de pierna inferior se ha medido en el gimnasio por dinamómetro. Los resultados de esta investigación han llevado hasta la conclusión sobre la posible importancia estadística del análisis de regresión de la natación con aletas a 50 m con tubo respirador en la superficie del agua. Los valores de la fuerza relativa de los músculos extensores de la pierna inferior y de la pierna son mejores predictores para la natación a 50 m con aletas. Los resultados parecidos no se han obtenido en la natación con aletas a 100 m. Estos descubrimientos probablemente sugieren que a distancias más cortas en la natación con aletas a 50 m las variables de fuerza de los músculos extensores juegan un mayor papel en comparación con la natación a una mayor distancia, natación con aletas a 100 m. La medición de la fuerza de las piernas en la natación con aletas tiene una importancia especial teniendo en cuenta que las piernas en general son responsables para la propulsión en la natación con aletas y hace falta seguir investigando con otros protocolos de fuerza, distintos ejercicios y en una muestra mayor.

Palabras claves: MEDICIÓN EN LA NATACIÓN/ DINAMOMETRÍA / ALETAS MONOFIN / MODELO DE LA PREDICCIÓN

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ANALYSIS OF THE MOTIVATIONAL SPEECH HELD BY THE NATIONAL TEAM COACH BEFORE THE FINAL FIFA U-20 WORLD CUP MATCH

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Abstract
In modern literature, it is most often stated that a sports coach should be moral, autoritative, educated, communicative, etc. Undoubtedly, a coach should be such a person, but we know relatively little about what a successful coach really *is*. A coach is driven by his knowledge, experience, but also by his implicit philosophy, i.e. deeper and hidden motivational factors, beliefs and attitudes about himself, his own role as well as about individual athletes or a team as a whole. Practice has shown that these coaching attributes affect functioning of a sports team. The aim of this paper was a pedagogical overview of a sports coach's educational work. The subject of this paper referred to the knowledge that could be classified into the implicit philosophy of a successful coach. The methodological context was the application of the *discourse analysis in semantic and meaningful identification of a successful coach's motivational speech*. Searching for an answer to the aim and subject of this paper, we performed the analysis of the motivational speech held by the national coach Paunovic to the players of Serbian U-20 football national team before the final FIFA U-20 World Cup match against Brazil in New Zealand (2015). Applying some methodological steps, the speech of the coach Paunović was divided into three discourse units, analyzed through the messages he sent to the players. The results of the analysis indicate that the coach's messages were characterized by dignity as well as by calling for unity and responsibility. There were no messages relating to depreciation or exaggeration of the opponent's team, there were no professional advice, threats or expressing negative emotions. The conclusion of this analysis implies explicit messages relevant for pedagogy, psychology, sports axiology, but also for technology of sports and football respectively.

Key words: DISCOURSE ANALYSIS / NATIONAL TEAM COACH / MOTIVATIONAL SPEECH / FIFA WORLD CUP / FOOTBALL / SERBIA

INTRODUCTION

In modern literature, there is a relatively large number of studies dealing with the research of personality traits and characteristics of a quality sports coach. It is most often stated that a coach should be moral, authoritative, well-educated, team player, communicative and competent, etc. (Galić, 2010; Oljača, 2001). Robinson (2010) stated that it is important for a coach to be good at planning and analytics or to be someone who is capable of creating and maintaining the „safe environment" suitable for training, growth and development of each individual. A coach is able to communicate effectively with others, providing constructive feedback as well as motivated for continuous learning and development (Crisfield et al., 2003). This job description frequently includes unconditional love and acceptance as something that should be cherished and nurtured by coaches in their work with individuals, groups or entire teams. Showing concern about each individual athlete, i.e. player, showing interest in what is happening in their private lives makes and develops a sense of unity and acceptance by each team member within a team or group. Coaches should constantly learn and develop, i.e. their openness to learning is of utmost importance (Cassidy et al., 2004). In technological and educational sense, the job of a coach is a complex process which is filled with interactive learning. Furthermore, learning is a process of constructing mean-

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ings, i.e. a permanent social process where meanings are exchanged through one's one work and activities (Krnjaja, 2009). A coach is a person who is constantly learning through his interaction with others (players, associates, audience, supporters, etc.) thus changing both himself and his attitude towards the profession as well as contributing to the community where he lives. In this paper, the *coach was considered* a leader and a team player as well as an associate within a learning process who respects the characteristics and experiences of each individual and strives to achieve common goals. Through his partnership with many actors, based on respect and importance distribution, dialogue and construction of common meanings, a coach creates a team's common framework as well as the environment where each actor can learn, develop and improve. In addition to his education, upbringing and qualities gained through experience, each coach has his own implicit professional philosophy. Implicit professional philosophy indicates deeper and hidden motivational factors that define him as a coach. This field is difficult for analysis in developing professional competences and it is also filled with beliefs and attitudes about oneself, one's own role, a team, a current situation and the team's future tasks as well. Practice has shown that exactly these beliefs of a coach directly affect a team's functioning. The implicit professional philosophy of a coach could be observed as a set of moral beliefs and stances which shape his behaviour in different professional and life situations, whereby, different coaches have different implicit professional philosophies about their own role within a team, i.e. the reason for which they are engaged in coaching (Robinson, 2010). Coaches' implicit philosophies may also affect the way they perceive individual players and associates as well as the nature of establishing their relationships. Therefore it is important that, during the process of developing his professional competences, a coach should be aware of his own implicit philosophy and the fact that the process of professional development should be followed by analysis and changes in his own beliefs and attitudes. It is important that this process is continuous, i.e. before, during and after specific training and competitive activities. It is also important that a coach himself is aware of that his own beliefs and attitudes as well as his experience can influence the pedagogical decisions he makes during his work.

Since the subject of this paper was the analysis of the motivational speech held by the coach before the deciding match, it is therefore important to point out the significance of the speech for the course of the match itself. Motivational speeches are those that inspire and increase the efficient work of the team itself, where we can distinguish three speech types (Vargas-Tonsing & Bartholomew, 2006): (i) speech of „control", (ii) strategy-oriented speech and (iii) emotional speech which is defined by the authors as the one which motivates players most, since it includes strong emotions regarding possible success of a team. The speech content is of special importance since through it a coach can express his intimate and deep emotions in relation to the upcoming match as well as his huge desire that his team should play with confidence and pride (Leidl, D. & Frontiera, 2009).

There is an insufficient number of scientific records related to the study of what a successful coach *is*. The personality of every man is based on an orginal genetic structure. The characteristics of a person also depend on their life and sports experience, but also on the quality of their education, which constitutes thier personal and implicit philosophy. Therefore, the aim of this paper was to collect more facts in order to determine the performance of the successful coach at the moment of a deciding sports event. By applying the discourse analysis as a method used in this paper, we tried to determine his attitudes, beliefs, emotions, etc. which are included in his professional dynamics and which, at the same time, make him special.

Discourse is recognized both as a source of knowledge and as a process during which verbal and non-verbal communication is analyzed in relation to a specific context. Speech and context constitute a communicative situation. In other words, a text (speech) and a context represent a communicative unit, suitable for discourse analysis. By analyzing a speech or a dialogue (semantic and linguistic context), a researcher examines and searches for the meanings and values arising out of the content of the analysis (methodological context). Thus, he tries to identify and verify the implicit philosophy of the persons who take part in the communicative situation.

The aim of this paper was to analyze the communicative situation where the coach was addressing the players before the deciding match – the World Cup finals. Specifically, we analyzed the speech held by

Mr. Veljko Paunović, a coach of the national under-20 football team of the Republic of Serbia, before the final U-20 FIFA World Cup match against the national team of Brazil. The match was played on 2015 FIFA U-20 World Cup in New Zealand, Auckland. In this match, Serbian U-20 national team won against Brazil 2:1. The reason for this analysis was the affirmation of the authors' scientific and professional curiosity, incited by the practical issues and statements presented in the Serbian public, as follows:

- the coach was most responsible for the success of the Serbia's U-20 national team. His motivational speech before the final match left a lasting impression on the professional and general public;
- the players pointed out the coach's leadership and his motivational speech before the final match as a factor of importance for the match outcome.

In training practice, it is known that a match can be won (or lost) by winning the inner, mental game. It often happens that a strong opponent loses a match against a potentially weak one (and vice versa) due to players' implicit beliefs. In addition, a coach's motivational speech before a match, according to the professionals as well as the players, significantly influence the players during the competition itself. Coaches' motivational speeches before finals are quite diverse. Thanks to modern technology and a growing need for highlighting the practice and behaviour models of the successful, these speeches have been recorded and analyzed nowadays. Thus, by searching the Internet, one can find the blogs including „coaches' best motivational speeches". Only by listening to these speeches, it can be noticed that they differ in many factors. These differences stem from the traits of a coach, i.e. his players, but also in relation to a competitive situation and the cultural values which are cherished in a given society.

Thus, some recordings of motivational speeches abound with battle cries and battle music in their background. There are also speeches which are, contrary to any sports values, full of efforts to humiliate the opponent. It seems that different motivational speeches fit into cultural values, since the players have responded positively to the speech. Therefore, one of the research questions may be whether a conclusion about the society the players come from may be drawn by analyzing a communicative context in sports. Certainly, it is possible to search for the answer to this question only when the athletes belong to the same cultural community. Unlike the heterogeneity of professional teams, there is a pronounced homogeneity present in national teams. Therefore, one of the research questions, which could be discussed, would be: which speech elements represent a good motivational incentive for Serbian football players? Finally, this research problem was pedagogically oriented. We tried to determine whether the motivational speech addressed to the young players included any educational contents and to what extent.

METHOD

The method used in this paper was discourse analysis. Discourse analysis is a research approach suitable for searching for the meaning of a text within a given context (Ber, 2001). As a type of pedagogical analysis it has been widely used since 1988, i.e. after publishing the article on classroom discourse analysis by Courtney, a professor responsible for initiating a course of the same name at Harward Univeristy. Since then, it has had many methodological, semantic, linguistic, gnoseological, epistemological variations (Gee, 1996, Faircough 2003, Ber, 2001). Today it is considered one of the most recognized sociological and pedagogical qualitative analysis which leads to objective qualitative conclusions.

Methodological steps in the realization of discourse analysis were supplemented by the text analyses by applying two software programs. Voyant is the first application for performing text analysis applied in this paper. The program is designed to indicate word frequency and links within a text as well as to identify distribution plots in the text. Another application used was LIWC (Linguistic Inquiry and Word Count software program, currently the best rated application for text analysis (Bjekic et al., 2012). The authors of this paper are aware of the current linguistic as well as methodological restrictions of the Serbian version of this software. Therefore, the English version was applied. For the purpose of the analysis, Mr. Paunovic's speech was translated into English, analysed using the LIWC sofware and then the results were translated into Serbian and presented in tables.

The application of the LIWC software tool enables a quantitative analysis of the words used. Each single word is recognized by the program as a unit belonging to a particular category. Categories are necessary to determine the meaning of a word in relation to the

context. The program itself contains about 4500 predefined categories through which the entered text is compared and analysed. Since the program identifies grapheme composition of each word and registers it contextually, as a linguistic category, it can also determine a linguistic style of the speaker. Through the linguistic style, the program recognizes speech attributes and points out the basic dimensions of the analysed person's behaviour. For instance, the „Cooperation" dimension, distinguished in the software scheme, is in a negative correlation with the words that contextually reflect negative emotions. Extraversion correlates with the words that express positive emotions and which contextually indicate social processes. It is also associated with the overall word production by a person who, in a less formal language, using the pronouns in the second and third person plural, marks social awareness and engagement (Pennerbaker et al., 2003 according to Bjekic et al., 2012). The „Conscientiousness" dimension positively correlates with using the pronouns in the second person plural as well as with positive emotions, etc. The application analyses the entered data in relation to the average common personal texts, messages (informal talks) and in relation to formal texts (public speeches, business correspondence, lectures, etc.).

RESULTS AND DISCUSSION

The motivational speech by the national coach Paunovic and the context where it was published has become public (and thereby available to the analysis) via modern media (http://mondo.rs/a806821/Sport/Fudbal/Veljko-Paunovic-sampionski-govor-pred-finale-Srbija-Brazil.html). We have presented it in its entirety:

„All of us have to take a maturity test. After all, our maturity is challenged today in the best and most beautiful way. It is our graduation day today, a football one. We are playing the World Cup final match against the best opponent in the world. Against Brazil. And I want to tell you we need to enjoy today. There should be no pressure, except our desire to win. It is the basic urge we were born for, that is why we play football. To enjoy and win, is that right? I want to tell you that no one should excell today. You have already done that. In what sense? Individually, fighting for your own reputation. All of you who are here today, everybody already knows about you. Top professional careeres are waiting for you. Today we need to play for the team. Today we need to be united, as we have been so far. And even more! Whoever our opponent is, we, guys, deserve it. This trophy (*pointing to the photo*). We, guys, are born for this, to win this trophy. Look at it closely, it should be ours. Anyway, we should only give our best. As we have been doing so far. Today, we need to seal a victory (*hitting his fist against his palm*). Today is our graduation day! (*another „seal" with a fist*). Today we are taking the final exam, we are graduating today! We are going home with the gold! I want you all guys to stand up. I want you all to hug each other, as we did last time, please hug each other. And guys, I don't want you to pray now, I want you now to look each other in the eyes. Anyone who needs to keep their eyes closed, let them do it. And think about why we are worth it. What everyone of you has done in their life and why (*pointing to the trophy in the photo*). Who everyone of us is and who we want to win this for. Please hug each other, let us feel each other. Let's remain silent for a minute. To feel the unity. To look each other in the eyes and tell to each other that we are going to do it for each other. To do it for us, for all of us."

The speech by Mr. Paunović lasted 2 minutes and 66 seconds. A total of 325 words was used. The context in which it was spoken was as follows: New Zealand, the team's last meeting before the final match, a teams' meeting room. The coach was standing facing the players, with a screen behind him.

The context was analyzed at several levels. At the first level it was divided into three meaningful units as follows: (1) Awareness (2) Task and (3) Calling for unity and uniqueness.

In methodological terms, the „ **Situation Awareness**" (hereinafter referred to: *Situation*) included the following parts of the text: „ All of us have to take a maturity test. After all, our maturity is challenged today in the best and most beautiful way. It's our graduation day today, a football one. We are playing the World Cup final match against the best opponent in the world. With Brazil. And I want to tell you we need to enjoy today. There should be no pressure, except our desire to win. It is the basic urge we were born for, that's why we play football. To enjoy and win, is that right?"

The meaningful unit „**Task**“ included the following parts of the text:

„I want to tell you that no one should excell today. You have already done it. In what sense? Individually, fighting for your own reputation. All of you who are here today, everybody already knows about you. Top porfessional careers are waiting for you. Today we need to play for the team. Today we need to be united, as we have been so far. And even more! Whoever our opponent is, we, guys, deserve it. This trophy (*pointing to the photo*). We, guys, are born to win this trophy. Look at it closely, it should be ours. Anyway, we should only give our best. As we have been doing so far. Today we need to seal a victory (*hitting his fist against his palm*). Today is our graduation day! (*a new* „seal“ *with the fist*). Today we are taking our final exam, we are graduating today! We are going home with the gold!“

The meaningful unit „**Calling for unity and uniqueness**“ (hereinafter referred to: *Call*) included the following parts of the text:

„I want you all guys to stand up now. I want you to hug each other,as we did last time, I want all of us to hug each other. And, guys, I don't want you to pray now, I want you to look each other in the eyes. Anyone who needs to keep their eyes closed, let them do it. And think about why we are worth it. What everyone of you has done in their life to deserve this (*pointing to the trophy in the photo*). Who everyone of us is and who we want to win this trophy for. Please hug each other, let us feel each other. Let's remain silent for a minute. To feel the unity. To look each other in the eyes and tell to each other that we are going to do it for each other. To do it for us, for all of us.“

In the following step, the entire text as well as each individual unit were analyzed separately.

Figure 1: The most frequent words in the speech by the national coach Paunovic (the result of the analysis performed by the *Voyant* software tool for text analysis)

Based on the font size, the frequency of specific words was visually assessed. By looking at the Figure 1, it can be observed that the text is dominated by the following words: *to*, *today*, *enjoy*, *win*, *play*, and *pressure*. These words represent a backbone of the entire message. Generally, except for the word „*pressure*“, all other words express positive messages and emotions addressed to the players. The links between the most frequent words in the entire text have been shown in Figure 2:

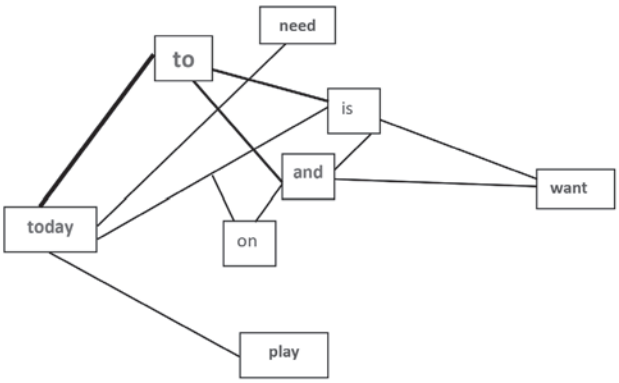

Figure 2. The links within the analyzed speech by the coach Paunovic

It is dominated by the words *need*, *to*, *want*, *play*, *today*. The particle *to* is central in grammatical term and it has no semantic meaning, since it links the expressions *need*, *want*, *today* and *play*. By analyzing the links within the text it can be noticed that the coach emphasized the value of the game itself, and not that of the victory or competition. He did not insisted on pressure. Thinking about the opponent is not preferred. There are no threats, the seriousness of the situation is not emphasized. This speech analysis has become even clearer when verbal plots within the text are observed (Figure 3).

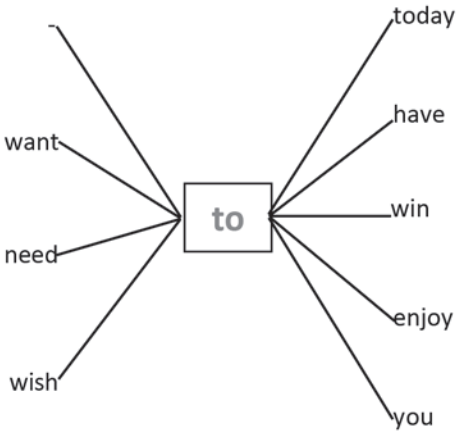

Figure 3. The links within a verbal plot of the „*Task*“ unit

As presented in Figure 3, the main message of the national coach to the U-20 national team was „ I want, we need to, we want to enjoy, win today. These, positively oriented discourse messages dominate the entire text as well. The LIWC analysis also determined that the text differs from common formal and personal messages (Table 1).

Table 1. The text analysis of the speech by the coach Paunovic (LIWC software tool)

LIWC analysis	**Coach's speech**	**Personal messages** (mean values)	**Formal speech** (mean values)
Personal reference (I, my, me..)	9,27	11,4	4,2
Social words (we, all, ours..)	16,29	9,5	8,0
Positive emotions	3,65	2,7	2,6
Negative emotions	0,84	2,6	1,6

The results of the LIWC analysis were translated into Serbian, and all the tables were adjusted to the specific tasks of this analysis. The results indicate that Mr. Paunovic used a considerably higher number of social words (*we*, *want*, *all*, etc.), i.e. a considerably higher number of the words that contextually indicate *positive emotions* and a considerably small number of the words expressing *negative emotions* in relation to their mean values in personal and formal speech.

Starting from the model analysis of the *Task* unit, the analyses of the other two situations were performed. Collectively, all the three situations that were singled out and analyzed have been presented in Figure 4.

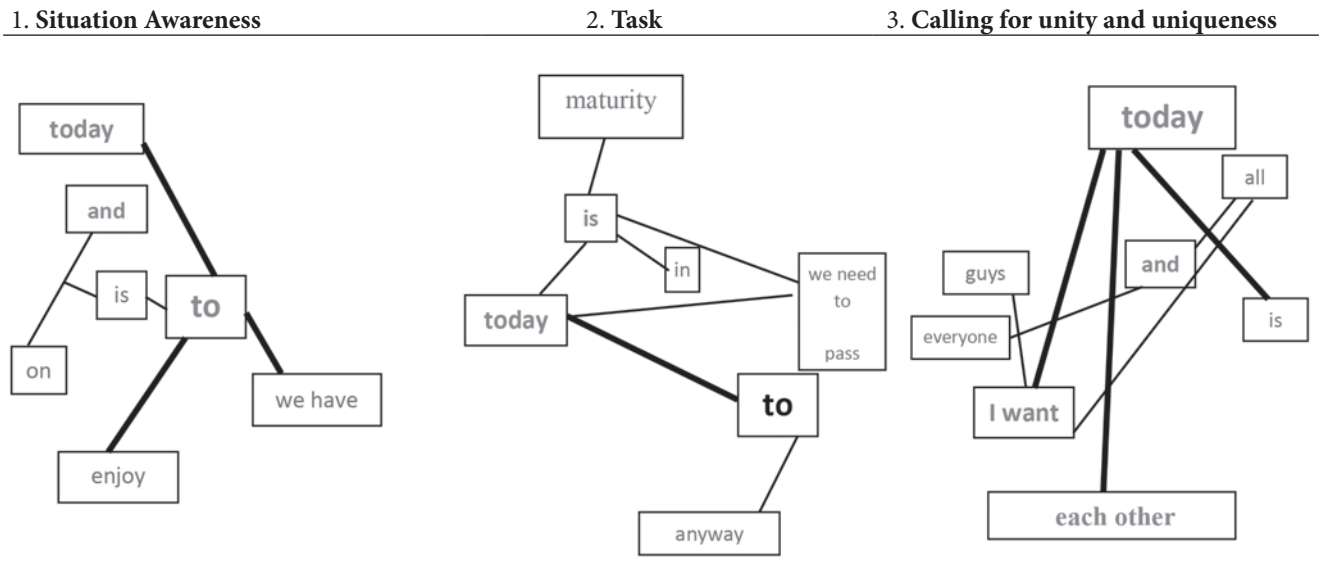

Figure 4. A display of the links within the discourse units

In the first discourse unit, the textual links were established between the words and compounds „Today, we have, enjoy, no (pressure)". The second unit was dominated by „Today, we need to, pass, anyway", and the third one included „Guys, today, I want, each other, all, everyone".

The comparative discourse analysis of all the three situations has been presented in the Table 2.

Table 2. The analysis of the text discourse units (LIWC software tool)

LIWC analysis	Discourse units			Personal messages (mean values)	Formal speech (mean values)
	Situation	*Task*	*Call*		
Personal reference (I, my, me..)	10,71	10,16	9,77	11,4	4,2
Social words (we, all, ours..)	**10,71**	**20,31**	**13,53**	9,5	8,0
Positive emotions	**10,71**	**3,12**	**0,75**	2,7	2,6
Negative emotions	**2,38**	**1,56**	**0.00**	2,6	1,6

Mr. Paunović used a greater number of social words („we, us") than it is usual in personal and formal speeches. The largest number of such words has been registered in the second discourse unit, conditionally called the „Task". The text shows that the coach used these words when he talked about the future, arduous venture: „Today we need to play for the team. Today we need to be united, as we have been so far. And even more! Whoever our opponent is, we, guys, deserve this ... „. On the other hand, when speaking about what they have already achieved, he excluded himself and addressed only the players: „You have already done it. In what sense? Individually, fighting for your own reputation. All of you who are here today, everyone already knows about you. Top professional careers are waiting for you ... „. Therefore, the coach did not take the credits for what they have already achieved, but shared the responsibility for what was yet to happen on the field. It can be assumed that modesty in his expression was motivating to the players (they already know that they can achieve a lot), he gave them courage and confidence before the upcoming match (they are not alone, they are together with the coach) and pointed out the significance of the coach's role in the team.

Furthermore, Table 2 shows that his speech is dominated by positive emotions, which are significant for competitive anxiety. In the last discourse unit „Call" there were none of them included. According to the results of this analysis, the personality traits that can be indirectly identified from this speech by Mr. Paunovic are *extroversion* (correlating with positive emotions and contextually identified social processes), *cooperation* (more positive and less negative emotions), *conscientiousness* (correlating with positive emotions and the use of the pronouns in second person).

In summary, the analysis of the three discursive units singled out the twelve, in our opinion, most important messages, i.e. meaningful units that constitute a backbone of the motivational speech by the coach Paunovic addressing his young national team. They are the following:

1. Inviting the players to enjoy the game, without any pressure.
2. Referring to the opponent in general, without exaggeration or depreciation (..."Brazil...Whoever our opponent is...").
3. Calling for the instinct (..."Basic urge, to play, win.. Born to win this trophy...").
4. Raising the players' self-confidence („You have already excelled...").
5. Enhancing the players' self-confidence by addressing the future („Top professional careers are waiting for you...").
6. Defining the first and main goal („Today we need to play for the team...").
7. Defining the reward (Trophy: this should be ours...").
8. Relativization in order to reduce pressure before the match („Anyway, we should only give our best...").
9. Comparison with the graduation, a maturity test („Today is our graduation day! We are taking the final exam, we are graduating today! We are going home with the gold!").
10. Gathering individuals into a team („I want you all to hug each other. As we did last time, please hug each other, everyone... I want you all to look each other in the eyes... To feel the unity...).
11. Respecting individual needs (Anyone who needs to keep their eyes closed, let them do so.").
12. Giving a promise to his team („...To do it for each other ...").

Generally, the messages are colored with positive emotions. The coach emphasized the beauty of the game and, in any way possible, tried to motivate the players and reduce the pressure before the final match. The players' attention was focused on the team by his call for unity and uniqueness. During his speech he pointed out the goal, but also that he was assured that the goal can be achieved.

CONCLUSION

The aim of this analysis was double oriented:

Firstly, the intention was to present the professional characteristics of a coach, i.e. the characteristics of a successful national coach and, by analyzing his motivational speech held before the final game, to determine the words which, to a certain extant, contain messages that may be considered desirable in the Serbian cultural environment. In response, an interested reader may draw a conclusion about the characteristics of the general cultural milieu of the society in which the speech was assessed as successful. By analyzing the discourse of the coach Paunović's speech, some more facts and conclusions about it can be presented as follows:

- the speech was clear, with precisely defined goals, it was very motivating for the players;
- the coach did not humiliate nor depreciate the opponent's national team;
- there were no threats, pressures or negative emotions included in the speech;
- the coach shared the merits for the results achieved at the previous stages of the FIFA U-20 World Cup with his players, he also shared the responsibiity for the future challenge with them, he emphasized the beauty of the game and the unity of the team, which makes the essence and definition of sport; he did not refer to the technical part of the game and he did not address the individuals.

Secondly, Mr. Paunovic's motivational speech which was addressed to the Serbia's U-20 national football team players in the final match on FIFA U-20 World Cup (2015) was very important from the pedagogical point of view on the coaching profession. The coach showed his implicit philosophy based on which he has also gained his great authority. The coach Paunović has acted as a positive behaviour model to young people, through educating and motivating the players, but also to the general public, through the media.

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ANÁLISIS DEL DISCURSO DE MOTIVACIÓN DEL SELECCIONADOR EN VÍSPERAS DEL PARTIDO FINAL DE LA COPA MUNDIAL DE FÚTBOL PARA LOS JÓVENES JUGADORES (SUB-20)

Resumen
En la literatura contemporánea más a menudo se menciona que un entrenador deportivo debe ser moral, autoritario, educado, comunicativo… No cabe duda que un entrenador debería ser así, pero relativamente poco se sabe de lo que es un entrenador exitoso. Al entrenador le motiva su conocimiento, experiencia, pero también una filosofía implícita, unos factores de motivación más profundos y ocultos, una convicción y postura de sí mismo, de su papel, de un deportista individual o del equipo completo. La práctica demuestra que estos atributos del entrenador influyen al funcionamiento de un equipo deportivo. El objeto del presente trabajo se refiere a los conocimientos que podrían subsumirse bajo la filosofía implícita de un entrenador exitoso. El contexto metodológico es la aplicación de análisis de discurso en el reconocimiento semántico y significativo del discurso de un entrenador exitoso. Buscando la respuesta sobre el objeto y objetivo del trabajo, se ha hecho un análisis del discurso de motivación del seleccionador Paunovic a los jugadores de la selección juvenil de futbol de Serbia en vísperas del partido final con Brasil en el CM para los jóvenes en Nueva Zelanda FIFA (2015). Por los pasos metodológicos el discurso del seleccionador Paunovic está dividido en tres conjuntos discursivos, analizados a través de los mensajes a los jugadores. Los resultados de análisis demuestran que los mensajes del seleccionador se caracterizan por la dignidad, invitación a la unidad y a la responsabilidad. No hay mensajes que se refieren al desprecio o engrandecimiento de la importancia del equipo contrario, han faltado los consejos profesionales, no hay amenazas, ni expresiones de emociones negativas. La conclusión de este análisis son los mensajes explícitos de importancia para la pedagogía, sicología, axiología del deporte, pero también para la tecnología del deporte y del fútbol en particular.

Palabras claves: ANÁLISIS DEL DISCURSO/ SELECCIONADOR / DISCURSO DE MOTIVACIÓN/ FIFA COPA MUNDIAL / FUTBOL/ SERBIA

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THE AESTHETIC ELEMENTS OF FAR EAST MARTIAL ARTS

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Abstract
Since Far East martial arts have to be perceived as an integral part of the entire culture and tradition of China and Japan, their aesthetic character is inextricably tied to the dominant traditional notions of these cultures, such as the concept of the unity of opposites, known as the yin and yang; the concept of the Way (Tao) as a symbol of constant self-perfection; the idea of Chi or Qi energy that fills the Universe as well each individual, etc. These ideas originate and are developed mostly from religious-philosophical systems that formed and influenced not only the martial arts tradition but all the layers of these two great cultures, performing arts included. Both performing and martial arts of the Far East have had an intertwined development, and strongly affected each other. The aim of this study was to point out a similar base and essence in other segments of cultural tradition.

Keywords: AESTHETICS / MARTIAL ARTS / PERFORMING ARTS / SPORT / CHINA / JAPAN

INTRODUCTION

Chinese and Japanese martial arts have a long and rich tradition. Emerged from the human need to respond to natural and social challenges of ancient times, they were cultivated and refined by many non-combat elements, becoming thus a part of expression by movement, gesture as dance, music, the culture of food, clothing, habitation, etc.

Anyone who has at least once been witness to a public display or demonstration of the martial arts skills of the top Chinese or Japanese masters, will definitely agree that these movements or even combating ways have a specific 'course, rhythm, order…' in order to provide a perfect look so that they can definitely be characterized as art.

Undoubtedly, it can be stated that when compared to Far East styles of kung fu, karate or t'ai chi ch'uan, the Western combat techniques such as boxing or wrestling, seem raw, unrefined or even rough, not because of the lack of combat efficiency, but for the lack of aesthetic components related to the delivery and overall visual impression.

This study will attempt to outline basic aesthetic notions that influenced the forming of specific combat styles in Chinese-Japanese martial arts that enable their classification as performing arts. Generally speaking, aesthetics in this paper is closely related to Far East combat traditions. For example, karate as one of these Easter arts is most often perceived as the art of self defense. "This understanding raises karate above the level of common martial arts, stressing at the same time an extremely high level of movement expression in efficiency of combat technique application. The essence of karate contains a philosophical and mental improvement, which together results in a perfect balance of body and spirit, and a perfectly conducted real combat" (Jovanović,1992,:13). It may be said that the very aestheticizing of combat techniques resulted in creation of the concept of 'combat masters' as a sort of a sage of the East, artists in their trade, that accentuate the self-perfection of movement. Little of these skills is related to purely practical application in self-defense. „Extraordinary use of the body is encountered not only in performing situations, but also in other situations which call for special, extraordinary behavior" (Barba,1996,:197).

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Such unusual and extraordinary situations are definitely imaginative or real combat that often require patterns completely opposite to those we encounter in everyday life.

Eastern ,martial arts tend to develop a specific human response to the challenges of life itself. Based on unity of spirit, body and movement, these skills, thanks to long-lasting exercising leading to movement and human excellence, affect and change the natural human essence and create new motor and life skills, together with stances and judgements that should serve as a new pattern of acting in different situations. "The mastering of martial arts by repetition of motions and movement, raises athlete's awareness on oneself, on different use of a body, its physical and mental capacities. One of the goals of martial arts is learning to be present at the right moment of the action. This type of presence is also important for performers that want to recreate, every evening, the right quality of energy that keeps them alive in the eyes of their spectators" (Barba,1996,:197).

Therefore, it is important on one hand to shed light on the parallel development of performance and martial arts of the Far East, and on the other hand to discover how the elements of life wisdom of the traditional culture are reflected on movements within the combat systems, increasing thus their specific aesthetic character.

The fact that the aesthetic aspect is in proportion with an attempt to include religious-philosophical concepts in combat skills is supported by the fact that the most aesthetic combat systems had not emerged before the Middle Ages (e.g. t'ai chi ch'uan, Ba Gua), when most Tao and Buddhist cults had already had complete philosophical concepts and widespread influence. Surely, this does not mean that there aesthetics is not present in older combat forms, but instead that later systems included all the motion elements that belong to performance arts (dance, pantomime, opera, theater or ballet).

Since Japanese martial arts have a Chinese model and roots, each expertise should begin form the roots, starting with Chinese martial arts and their connection to performance arts and traditional symbols.

MARTIAL ARTS, PERFORMANCE ARTS AND RELIGION IN CHINA

In an attempted to chronologically lay out the parallel course of those aspects of culture that developed similarly to martial arts in Ancient China, one should start with those movement to be included in performing arts. In that sense, "warriors' dance" (*Jiaodi*) is very interesting – it owes its origin to a ritual performed by early armies during their inspection of troops at the time of the Warring States period ((475-221 BC), and its particular expansion occurred during the Han dynasty (206 BC – 25 AD). During that period, the warriors' dance became a show performed in the palace but also before ordinary people (Chongshen,2010,:181-182).

During the Sui (581 – 618 AD) and Tang (618 – 907 AD) dynasties the warriors' dance evolved into war games held annually during the Lantern Festival. On those occasions large cities hosted motion arrangements consisting of various animal imitations, acrobatic demonstrations, demonstrations of strength and endurance, swordsmanship, etc. (Chongshen,2010,:181-182). Motion techniques used by those acrobats and demonstrators, such as jumping, spinning, rolling, falling and hitting were adopted by all combat systems referred to today as WUSHU (warrior skills). This did not only substantially enrich the technique, but it also added a new dimension of expression and virtuosity leading to respecting the **audience**. Since then, Martial arts have combined not only deadly motion techniques, but also skills and methods of performance that will attract the spectators .

Besides the "warriors' dance", throughout centuries Wushu remained inseparably linked to dancing. "It's difficult to identify differce between Wushu, Wushu-dance and modern dance" (Chongshen,2010,:183). Many forms of modern dance originate from Chinese Wushu (Chongshen, 2010). Through time, dance separated from Wushu. Ancient annals recorded a type of dance practiced after victory by soldiers on the battlefield, as a sort of "dance with sword" or "dance of joy" to honor their victory. During the Sui and Tang dynasties a sort of three-act opera was composed under the name „Emperor Qin defeats warring armies". It had all the elements of a combat spectacle with different armies taking turns (Chongshen,2010).

For this analysis from the "warriors' dance" we should emphasise the dance with a sword, as especially important because it is the most suitable for expressing complex feelings. Motion as expression of feelings is contained in delicate transformation of strength and softness of movements (Chongshen,2010). Generally, the sword is used in Chinese martial arts as well as in classical theater in order to express a very complex and subtle symbolism of feelings and understanding of the world. T'ai chi ch'uan as a form of combat system is definitely the closest to full aestheticization and the most similar to dance. The form of *t'ai chi ch'uan* is a story told through movement in which every movement possesses its own symbolism and name (e.g. "white crow spreads its wings" or "bringing a tiger to a mountain" and others) (Liu,2004). The entire style of tai chi comprises not only barehanded forms without the use of weapons, but also forms with a sword, staff etc.

Besides dance, we must mention the essence of motion and expressive traditional Chinese opera which has borrowed many of its elements from Chinese martial arts. "Wushu concepts, as yin and yang, the eight trigrams, and tai chi are stage adapted, which brought to the creation of one of the mail rules like *Zi-wu*, a type of yin-yang form, one of the basic, performed in the shape of the letter S, etc." (Chongshen,2010). All these influences have substantially enriched martial arts and performance arts alike, giving them a unique combat touch.

On the other hand, one should discuss the religious-philosophical background that makes the conceptual framework for understanding the practice of Chinese origin martial arts. There are three dominant religions in China: Confucianism, Taoism and Buddhism. All three were equally effective in their influence on martial arts. Additionally, some Taoist and Buddhist cults eventually included regular training and perfecting martial arts in their religious life. To reach the response to the subject of this paper (basic aesthetic notions in martial arts), only the basic terms originating from these philosophical systems that have formed modern martial arts but also the entire sports movement (conditionally Olympic values as well) should be mentioned. "The moral ideal of Confucianism is personal perfecting, a tireless 'surpassing oneself' (*ke ji*), the Path (*Dao*)." (Maljavin,2008). Personal perfecting is a process of individual effort to reach a high level of perfection, making the person aiming for it morally and aesthetically sublime. This will especially affect the development of the samurai ideal in Japan as a " idealized knight, at the same time educated philosopher, artist and supreme warrior (Filipović,1999:42). This sublimity of a noble person in a purpose in itself – "a refined person is not a tool" for a specified purpose, he is broadly educated, in one word, "complete" – *kijin tse* (gentleman) (Veber,1997).

"The Confucian ideal of constant perfecting in things that make a noble and sublime person will eventually become an ideal of perfecting in all types of art, and subsequently in martial arts that at an individual level were not practiced only for their practical use in self-defense, but the perfecting itself became an ideal. It did not possess an immanent boundary, because in time the practical and utilitarian values increasingly gave way to aesthetic ones" (Filipović, Jovanović,2012).

Taoism may well be defined as philosophical and religious course contributing most to the development of martial arts in China, providing them with its specific philosophical base on which they developed into what we today consider Chinese KungFu. More importantly, Taoism together with some older traditions of Chinese culture (*Yi Jing* – the book of changes) is the source of a multitude of terms that will play a key role in forming the non-technical segment of martial arts, for example: *Tao* – the way (Japanese *Do*); *Wu-wei* – spontaneous, non-disturbing activity; *yin-yang* ☯ - unity of opposites, etc.

The last of the teachings related to martial arts, and the only one 'imported' to China is Buddhism. *Chan* (Japanese *Zen*) Buddhism represents the highest phase in the evolution of Buddhist ideals. The name of this school derives from the Sanskrit word *diana* – meaning meditation, playing an important role for all representatives of Buddhism, but for representatives of Chan it became a goal in itself.(Maljavin,2008). The founder of this school, according to legend, is an Indian preacher and the patriarch of Buddhism from the VI century, **Bodhidharma, who** arrived in China in 520 AD. That school, according to tradition, completely abandoned the study of sutras (Buddhist texts), rituals and warship of Buddha, and began interpreting meditation in a new manner – as a spontaneous self-discovery of "the true nature of man" in his everyday life, thus coming closer to

the basic Taoist ideals than any other Buddhist cult (Vats,1984). Physical work was highly respected by Chan teachers, especially collective work, and was nearly equal to meditation.

Bodhidharma himself is accredited with the "canon of muscle and tendon perfecting" (Maljavin,2008),which is actually a treatise on gymnastic exercise. A legend says that Bodhidharma had taught Shaolin monks a more direct and immediate approach to Buddhism, implying long hours of meditating in a seated position. To facilitate these long hours of meditation, Bodhidharma taught the monks breathing techniques and exercises, which developed strength. According to some authors, Bodhidharma himself was the son of the South Indian king Sugandha, his third child, and as a member of the warrior race was familiar with warrior training and the skills of ancient Indian warriors (Simić,2005), only to later embark on the way of Buddhism. That may be the reason why nearly all styles and schools of martial arts refer to Bodhidharma, especially Japanese Karate. Through his teachings, meditation and movement expressed in martial arts become one, in many styles and schools. blended into a whole and got today's appearance

MARTIAL ARTS AND PERFORMING ARTS IN JAPAN

"Japanese martial arts – like many others throughout east and southeast Asia – have a serious art dimension – an explicit aesthetical character – that makes them an important part of Japanese cultural tradition."(Ben-Ari,2005). The emphasis of ethical, aesthetical and meditative components over pragmatic ones was especially apparent in Japan at the age of the Late Shogunate in the XVIII and XIX centuries, when "warrior skills" (*Bugei*) give way to "the way of the warrior" (*Budo*) .(Filipović,1999). In that period of relative peace the necessity for combat readiness decreased, so alongside combat systems – *jutsu,* in which a certain spiritual inclination served toward increasing the system's efficiency, various paths (*dō)* emerged, for which exercising the skill was a means for reaching a certain spiritual inclination or self-perfecting. The art of swordsmanship – *kenjutsu*, becomes way of the sword – *kendo*, the art of archery *kyujutsu,* becomes *kyudo* – way of the bow, and bare-handed combat techniques *jujutsu* become the gentle way – *judo,* stand equal to other famous skills raised to the level of art as the tea ceremony – *cadō,* a special way of arranging flowers called ikebana - *kadō,* calligraphy – *shodō*, thus creating a type of **DO** culture. All this testifies about a strong influence of Chinese Taoist philosophy which stresses Tao – the way, in Japanese – DO.

The influence of religion, especially Zen Buddhism, was crucial for this transformation of combat systems towards arts. The pacification of Japan meant that swordsmanship and other combat skills shifted their focus from self-defense towards self-perfection. Thus, at least in Japan's more recent colonial history, the potential for further militarization, symbolized by combat tradition, is transformed from a tool of repression into a path of deliverance by the process of aestheticization and deeper connection with religious concepts (Ben-Ari,2005).

As it was underlined in the previous section, it was in China that martial arts started introducing an observer as an element to be taken into account when assessing performance technique. Furthermore, the observer does not have to be another person, but can be the performer himself (Klens-Bigman, 2002). So, in absence of an observer, the performer himself can observe and adjust his performance according to an idealized image that he possesses in his mind of how each movement should ideally look. That is why Japanese kata and Chinese forms can be practiced individually. It may be the idealized image which the performer holds in his mind – a visualization of kata – that has been developed over time and transferred from master to a pupil, that makes it easier to establish clear aesthetic concepts that dominate Japanese martial arts. The origin of these concepts is definitely Chinese, but adapted and processed through the Japanese cultural matrix since the Heinan period (710 – 1185 AD) when the largest influx of Chinese culture occurred.

All concepts included in this analysis are in identical form and traditional performance arts of Japan, like dance and drama. The foremost on the list of terms is definitely the Chinese equality of opposites concept of **yin and yang.** Symbolic qualities attributed to yin and yang among others are cold, the moon, femininity for Yin; warm, the sun, masculinity for Yang. It is important to understand that this symbol

above all represents the *unity* of these two opposites, one unimaginable without the other, and that everyone needs both in order to achieve balance. This balance is at the core of Japanese, just as Chinese, martial arts, so a weak person must first develop strength in order to perform kata well, whereas a strong person must develop softness and flexibility. The ideal kata must be a combination of firmness and softness, speed and slow movements, flexibility and contraction, etc.

The creator of the short form Yang-style t'ai chi ch'uan,Cheng Man-ch'ing, was asked on one occasion, about how quickly his form could be performed. "As long as you can discern yin from yang", he said, "you may perform as quickly as you can." The older pupils finally agreed that master Cheng had meant the total separation of weight shifted from one side of the body to the other while performing the form step by step, and the change of position from one side to the other that has to be smooth and complete, balance but not blending." (Klens-Bigman, 2004).

The next concept that we must mention is the Japanese term for interval, also used to describe the quality of motion through time and space – **Ma** (gap, pause, space, interval). The symbol that represents Ma is a gate, through which the sun is visible. This term also represents the distance between us and our partner, which is also the first way to experience Ma.(Klens-Bigman, 2002). The best way to see this aesthetic quality in practice is to observe two practitioners performing the same kata. The difference in their delivery illustrates their respective possession of Ma. One of them may perform the kata flawlessly in the technical sense, but at the same time mechanically and soullessly, so he is said to have bad Ma. The other might perform movements with elegance and harmony, "bringing to life" the story that the kata carries, thus he is said to have good Ma. This quality makes the difference between a correct yet "lifeless" performance of a form and the exceptional and beautiful one that evokes excitement.

When two or more people with a good Ma perform the same form, their harmony and timing evoke a visual pleasure for the observer, which is also one of the indicators of a good Ma. This quality contained in motion content differentiates an accurate but "lifeless" form performance and an exceptional and beautiful which provokes delight.

When two or more persons with good Ma performs the same movement form, their compliance and sense of duration and timing is what inspires a visual delight in observe, which is also an indicator of a good Ma. "A famous Japanese dance instructor that I once interviewed told me that Ma cannot be learned. As a talent, it is inconceivable, it is a quality easy to recognize, you either possess it or you don't." (Klens-Bigman, 2004,:4).

The **Jo-ha-kyū** concept is another one that exists both in performance and martial arts. It is closely related to the previously mentioned concept of Ma. Roughly translated it can be represented by three phases (slow – quicker – swift) (Klens-Bigman, 2004). It belongs to the quality and change of movement expression of an actor or dancer or whoever is performing a twist, a strike or a movement in a combat form.

"The first phase is determined by one growing force and another force opposing the first one (**Jo** meaning to suppress). The second phase (**Ha**, to break) is the moment when the resisting force is overcome, until it reaches the third phase (**Kyū**,rapid), when the action culminates – it releases all its power and stops unexpectedly, as if encountering an obstacle, a new resistance" (Barba,1996). This is how it manifests in classical Japanese theater. On the other hand, we have the same course in Japanese martial arts. This concept has a cumulative characteristic of collecting energy in order to explode (catharsis) in a single impact, throw, or a blow in sword fighting. Similarly, the form of training mostly follows the same sequence of actions obeying the **Jo-ha-kyū** concept. Initially, warming up serves as an introduction, followed by techniques or kata, ending the training with sparring or kumite in which the accumulated energy is "burned".

The **Wabi-sabi** concept itself is not so much present in the delivery of movement and the forms of Japanese martial arts, but it lies in their spirit. On one hand the term **Wabi** aesthetically means simplicity and stripping down to basics. On the other hand the term **Sabi** refers to the feeling of loneliness and retraction (Klens-Bigman, 2004). The examples of this concept are easiest to find in the manner of conducting the tea ceremony and in Japanese interior and exterior design. The tea ceremony begins with a walk down a short path, through simple scenery to the tea ceremony house which represents the separation from everyday life. The house entrance is so small

that those entering must bow and thus show their humility. A samurai entering the tea house is unable to draw his weapon because of the confined space, and is likely to leave it outside. The purpose of this is to state that one's status should not be emphasized inside the tea house. The tea house interior represents simplicity and minimalism in decoration. Its walls might hold a few scrolls or a vase with a single flower. Such a room should not be luxurious, or contain objects that might distract from the tea ceremony itself. The tea house should be a haven and a retreat for contemplation.

The most affected concept by this principle is the Dojo, the place for practicing the path of martial arts – i.e. training room. The training kimono is also an example of simplicity and minimalism, the white color represents the will and readiness to sacrifice, etc. Japanese martial arts, especially karate as the Japanese counterpart to Chinese barehanded combat, has been considerably changed under the influence of this concept. Compared to Chinese forms, Japanese kate are much simpler, and their movements do not blend with each other, as is the case with their Chinese counterpart, but are accentuated as separate units with a clear end point between two movements.

Last of the concepts that we will mention here is **Yūgen**. Zeami Motokiyo, actor, aesthetician and Noh drama playwright from the 14th century described yūgen as a kind of beauty with elements of sorrow (Klens-Bigman, 2004). It eludes young performers whose talent and performance are based on physical appearance and charm, but lack what age and experience bring. Experienced performers possess a certain melancholy in their performance, which comes with the life that person led, with all their ups and downs, giving a unique note to their delivery which in turn becomes strong and distinct. Yūgen is a very rare quality, and as such is encountered in a small number of great masters, that are able to leave a strong impression on the audience. This quality in martial arts is not reflected in the physical component through the delivery of a specific technique that might be delivered more correctly by a thirty-year-old, but in the perception of unity possessed by old masters whose technique transcends the style itself and becomes "the art of movement". This is why demonstration by older practitioners and masters is very important in martial arts, contrary to sports to which the concept of old athletes is almost unknown.

CONCLUSION

The importance of studying aesthetics in martial arts goes hand in hand with the increasing interest of anthropologists, sociologists, and psychologists in studying occurrences such as moments in everyday life – religious rites, weddings, funerals, graduation ceremonies, etc. On the other hand there are mass entertainment events such as reality shows, festivals, circuses, parades, television shows, video games and, of course, large sporting events, tournaments, championships, Olympic Games. In this wide corpus of public events under the scrutiny of researchers studying the performative aspects of each of these occurrences, it is interesting to mention and raise the question of studying the performative and aesthetic character of Far East martial arts, which today are not just a local occurrence, but are practiced throughout the world. They are unique for comprising several different aspects in their appearance. On one hand every observer or analyst has to pay attention to their practical function – they are a highly stylized and channeled form of physical aggression, packaged into a culturally acceptable form, tending to return the attackers energy to himself, i.e. to pacify the very tendency towards violence, thus removing the concept of violence from society. On the other hand, the removal of violent tendencies benefits from the choice of cultural concepts that have been transposed into combat systems from the religious-philosophical realm, furthermore transforming them in the direction of pacification, and emphasizing the practice of physical perfection as a means of individual self-realization and personal self-cultivation. For all these reasons, the combat aspect is pushed aside, it has marked the path for a very developed body culture that is highly aestheticized and stylized, with a rich spiritual background.

Performance has played an important role in martial arts, and the audience has been taken into account from the earliest days of combat system creation, not just movement application in battle. So, the aesthetic aspect is very strong and plays an important role, even if subconsciously, in the creation and practice of martial arts. It seems that this aesthetic influence has caused the weakening of aggressive and violent elements, which initially motivated people to create movement to be used as defense or for attacking oth-

ers. In order to obtain the most comprehensive answer for the subject of this paper, it was important to emphasize all terms and concepts woven into the fine structure of of Far East martial arts, and consequently to decode martial arts influenced the reduction of violence in societies whence they originated, and why the people from those parts of the world where life is often harsh, China and Japan, are considered by others to be models of calmness and life satisfaction.

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LO ESTÉTICO EN LAS ARTES MARCIALES DE EXTREMO ORIENTE

Resumen
Teniendo en cuenta que las artes marciales de Extremo Oriente tienen que observarse como parte inherente de toda la tradición cultural de China y Japón, su carácter estético es inseparablemente vinculado con los conceptos tradicionales que dominan estas culturas, tales como el concepto de la unidad de los contrarios, mejor conocido como Yin y Yang; concepto del Camino (Tao) como símbolo del auto perfeccionamiento continuo; o concepto de la energía Chi o Qi que impregna todo lo que existe, tanto el cosmos, como los seres individuales. Los conceptos mencionados, así como también muchos demás deben su origen y desarrollo ante todo a los sistemas religioso-filosóficos que formaron e influyeron en todas las capas sociales de estas dos grandes culturas, y no solo en su tradición marcial. Las artes performativas, hoy día conocidas como artes escénicas, tampoco quedaron privadas de estas influencias. Ellas tenían su desarrollo trenzado con las artes marciales de Extremo Oriente e influyeron fuertemente unas a otras. El objeto del este trabajo es presentar los conceptos básicos vinculados con lo artes estético en las artes marciales de Extremo Oriente (China y Japón). El objetivo del trabajo es señalar una raíz y esencia parecida, también en otras partes de la tradición cultural.

Palabras claves: ESTÉTICA/ ARTES MARCIALES / ARTE ESCÉNICA / DEPORTE / CHINA / JAPÓN

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KNOWLEDGE IN ATHLETICS – FROM PRACTICE TO INNOVATIONS

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Abstract
Continuous improvement of practical and theoretical knowledge represents the basis for further cognitive paradigm and innovations leading to new, more efficient practice in athletics. The need for affirmation of knowledge (everything we know) stimulates the process of acquiring knowledge about a human in this sports discipline (ontological context) including knowledge based on scientific-research work (methodological context). It is a fact that application of the scientific method has led to new knowledge in favour of athletic practice and to establishment of new cognitive horizons in studying the scope of human sports performances. The source of knowledge is athletic theory and practice. At the same time they are the starting point for studying dynamics of human performances manifested through various athletic disciplines. For a number of analysers, results achieved on big athletic competitions provoked a discussion about platforms and ''conservation" of human abilities, whereas for the others it was a starting point for inquiry about the final reach of knowledge about human athletic being (gnoseological context). The origin of knowledge about the athletic being of humans dates back to the ancient philosophy of Plato and Socrates. Thus it can be claimed that the source of knowledge is as old as discussions about nature of change of a human being under the influence of exercising. In this study athletics is presented through the space of knowledge (subject of the study) integrating primordial and scientific with the outcome such as new and efficient training and competition practice.

Key words: ATHLETICS / GNOSEOLOGY / PHILOSOPHY / TECHNOLOGY / INNOVATIONS

INTRODUCTION

Various scientific-research and practical studies conducted by generations of experts led to formation of a system complex and complete enough in the areas of running, jumping and throwing, stimulating permanent development of training and competition technologies, reflected best in pushing the limits of a human athletic being. It can be said that knowledge leads to uncertain competition results. Therefore, a raising question is what we should know about capacity of athletics as a sports branch to change knowledge about human biological, social, psychological and motor performances. This is the first question to be asked while searching for the answer to *the subject* of studying athletics. Without clear definition of this subject it will be difficult to formulate definitions and taxonomy of knowledge about a cognitive human and the athletic being (ontological context). Methodology of athletics as objective and systematic knowledge searches for the meaning to fulfil a process of acquiring knowledge and lead to a new practice. In order to conduct a survey in athletics, referential *knowledge* (empirical and theoretical substance) is necessary for comparison with and explanation of intrigues of a certain phenomenon (theory of athletics), that is, ''to form and classify theoretical principles and a summary of single pieces of knowledge according to gnoseological rules, where laws of the phenomenon and every individual case will result from." (Lalević 1974).

Methodology of athletics tries to perceive, study and explain facts and phenomena in their nature. The first natural element is a human – an athlete. In essence, application of the scientific method leads to theories which systematically present knowledge about human nature or a group of phenomena integrated in athletics. Results of the scientific method

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imply *practical* application, which methodology and gnoseology are directed at and which theory of athletics is established and developed on.

Theory of athletics seeks and aims at knowledge which discovers principles and laws as well as improvement of performance of all participants of athletic training and competition (athletes, trainers and sports experts in all sports fields...). Knowledge about athletics has always been contemporary in each period of its development. In the latest big period of its development, and it is the Olympic movement, the aim is knowledge with clear methodological goals – and it is scientific verification of psychomotor, motor, energetic, coordination criteria of an athlete's movement. This traditional corpus of scientific interest implied the road to knowledge based on traditional common scientific areas and additionally embodied science into training practice (system of sports sciences and other scientific areas and systems). On the other hand, stimuli or directions for contemporary athletics development are connected with science of the third and the fourth industrial revolution.

Contemporaneousness does not imply that athletics renounced the ancient philosophical comprehension of human exercising being. In other words, its contemporaneousness is based on the ancient tradition full of philosophical disputes and opinions on ancient athletic practice shaped as its metatheory (ancient gnoseology, ontology and methodology). Its axiological side or its value context is very significant and it leads to an athlete acting in accordance with the highest human and divine norms. Generalisation of centuries of multiple human development through athletics can be shown through the process of getting knowledge and its methodology, that is through (Hassi, 1997):

- research of some of the existing situations or problems;
- research which will provide a solution to the problem;
- research of so far existing theories;
- research aimed at construction or creation of a new procedure or a system;
- research offering explanation of new phenomena;
- research which will create new knowledge and
- combination of two or more of the above listed situations.

Each of these intentions aims, through methodology, at new facts to build new theories on or present previous theories with higher quality. A fact that should not be disregarded is that the purpose of research is equally important in order to enable a researcher to research certain aspects of athletics he/she is interested in – in that way *personal achievement* can be added to the *existing knowledge*. The best way to develop personal understanding of a certain field important for athletics is affirmation of its philosophy, its gnoseological, ontological and methodological side.

COGNITIVE SIDE OF ATHLETICS

Greco and Sosa (2004) advocate the viewpoint that *theory of knowledge* is launched by two main questions: "What is knowledge? " and "What can we know?". If we think that we can find out something, as almost everybody thinks, the third main question rises "How do we know what we know?". Majority of things written in epistemology (deals with scientific knowledge) and gnoseology (deals with the theory of knowledge) in all the times deals with at least one of these three questions.

Kunzmann et al. (1991) quote Socrates's standpoint on knowledge: "Knowledge Socrates seeks is *practical knowledge* with cognition of good and evil, made safer by critical self-examination and aimed at *real use in practice*".

Plato in his work "Laws" (1971) talked about a very significant phenomenon – the way knowledge is transferred. He thinks that *a teacher should give all the knowledge to his student* and a student should grasp it with gratitude: "Moreover, in this situation, we must give orders to both students and future teachers – when in our laws we come to that issue – for the ones to follow their teaching with love and for the others to receive it with gratitude". He also talks about knowledge which reflects itself in knowing the essence of a problem and it is considered to be necessary for a doctor as well as for a trainer of athletes.

As opposed to Plato, Aristotle did not want to improve the world but *to find out everything that can be a subject of knowledge*. Aristotle (1984) in his work "Politics" talked about knowledge necessary for both

doctors and trainers of athletes. It is thought that knowledge about solving a problem should be provided by more than one competent person in order to agree with one another and reach the middle, that is the best solution. He says: ''Moreover, when doctors are ill they call other doctors (to treat them) and teachers of gymnastics do exercises in front of other teachers of gymnastics, because they cannot make the right decision about themselves since they are excited. Therefore, it is clear that those who seek justice actually look for the middle, and law is the middle ".

Locke also talked about knowledge (Kunzmann, Burkardand Wiedman, 1991), one of the major representatives of British empiricism, that is philosophy based on *experience*. It is considered that every knowledge depends on experience and is subject to its control. His famous phrase is: "There is nothing in our mind that was not previously in our senses." ("*Nihil est in intellectu quod antea non fuerit in sensu*"). His *theory of knowledge* is in the centre of Locke's philosophy, which is developed further in his work "*An Essay Concerning Human Understanding*". Its task is to clarify the origin and basis of human knowledge, as well as to find the limits of knowledge. Locke says that an idea is everything that spirit perceives in itself or is a subject of direct perception, opinion or intellect. Experience has two sources: *external sensitive perception* (*sensation*) and *internal self-perception* (*reflection*). Ideas originating from these two sources are either simple or complex.

What is important to point out and /or give an answer to is whether there is a contemporary cognitive side of athletics in Serbia. The answer to this question can be looked for through the academic tradition of athletics. In the era of contemporary universities, knowledge represents the backbone of development of an individual and as well as of society. In connection with this, affirmation of all missions of a university (teaching, science, development of society) is important for development of sport and athletics. Jevtić (2017) summarises significant prerequisites of this university triad and emphasises that key competences, as a result of education contain knowledge, skills and entrepreneurial attitudes. He describes *knowledge* as a skill to identify business possibilities, skills are used for proactive action within a project task (planning, organization, management, monitoring, communication) in individual and team work, whereas *entrepreneurial attitudes* can be seen in initiative, proactivity, independence and innovativeness, motivation and firm orientation towards achieving goals. The author concludes that for participation in creating exercises, and in the same way it can be said for those in athletics, as a product which changes nature of an athlete, his social as well as his economic environment are necessary, as well as *knowledge and skills, expert competencies* gained through interdisciplinary and multidisciplinary academic network and education.

Stefanović (2011) thinks that efficacy of a scientific development strategy in sport depends on five elements: formal framework, aims, results, conditions of implementation and means. He says that projection of sports science development is the imperative for every state which has a wish to be successful in sports competitions, educational staff is necessary to exist – to define clearly what *knowledge, abilities and skills* every student should achieve within a particular educational profile. He also says that on the basis of the European and UNESCO nomenclature of sciences, all knowledge students gain are first classified into one of the scientific fields and then into teaching disciplines. This is why it is expected that new teaching plans and programmes have high transferring value in accordance with needs of all graduate students who will have *the obligation to study during their whole working life.*

What would be *the essence of the previous quotes if not improvement of knowledge*? D. And T. Hoobler (2002), while surveying Confucianism, wrote wise thoughts on increase of knowledge by Chu Hsi:

> "Increase of knowledge consists of *researching things*.
> When things are researched, knowledge increases;
> When knowledge is increased, will becomes genuine;
> When will becomes genuine, mind becomes faultless;
> When mind is faultless, personal life is cherished... "

Improvement of human knowledge reflects itself in an effort to study the problem which previously was unknown systematically (however, in essence, every solution creates a new problem). Thus, for an athlete, participation in athletic competition should be the meeting point of his/her self (his/her abilities,

skills, attitudes...), his/her knowledge (about him/herself, about sport, about sports preparation, about preparation for competition ...) and skills. The ancient continuum of values is based on respect of rules and opponents. This is a significant prerequisite and measure of contemporary sports values, habits, the code of ethics ... but also of a wide range of different forms of knowledge with different names – without them there would be no athletes, no trainers, no training process and in this way no athletics. Therefore, on the road to rising methodological, gnoseological and axiological in athletics, it is necessary, through logical and systematic approach, to structure a cognitive framework for success or in other words as metatheory of athletics understands it, careful and systematic gathering and application of means for solving a problem are necessary for development. By structuring a cognitive framework, possibilities for achieving excellence of all participants in athletic sport are increased. Since excellence is a goal of every human activity, and of sports (trainings and competitions) as well, multilateral knowledge, habits, skills became the basis for its affirmation. It can be said that athletics itself recognized a semantic trap which, at one period, made success in a competition equal with excellence, what led to a misunderstanding of excellence followed by a mistake in studying and in acquiring athletic knowledge, habits and skills necessary for support of needs and developmental tempo of each individual. Reaching excellence is most often achieved by innovations. That innovative step is fulfilled by theoretical and empirical knowledge. Thus, Ven (1997) says that "*research implies careful and systematic means of solving a problem*" and his opinion is that "*good-quality research* is a foundation of each scientific discipline". Without well-designed and methodologically correctly conducted research, athletic disciplines would stagnate because the limit of an athlete, which has been talked about in the world of athletics since the beginning of its modern – Olympic status, would be reached without non-innovative and non-intriguing practice. However, there was a breakthrough at each level of expert-scientific expertise which overcame boundaries in understanding complexity of a human sports being, intrigue of their soul and their body.

Tendencies which led to technological breakthrough of athletics in 20th and 21st centuries were accessibility of results of methodology of athletics, perceived as new knowledge and solutions for its practice. "It is nice to make life more beautiful by new knowledge". "*Inventas autqui vita mexcoluere perartes*.", written on the back of a Nobel prize medal (*Alfred Bernard Nobel*), leads us to understanding the value of knowledge (quotes from Virgil's "Aeneid").

In accordance with the previously said, epistemologically perceived needs and abilities and final range of athletic knowledge achievement, universities represent a place for its understanding, creation and dissemination. "Thus, in Serbia, a project is being realized, which besides the existing two missions (teaching and research), should develop and implement the third mission of a university comprised of three pillars of development, and it is **transfer of knowledge** – technology and innovations, continuous studying, and achieving socially responsible behaviour of Serbian universities … because, common denominator for creators and disseminators of knowledge is prosperity of science and society based on *innovations*" (Jevtić, 2017). This is what academic essence (epistemiological and gnoseological) of athletic theory is, starting from a university departments towards training practice leading to excellence. Transfer of knowledge and technology into real training – competition situation leads to innovations which make an individual excellent and fills athletics with new records.

COGNITIVE BEING OF AN ATHLETE

It is a fact that science offers new useful knowledge used in the field of athletics. *Knowledge about their own bodies* is extremely important for athletes. Thus, human movement rests on information coming from the limbs, the motor cortex, internal organs, external surrounding... All of these create neuro-motor prerequisites for keeping the position and orientation while moving. On the other hand, the largest number of stimuli is for those an athlete is not aware of (sometimes we are not aware of either value or mission of knowledge), but which have influence on and change his/her consciousness and efficiency of movement. An individual reaches this self-knowledge through exercising. Therefore, an athlete acquires knowledge through sports (motor skills, cognitive skills, social skills and knowledge, terms, concepts, principles,

communication ...), stimulates understanding (of relations while moving, challenges, dangers) and application of acquired motor, social, cognitive and affective skills in sports and in real life situations as well. An athlete develops analytical mind (understands entirety and its parts, as well as cause-and- effect relationships of movement), synthesizes knowledge (synthesis of feelings, movements, moving, skills, habits, abilities...), makes conclusions and decisions (self-evaluation and evaluation)". In other words, by doing exercises an athlete closes the circle of knowledge and creates assumptions for new knowledge which will "challenge the current level of his/ her training performances".

The question which raises is *whether a hurdler acquires knowledge when in 400m race* he/she runs over the last – tenth hurdle and when his/her senses are less sensitive due to fatigue. At that moment an athlete differentiates a large number of new information and also adapts them to the task and that is not to touch a hurdle frame and not to slow down running in the finish of the race. Then, in order for a sense of sight not to cheat the body (in our case the swinging leg), a hurdler will jump over the hurdle significantly higher than necessary in order not to touch it. In this case experience is very important and sensations of fatigue become a challenge for new studying and new knowledge which in the following training will move a fatigue threshold when an athlete works on maintaining skills under conditions of high physical and psychical effort. A sportsperson will work on the analysis and direction of information he/she receives during high degree fatigue and together with his trainer he/she will work on overcoming problems from the race. Consciousness and experience lead to quality skills and competition speed of a hurdler, just like Ava Arsenie advised everybody who came to him - what he taught others, *he first lived through himself* (Sirin, 2000). Analysis of knowledge about oneself and movement embody *natural knowledge reached only by self*-**research and on personal methods of research**. Given competition situation is a sign or a trigger for a doubt or new self-evaluation. Saint Maxim the Confessor (1997) says: "A man is (spiritually) strong if he incorporates knowledge into his work". Holy father Justin Popović (Saint Isak Sirin, 2016) in chapter Gnoseology of Saint Isak Sirin says: "**Knowledge is offspring of a healthy soul** – γέννημα εστι τῦς ὑγείας τῦς ψυχῆς; and a soul can be cured by long practicing of virtues. Those who are perfect have healthy soul and knowledge is given to them.» Further on he says: «A conviction that the problem of knowledge in its basis is a **religious-ethical problem** reigns in gnoseology of Saint Isak Sirin ". And we know that even today there are the same requirements – ethic commission is asked to confirm *authenticity of research*.

ATHLETICS – FROM KNOWLEDGE TO INNOVATIONS

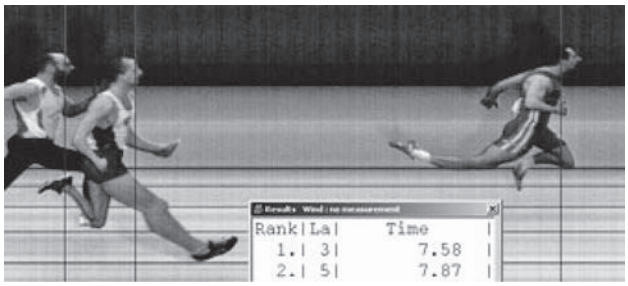
Alberts (2010)[1] pointed out directions of development of contemporary and future scientists in order to keep high level of scientific standards. In the first place, he talked about *credibility of results of research.* He emphasised that if a science is supposed to develop itself and take its relevant role in progress of the mankind, then it is duty of everybody in a scientific community to help creation of scientific environment with **high ethical standards and creative productivity**. This statement also exists in a scientific mission of a university and University of Belgrade regulated this issue by Code of Professional Ethics, which applies to all written work done by teaching and scientific staff. Ethical norms apply to all professors, research fellows and students and it refers to non-academic behaviour, among other things to **originality and authenticity** of research work. In the case of athletics, it can be concluded that sports workers should base their academic trend on high ethical standards which will lead to humane and ethical behaviour in experiments and theoretical analysis leading to originality and authenticity of results of research.

Today, it is very important to keep up with a trend of new knowledge useful for sport. Consequently, a question arises – how are knowledge and technology used in athletics? Stefanović (2009) says that their characteristic of expansion is expressed in the nature of both knowledge and technology. He says that their constant improvement is necessary which implies different resources, first of all human, financial, material, organizational... He claims that it is only pos-

1 The honourable president of the American National Academy of Science, former president of the National Scientific Committee and since 2008 editor-in-chief of a scientific magazine "*Science*".

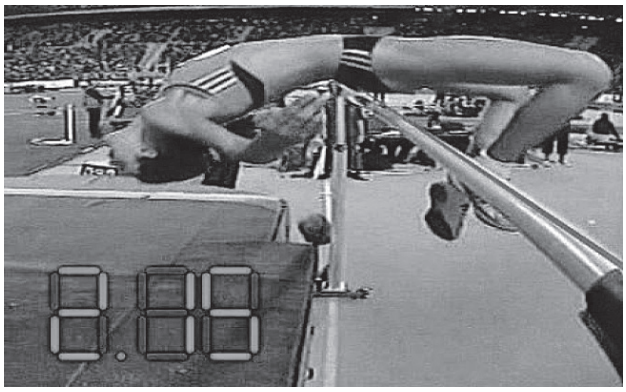
sible for an athlete to stay competitive on the world market of knowledge if he/she has the best training and competition preparation organised and realised. Resources of knowledge, which experts belong to (from the field of sport or through outsourcing) are at the background. Without them, level of development of athletics would be questioned. Review of developmental tendencies of contemporary technologies (where athletic sport is included) implies that *acquiring and transfer of knowledge* from very important areas for the mankind must not be neglected. There is a large number of research surveys in the field of science, which even got the Nobel prize and which are directly applied in sports, including athletics. Contemporary era brings new technologies from the field of telecommunications, new materials, optoelectronics, robotics, quantum medicine, so it can be said that athletics shared the challenges of the third and is getting ready for the vision of the fourth industrial revolution. Optoelectronics, based on new optical materials used for optimal transformation of optical signals into electronic ones and vice versa, can be emphasised as the characteristic of the third revolution. Practically, almost all new technologies of light (lasers, sensors, optical discs, etc.) represent functional integration of optical and electronic components which are more and more often used in sports and consequently in athletics. Laser ray is used in athletic throwing for measuring length of a throw. In running disciplines this technology is used for monitoring changes of kinematics and kinetics of strides. It is also used in running on finish line in a case of photo finish. Photo finish is automatic photographic device for recording order of runners coming to the finish line together with marking the time needed for running on a certain distance in athletics. A camera is positioned in the continuation of a finishing line. Finishing line is recorded, through a narrow vertical fissure, on a film which moves horizontally inside the camera in the same direction competitors run. At the same time, time markings at the bottom of the film are registered by a precise electronic clock[2]. It is a matter of time when measuring will be performed in milliseconds, since two sprinters can have the same result on the second decimal.

2 *http://staznaci.com/fotofinis*)



Picture 1. Photo-finish of a 60 m veteran race

Jovanović invented a device for precise measuring of high jump – "lasermeter", which by using laser rays measures height of a jump in millimetres. Canadian company "Farly Technology" from Quebec tested the prototype for months so that the product could get a licence. This invention won *Silver medal on the Innovation Fair in Novi Sad* (Janačković, 2008, Picture 2).



Picture 2. Precise measuring of high jump by "lasermeter"

Jovanović says that he did not invent laser and that, considering electronics, all the parts of a device had already existed but the principle of using a laser in measuring results of this athletic discipline is new. He got the idea while watching how results and the path of a tennis ball are processed. He says that we are witnesses of the Olympic disciplines competitions, where results are measured in millimetres and hundreths of a second, whereas in a high jump discipline we still have the situation that somebody jumps more than ten centimetres higher than the position of a crossbar and the result recorded is only at the height of a crossbar. His idea was to design a device which would emit laser rays at a distance of a half of a millimetre. The exact height is read when the rays are cut.

The device consists of two parts, a sensor unit and a processor unit. Sensors which emit and receive laser rays are positioned on poles at the height of 170 to 250cm, at a distance of 0.5cm. This is how a laser ray network is created and when a jumper cuts it, the exact height of a jump is detected. Rays can be visible and invisible and a control stick can be placed in order to see the difference. The only advantage of new dispositions is that with the first jump, when the control stick is at the lowest height but when competitors are the least tired, the world record could be broken; however, it is still too early to talk about application of this device in sports since certain procedures must be fulfilled.

It is very important to use *the system of computer monitoring of body movements* for hurdlers, high jumpers as well as during performing all the skills of a sports movement, especially for athletic disciplines where efficiency and economy of technique of moving performance has crucial influence on the result. Today, knowledge about efficiency and economy of movement of athletes is monitored by a system of information originating from sensors positioned on referential anatomical points of primary joints. Results of the measuring are analysed within kinetic and kinematic measures and also through acquisition and 3D signal analysis.

Remote monitoring connects an athlete and a trainer who in a previously defined space, time, and intensity of effort, gets information about heart rate in a minute, lap time, average speed of running, number of strides in a minute, length of strides, determines tempo and its variations. What is important is that these systems function bidirectionally, so that information received on a receiver, after direct acquisition, is delivered to the athlete not only as information but also as a new training task – exercise.

There is a well-known example of a South African athlete Oscar Pistorius (without lower legs) who wanted to compete in the Olympic Games in Beijing in 2008 in a 400 m race. Before that he had to prove to the World Athletic Federation that the robot which moves his prosthesis made of carbon fibres did not give him an advantage. He broke the world records on 100 m, 200 m and 400 m at the Paralympic Games. However, he did not run in Beijing because he had not met the qualifying standard of 46.30 s, what is slightly faster than his personal record of 46.56 s.

A team of experts proved that Oscar Pistorius's special prosthesis gives him an advantage over his opponents for 10 or more parts of a second compared with the time he would have in a 400m race if his prosthesis behaved as natural limbs. That conclusion was announced for the first time by human performance experts Peter Weyand from the university ''*Southern Methodist*" in Dallas and Matthew Bundle from Wyoming University (Weyand and Bundle, 2009). Pistorius's prostheses are half the weight of a male sprinter's legs without body deformities. Results of the research showed that a larger part of 15 to 30% of speed advantage Pistorius had, are explained by the way his lightweight "blades" enable him to change the position of his thighs fast: "Even when compared with male sprinters who can adapt themselves to speed in the most severe way recorded in human history, Oscar Pistorius has time necessary for a change of position of thighs which is literally out of the limits! Usain Bolt overtakes his opponents with 2–4% higher speed. Theoretically, with maximum speed, a well-trained paralympic athlete could move his thighs with light-material prosthesis 15% faster in comparison with six latest 100m record holders, including Usain Bolt."

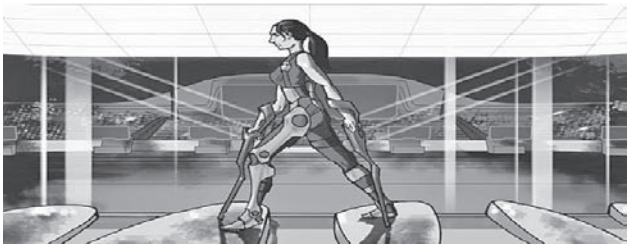
Weyand and Bundle (2009) confirmed that:

- Pistorius's prosthesis, so-called "lightweight blades", enable him to move his legs 15.7% faster than six latest 100m record holders; here we probably have, since this is rotational movement, faster rotation of its segments due to smaller inertia moment.
- flexible lightweight "blades" enable Pistorius to reach the same running speed while running sprint and at the same time receives 20% smaller ground reaction force than runners with natural limbs because of a smaller degree of shock absorption muscle engagement and
- prosthesis flexibility and its geometry reduce muscle effort which Pistorius needs for sprint to less than half the effort necessary for the "natural runners" category.

Sudden development of training technology based on computer and modeling techniques influenced the need to introduce this kind of changes into sport (Stefanović, 2011). *Robotics* belongs to the group of the most advanced techniques today. It has found its place in athletics, especially for the disabled people. Confirmation of this supposition/statement is a sports spectacle, from robotics domain, in athlet-

ic competitions among other sports disciplines held on 8th October 2016 in Zurich[3]. *Cybathlon* is a competition which tests athletes' abilities with the help of robotics. The basic aim of this competition is to provide a platform for development of *a new assistive technology*. Cybathlon had six sports events: cycling race, *leg prosthesis race*, wheelchair race, *exoskeleton race*, arm prosthesis race and for paralysed competitors brain-computer interface race, where brain of a paralysed competitor is stimulated by a computer interface to participate in a computer game. Two medals were awarded for each discipline – one to the winner competitor and the other to the winner producer.

Picture 3. Leg prosthesis race (source of the picture: www. google.rs cybathlon, an olympics for bionic athletes.)



Picture 4. Exoskeleton race model in Zurich 2016. (source of the picture: www. google.rs cybathlon, an olympics for bionic athletes)

Our body improvement is a space where *artificial intelligence* (AI) found its interest for research. One of the first commercial AI 'products' are *expert systems* (ES). Expert systems is a computer programme which emulates solving of a problem in a way an expert (a human) does. In order for a programme to be called ES, it has to *contain* ***expert knowledge*** *from a particular field* and *to enable automatised reasoning* (Stefanović, 2011).

Most often, an ES is not developed by programming in a particular programme language but by using relevant software tools, that is software shells. There are particular reasons for this: faster development and testing, easier maintenance, not all key ES components have to be programmed. Advantages of this system are numerous. The need for such systems increased with faster tempo of living. On the other hand, "wasting " time while waiting for relevant profile experts to come and try to solve or help with particular problems is shorter. There is a need to solve these problems, at the beginning less complicated and later very complex ones, by computers using easily accessible corresponding programmes. This is the biggest advantage of ES because they can be used anywhere and at any time.

An expert, a knowledge engineer and a user take part in development of ES (Stefanović, 2011). ***An expert*** (lat. *expertus*) is an authority, a practitioner in a particular field (Stevanović et al.2011), and *expertise* is *testing* done by experts. Even Socrates talked about an expert from the field of athletics. De Botton writes about Socrates's method of logical thinking which refers to the knowledge of experts (2002):

"In order to follow Socrates's example, we should, when faced with criticism, behave like athletes training for the Olympic Games. A trainer suggested an *exercise for a javelin throw* which strengthens calf muscles. It implies standing on one leg and doing weightlifting. It looks strange to the people watching us who make fun of us and object because we are reducing our chances for success. We hear somebody, by accident, in the bathroom , saying that: *we are more interested in showing our beautiful calf muscles than helping our town to win the games (ήμιν μέλει μαλλον το τά σκέλη καλά έπιδεικνύναι ή το βοηθειν πρός τήν ολυμπιονίκην).* Cruel, but still there is no reason to panic if we listen to Socrates in his conversation with Criton:

Socrates: When a man trains gymnastics seriously, does he pay attention equally to each praise or reproach or opinion or only if it comes from *a competent person*, a doctor or a gymnastics teacher?

Criton: Only if it comes from a competent person.

Socrates: It means that a man should be afraid of criticism or be joyful only to a praise of a competent person and not of a crowd.

Criton: Obviously.

Socrates: He should do and exercise, eat and drink only according to his instructor's advice and not according to the opinion of the rest of the world, because he has the **expert knowledge**. Value of criticism depends on the process of thinking of a critic and not

3 www. google.rs cybathlon, an olympics for bionic athletes, in Zurich in october 2016.

on their number or position. Don't you think it is a good principle that people should not respect the opinion of every man but only of one group of people and not the others, that they should respect the good ones and not the bad ones? Good people are those who have understanding and knowledge whereas the bad ones are those without understanding. Therefore, dear friend, you should not worry much about what the world will say about us, but what the expert on justice and injustice will say."

A knowledge engineer is a person who conducts an interview with an expert and collects ("elicits") knowledge. Then he/she makes a choice of relevant techniques for making conclusions, selects developmental tools, that is developmental shells, formalizes, formulates, arranges expert's knowledge and eventually tests the ES. What a knowledge engineer in AI is that is a *sports technologist* in sport. A profile of such a person is significant for sport because it is important that there is someone who is educated and who can transfer knowledge from the science/theory into athletic practice.

A user uses a completed ES, participates in formation of requests and he/she can also participate in testing and writing documentation for ES. Most often ES users in athletics are a trainer and an athlete.

CONCLUSION

People must be wise to preserve its culture, knowledge, language and documents during thousands of years. Respect of the past, transfer of knowledge to future generations is a foundation for wisdom in hearts of researchers. In the essence, an effort should be made to help and enable a researcher, in accordance with his level of development, to use all important information and knowledge from the complex field of athletics reasonably (in a way they should be used) – through writing scientific research studies and presenting them to the others.

Even Holy Fathers, Greek philosophers and philosophers of new era argued about importantance of knowledge for researching oneself and the others and they also emphasised personal experience as a significant factor. Nowadays it is very important to be informed about novelties in the world of innovative technologies, not only in sports/athletics but in a wider scientific milieu. In order to persist at the top of the world competitions, an athlete is forced to use the latest knowledge from the field of a wider circle of scientific research. Resources of knowledge, that is experts from various fields, are at the background and athletics could not exist at the level of development it is at today without them.

Transfer of knowledge (technology and innovations, permanent development, etc.) is a significant factor for the progress of science and athletics as well as a segment of a sport science. Contemporary tendency in development of the most important existing technologies (where sport is also included) implies that acquiring (values) knowledge from these very important areas for the mankind must not be neglected. Expert systems with an expert, a knowledge engineer and a user (a trainer and an athlete) incorporated into research should be part of athletic sport development.

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CONOCIMIENTO EN ATLETISMO - DE LA PRÁCTICA A LA INNOVACIÓN

Resumen
La promoción continua de los conocimientos prácticos y teóricos representa la base para un nuevo paradigma cognitivo y llegada a innovación que condice hacia una nueva práctica más efectiva del atletismo. La necesidad de afirmar el saber (todo aquello que se sabe) estimula el proceso de conocimiento sobre el hombre en esta actividad deportiva (contexto ontológico) incluyendo también aquellos conocimientos basados en el trabajo de investigación científica (contexto metodológico). La aplicación del método científico ha llevado hasta nuevos conocimientos a favor de la práctica atlética y hasta el establecimiento de nuevos horizontes en el estudio de los alcances de los rendimientos deportivos del hombre. La fuente del conocimiento son la teoría y la práctica atléticas. Ellas son al mismo tiempo la base del estudio de la dinámica de los rendimientos del hombre que se manifiestan a través de distintas disciplinas del atletismo. Los resultados en grandes competencias de atletismo han llevado a un número de analistas hasta el debate de niveles y "conservación "de las habilidades de hombre, mientras que para otros esa era la base para preguntarse sobre los limites extremos del conocimiento sobre el ser atlético de hombre (contexto gnoseológico). El origen del conocimiento sobre el ser atlético de hombre proviene de la filosofía antigua de Platón, Sócrates, así que se puede decir que la fuente del conocimiento es tan antigua como el debate sobre la naturaleza del cambio del ser humano bajo la influencia de los ejercicios. En este trabajo el atletismo se presenta a través del espacio de conocimiento (objeto de trabajo) que integra lo primordial y lo científico y con la procedencia que es un nuevo y eficiente entrenamiento y la práctica de competencia.

Palabras claves: ATLETISMO / GNOSEOLOGÍA / FILOSOFÍA / TECNOLOGÍA / INNOVACIONES

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