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SKELETAL MUSCLES: PHYSIOLOGICAL-BIOELECTRIC AND ENERGY FEATURES, CONTRACTION INTENSITY AND STRENGTH

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Abstract:
Good knowledge of functions and specific features of a muscular system enables working with athletes in a facilitated, more professional, more quality and safer manner as well as solving issues regarding qualitative use during the training process. Knowledge of the features, legality of skeletal muscles and their functions enables setting grounds for different hypotheses when the issue is athletic sports, and top performances for which we find answers. Accordingly, knowledge of the mentioned muscular features and marks is crucial for every subject whose work is related to sports. Only with a proper knowledge of the legality of the active part of locomotor system, it is possible to implement modern cybernetic models and transformational training processes not only within athletics, but other sports branches as well. This paper analyzes certain physiological legalities, mechanisms and energy processes of muscular contraction.

Keywords: muscular contraction, functioning mechanisms, muscle energy

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1. Introduction

From the aspect of athletics and other sports, it is necessary to be familiar with the core of physiological, bioelectric and energy features of muscles. The simplest sprint start in sprinting disciplines, long jump, high jump, shot put, various athletic running disciplines, etc. cause certain changes in the athlete's organism. Those changes are first visible on a cell level, then tissue, organ and, eventually, organ systems. These changes are mostly latent. Not before performing a movement (start running, object lifting, jumping) does this latent feature transform into a manifestation of muscular work that can clearly be seen, based on which a certain value can be measured (running speed, throw length, jump length and height, etc.). One must understand certain legalities of muscular-nervous system functioning well so that they could easier understand top performances that are achieved in athletics (Bolt, 9.58 sec – 100 m), overcoming the boundaries of realistic human abilities (Pavlović, 2014). Basic physiological features of muscles are: stimulus, stimulus conductance and contractility. Due to bioelectric and biochemical processes, muscles contract, which creates a certain amount of force. The amount of the force created which muscles use on their adjoints depends on the number of simultaneous active motor units and their action potentials (Dragaš, 1998). Muscle strength factors of a movement are the size of the cross-section of a muscle, the ability to activate the maximum number of motor units, the ability of the organism to send nerve impulses, neural muscular coordination (composition of energy matters), bone lever types, temperature (Stojiljković, 2003; Pavlović, 2014).

All skeletal muscles are innervated through branches of motor nerves and their innervation depends on the place of muscles and nerve cell positions. In certain normal conditions, one motor neuron can send its impulses through its neurites onto a high number of muscle units, from 10 (eye, fingers) all the way to 100 and above (postural musculature). Every muscle fiber that innervates one neuron is called motor unit (mion). The number of mions differs in various muscles, thus muscles used for finer movements have a lower number of mions than those used for musculature maintenance (stato musculature). If greater force needs to be used or muscle contraction speed increased, then a higher number of motor units is included in the movement, which depends on the CNS that extraordinarily controls and coordinates work of all skeletal muscles (Stojiljković, 2003).

One of the basic physiological features of a muscle cell is contractility, which occurs upon stimulus transferred through nerves. All those nerve fibers end up in a muscle as a sort of a spread called motor plate, and represents the so-called peripheral synapsis, i.e. a meeting point of a nerve cell axon with muscle fiber or a meeting point of two nerve cells. Synapses can be excitational (stimulating) and inhibitory (breaking) and perform the impulse transfer from the nerve to muscle fiber. This arises a question of how does it work on a cell level, all the way to the reaction of a certain muscle group?

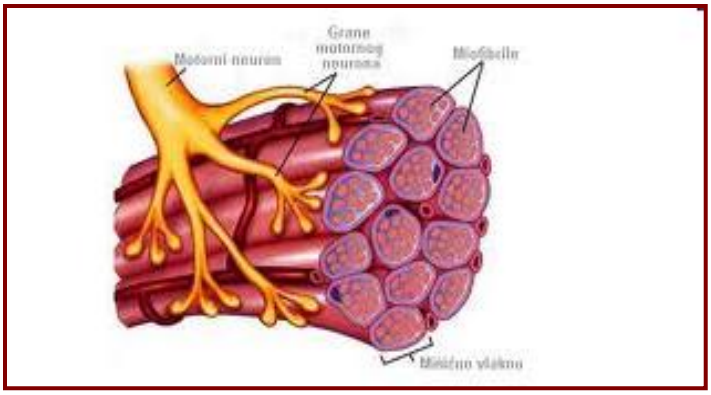

Figure 1: The innervation of skeletal muscle – MION

For instance, in athletics while performing a sprint start, a huge reaction speed is created (120-150 ms) which is the consequence of a well-functioning neural muscular system of an individual (T. Montgomery, 104 ms). Motor neural fiber (neurite) before contacting the muscle fiber loses its myelin sheath and splits like tree roots that contact the wrinkled surface of a muscle fiber membrane, which provides a greater contact surface. Neurite end is covered with a presynaptic membrane, in which vesicles there is the transmitter *acetylcholine* which only helps perform excitation. When the bioelectric stimulus of a neurite end occurs, the vesicle is sprinkled and the transmitter spills into a synaptic crack. By prinkling one vesicle, around 10.000 acetylcholine molecules are released, which is attached to protein receptors penetrating altogether through the muscle membrane. The transmitter and receptor tying process lasts several milliseconds which is enough to open ionic channels for entrance (Na^{+}) into the cell (negative charge), during which an action potential occurs (lasts 2-4 ms). At the same time, potassium ions egress (K^{-}) which interrupts the interaction on the cell membrane, which creates a potential difference between the outer and inner side of the membrane that is negative (-90mV) and starts growing to 0mV, transitioning to a positive state (+50mV), (Astrand & Rodahl, 1986; Nikolić, 1995, Pavlović, 2014). This positive ion entrance process and negative ion egress is called depolarization. Depolarization wave speed of the skeletal musculature amounts to 5 m/s. The interruption of a depolarization wave closes the entrance channels (Na^{+}) into the cell and its prompt elimination initiates by activating a sodium-potassium pump which spends a significant amount of energy. When the cell membrane is being depolarized, muscle cell cannot be stimulated for 1-3 ms, and that period is called the absolute refractive period. Muscular contraction occurs after that (Fig. 2).

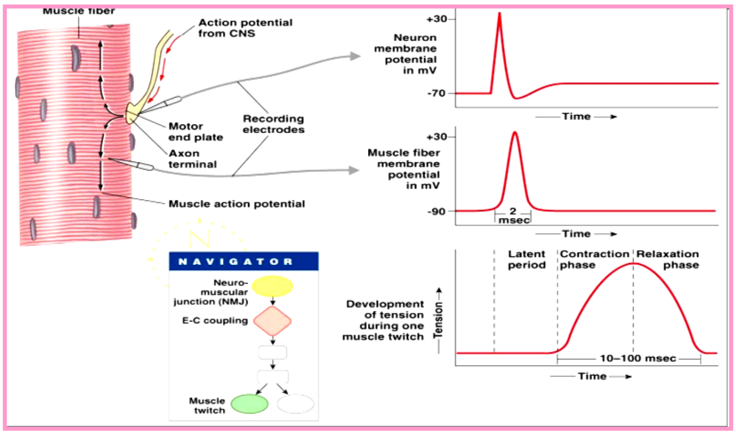

Figure 2: The bioelectric processes in the muscle cell

2. Mechanism of muscular contraction creation

The process of initiating muscular contraction is related to the process of muscle cell depolarization. Immediately after that begins the process of repolarization, along with which start myofibril sliding and the initiation of muscular contraction. As a constituent part of myofibril (contractile elements) four proteins participate, which are responsible for muscular contraction. These are thick myosin fibers, somewhat thinner actin fibers, tropomyosin with elongated molecular composition and troponin with its three parts: I, T and C; T and C are so-called regulatory proteins that perform the opening of ionic channels for entrance of Na^+ into the cell. These proteins are parallely placed along the cell and are closely bonded to the cell membrane where there are up to several thousands of them in each cell (Dragaš, 1998; Pavlović, 2014). Myosin component consists of body and head whereas actin consists of a round-shaped protein, i.e. globules that are grouped in long chains spirally twisted around their longitudinal axis. Thin actin fibers are tightly bonded to a Z-disc and one of its part is situated parallely between thicker myosin fibers. Actin fibers are only a few microns thick and are grouped around the thicker myosin fiber. That relation is 1:6, which means that six actin fibers are grouped around one myosin fiber. These two proteins and round plates called Z-discs (Z-lines) comprise the basic myofibril structure. Myoglobin is placed around myofibril, it is similar to hemoglobin, red and bonds oxygen to itself. Myoglobin is more common with red muscle fibers that contract slower because of the allevated presence of O^2 in relation to white (Bajić and Jakonić, 1996).

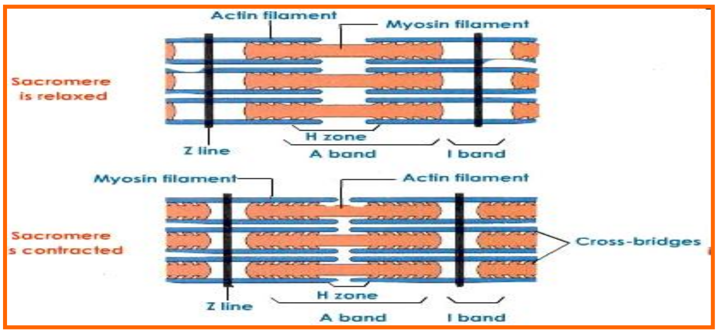

Figure 3: Sarcomere - relaxed and contracted the condition

The space between two Z-discs is called sarcomere, where brighter spaces on sarcomere create actin, and darker create myosin. While muscles are in a standstill, in this area actin and myosin fibers do not intertwine but there is a contraction this area disappears. Thicker myosin fibers have a part of molecule that is called head which is consisted of four smaller, ordered in a thorn-like manner across one semi-circle with an exact spacing. There is a theory that the actin surface has indents inside which myosin heads prowl, at which time they make a movement similar to rowing, moving actin fibers towards the inside, which also moves Z-discs, thus performing a contraction. During the contact with actin, not all four heads of meromyosin participate, but only one, which depends on the used muscle force. If greater muscle constraint is needed, and there is a longer excitation of neural muscular synapsis, then two, three or even four meromysin heads participate in the contact (Astrand & Rodahl, 1986). The energy for pulling actin fibers in is secured with solving ATP, while regulatory proteins troponin and tropomyosin together with Ca are responsible for the initiation of sliding actin fibers.

Muscles mostly create a certain muscle force of higher or lower intensity. As a consequence of manifestation of force of certain intensity, muscle contractions that perform mechanical work are created (jump, rebound, lift, sliding move, run, etc.). Accordingly, muscular contraction can be twofold in relation to the force generated by the muscle and forces which muscle force opposes to. When force sizes are equalized, muscle barely shrinks during which isometric contraction occurs. Contraction which changes muscle length is called isotonic contraction during which mechanical work occurs. Contraction which approximates muscle adjoints is called concentric or myometric, and when muscle adjoints separate excentric or plyometric contraction. Based on these changes, all cyclic and acyclic athletic movements are performed (Kukolj, 1996; Stojiljković, 2003; Pavlović, 2006; 2014).

Skeletal muscles are tense even when standstill. That tension is considered a basic degree of contraction of skeletal muscle called muscle tonus. Tonus is a physiological characteristic of a muscle and represents the lowest degree of muscle tension that can be maintained for a long time without fatigue occurrence. Although for a long time there has been a dilemma whether it is tonus of central origin or consequence of collection of liquids in muscles after work and fatigue occurrence, it is still proven that the it is of central origin as it occurs in the sleeping phase when muscle constantly sends impulses about the stretching state across tendons and joint capsules in sensory areas, and CNS uninterruptedly sends back corresponding signals to muscle fiber (Pavlović, 2014). One of the muscle characteristics is its elasticity. On average, a muscle can be stretched to one third of its normal length and as we get older muscle elasticity decreases and reduces muscle tonus (Fitts, 1994). Depending on the muscle fiber type, numerous physiological processes in them will also depend, for instance contraction time, fatigue resistance, energy source, mononeuron size, etc. (Figure 1). In athletic disciplines the fast, explosive, powerful and exact movements dominate. The manner of movement manifestation depends on the discipline. Sometimes it is important to lift a huge weight (weight lifting), sometimes to throw to a certain length (discus, shot, hammer, javelin), and sometimes to jump as farthest or as highest as possible. However, it all depends on the muscle type, and mostly on the muscle contraction intensity and strength. To better understand this issue, muscle behaviour and some of its specific features it is crucial to understand the legalities of muscle functioning, i.e. muscle contraction intensity and strength.

Table 1: Characteristics of muscle fibers (Fitts, 1994)

Type of fiber	**Slow I**	**Fast IIA**	**Fast IIB**
The time contraction	slow	fast	very fast
Size of motoneurons	small	big	very large
Fatigue resistance	high	median	small
The activity	aerobic	Anaerobic-long	anaerobic-short
Production of forces	small	big	very large
The density of mitochondria	big	big	small
The density of capillaries	big	median	small
The oxidative capacity	big	big	small
Glycolytic capacity	small	big	big
The main source of energy	triglycerides	CP, glycogen	CP, glycogen

Table 2: Percentage ratio of the diameter of the fiber m.quadriceps hamstrings in both sexes of different ages (Perić, 1999)

Typ of fiber	Percentage distribution	Size cross section (micrometer²)			
		Male		Female	
		16. years	20-30. years	16. years	20-30. years
I (SO)	52	4880	5310	4310	3948
IIA (FOG)	33	5500	6110	4310	3637
IIB (FG)	14	4900	5600	3920	2235
Number participants		70	10	45	25

3. Muscle contraction intensity and strength

The final common denominator in sports competitions is: what can muscles do? How much intensity can they develop when it is needed, how much strength can they produce during the performance of work and how long can that activity last?

Certain phases of muscle contraction intensity as well as changes that bring it up can be seen using the special instrument, kymograph. On the acquired myogram phases of muscle contraction can easily be seen. "It" first starts with latent period or hidden period of contraction, then contraction occurs (muscle shrinking) and finally releaving phase and decontraction. During the latent period, changes already described occur: bioelectric processes on membrane, entrance of Na^{+}, releaving of K^{++} ion, etc.Muscle shrinking process occurs when actin and myosin myofilaments slide. Muscle generally constracts only under influence of series of impulses, but not individual impulse which brings up permanent muscle shrinking, i.e. tetanus contraction (Dragaš, 1998; Stojiljković, 2003; Pavlović, 2006; Perić, 1999). Depending on the number of impulses, muscle contraction can be performed as a smooth tetanus or serrated tetanus. If muscle contraction is of a smaller intensity and lasts longer, smooth tetanus occurs, but if muscle contraction is of a higher intensity and lasts in a short period of time, serrated tetanus occurs due to fatigue occurrence, i.e. reduced amount of transmitters on the periferral synapsis. Tetanus contractions are four times stronger than individual ones because they are a consequence of high number of stimuli even up to 50/sec. The only body muscle that contracts with an individual muscle contraction is cardiac muscle. Regarding muscle contraction, is interesting that the muscle contracts in accordance to the all or nothing law. It means that, if contraction occurs, muscle shrinking will always be maximum depending on the muscle type. Differently put, muscle reacts to a stimulus with a maximum shrinking or does not react to it at all if it is below the stimulus threshold, which depends on the membrane potential (Bajić and Jakonić, 1996).

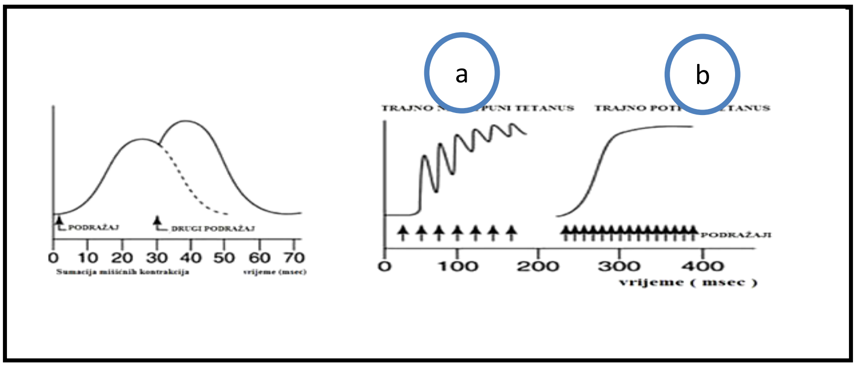

Figure 4: The **c**ontraction of tetanus: a) incomplete; b) complete

These changes can be analyzed on the example of sprint start in athletics. After the starter pistol goes off, we perceive the signal through our hearing apparatus (receptor) that informs the athlete about the new outside stimulus. This starter signal is transferred via sensomotor afferent paths and processed in certain CNS zones as a signal for starting performing muscle work. The muscle undergoes bioelectric changes, first on a cell level (process of action potential and depolarization), which are the first prerequisites for initiating myofilament sliding. On the basis of cell changes, myofilament sliding occurs which leads to shortening (lengthening) of muscle fibers, bundles and eventually entire muscle which as effector performs mechanical work with necessary energy. Not before that does stretching out, i.e. pushing of the athlete off the start blocks occurs and start acceleration initiates. Those reaction speeds are small (T. Gay 136 ms).

Muscle contraction strength is demonstrated in multiple ways. Sometimes we are able to perform easier tasks, such as lifting a very light object (pencil, rubber, bag, etc.), and sometimes even a heavy object (weights). These and other similar activities use the same muscle groups that do the same work. These activities have a different character and intensity that depends on the weight size. This weight size is directly proportional to the number of active motor units, which means that if the weight is smaller, a smaller number of motor units is used, unlike bigger weights when a bigger number of motor units is used. Each movement is precisely controlled, where indicators could be movement amplitude size, movement speed, movement frequency, number of repetitions, etc. Strength of this contraction is performed in different centres of cerebral cortex, spinal cord through different receptors, proprioreceptors, ligaments, joints, muscles (Nikolić, 1995). Each data is processed in main nerve centers that process the delivered data and send an adequate reply, which can even be a correction to the received signal. The main role in the control of muscle contraction size has specific muscle fibers, so-called intrafusal muscle fibers or muscle spindle (IF) that act as sensors

(Stojiljković, 2003). Each muscle has a certain number of intrafusal fibers, depending on the muscle type. Muscles that perform manipulation movements are rich with this IF musculature, even up to 30 IF muscles on 1 gram of body mass, while postural muscles (m. latissimus dorssi) and other are less rich in comparison. The IF fibers are situated parallely to all muscle fibers, and their ends are bonded with tendons. Work principle of sensory fibers is the feedback principle. When muscle straining occurs, the middle part of intrafusal musculature is stretched which sends impulses on that change to spinal cord where there motor cores of that muscle are stimulated and it contracts. This is the case with muscle contraction. However, when a certain weight is to be lifted there is an opposite reaction; intrafusal musculature ends stretch first, and then the entire musculature. These contractions are precisely dosed in accordance with the weight size.

Muscle contraction strength also depends on the number of muscle fibers active in a muscle activity. Number of muscle fibers is genetically predetermined, so some persons have more muscle fibers than others, and thus are stronger. For example, if we compare two non-training persons, same age, same weight and height, i.e. morphological status where under the same condition one can lift 80 kg bench press, and the other cannot, a question arises: how is that possible? It means that the person who lifted 80 kg has a genetically better muscle tissue structure, i.e. higher number of muscle fibers (myofibrils) which perform muscle contraction (Pavlović, 2014). This rule is not applicable to persons undergoing training, because high strain causes accumulation of muscle fibers by consuming certain proteins through food. However, persons with a higher number of muscle fibers can be at an advantage. Apart from that, muscle contraction strength influences condition of muscles, fatigue and types of muscles performing work (Fitts, 1994). It is considered that the strongest muscles in human body are those which oppose the effect of gravity, enable human body to maintain upright posture (neck, back, pelvis, quadriceps). If the contraction conditions are the same, i.e. muscle stimulus, temperature, muscle fatigue, then muscle contraction strength can depend upon the initial muscle length before the contraction. If a muscle is stretched to maximum, it has less contraction strength than if it were only slightly stretched. This is the reason it is best to work with the optimal muscle stretch. Maximum strength can be expressed in maximum weight a muscle can lift. It can be very high, and can even be multiple times higher than the body weight (according to Russian authors even 7 kg/cm^2) of the cross-section (i.e. m. gluteus maximus 1200 kg). For instance, foot muscles do not only carry the body weight, but even the weight a person carries on their back. Human skeletal muscles are capable of achieving pressure strength of 3-4 kg/cm^2 (Guyton, Hall, & Saunders, 1999). It is counted based on anatomic and physiological cross-section of a muscle. Anatomic cross-section is the cross-section of fibers under the 90° angle in relation to the longitudinal muscle axis, whereas physiological cross-section is the cross-section perpendicular to the course of certain muscle fibers. Spindle shaped muscles have different cross-sections, whereas other muscle types (feather, square, deltoid) have a much higher physiological cross-section (Pavlović, 2014).

Table 3: The microstructure and biochemical changes in muscle fibers that occurred under the influence of training of various types of motor skills (% change from the initial level) (Yakovlev, 1983)

Parameters	Endurance	Speed	Strength
Relative muscular mass% of the total body weight	9	32	39
Cross section, the thickness of the muscle fibers	0	24	30
The number of mitochondria per surface section MJ	60	30	-
The protein content			
Sarkoplasma reticulum	5	54	60
Myofibril	7	63	68
Sarkoplasma	23	57	30
Myosin	0	18	59
Myoglobin	40	58	-
CP	12	58	53
Glycogen	80	70	38
Receiving via reticulum Ca	0	15	53
Phosphorylase	23	40	20
Oxidative enzymes	230	100	-
Speed glycolysis	10	56	28
Speed oxidation	53	45	20

During the training process and the competition, especially characteristic for athletics is the state of a well prepared organism, muscular and other systems of the organism that will function the best in conditions of hard work.

Muscle contraction strength depends on the initial muscle length (stretchedness), type of lever to which a muscle is attached to, muscle fatigue, organism temperature, sex, age, etc. The optimum initial muscle strechedness is the best for performing any type of work. Contraction strength depends also on the lever to which a muscle is attached. The higher the lever force tentacle, the less strength is needed for its movement and vice versa. Greater muscle force is needed if the work is done using one joint (Mc Ginnis, 1999). However, most movements inside the organism are performed using two or more joints, so the contractions are smaller in relation to the force used, which saves energy than if two or three muscles were to be engaged (Jovović, 2006). If fatigue occurs, energy-generators that cause muscle contractions are reduced. Elevated body temperature over 37.5°C affect negatively on muscle contraction and force usage so not any activity is recommendable during that period. This is especially important during the training process when strains are supraliminal aiming at transformation of certain abilities. In relation to men, women have 70% slow (red) and around 80-85% fast (white) muscle fibers (Miller & Tarnopolsky, 1993; Perić, 1999; Pavlović, 2014). The amount of body mass is also smaller on women, which means they can only use 65-80% force in relation to men of same age and same physique. Nonetheless, let us not misunderstand the fact that, though the structure and physique are the same, under certain circumstances and controlled training women can get achieve higher results, approximating to those men achieve (Nikolić, 1995).

Table 4: Schedule of red fibers in some muscles obtained autopsy (Nikolic, 1995)

Muscle	% red fibers (range)	
	Male	Female
m.quadriceps fem., vastus lateralis	40-65	35-40
m. rectus femoris	38-50	30-55
m.gastrocnemius	40-58	40-65
m.tibialis anterior	65-80	57-80
m.soleus	75-100	85-90
m.deltoideus	43-80	55-70
m.biceps brachii	38-60	60-70
m.triceps brachii	15-50	35-40
m.longissimus dorsi	56-60	58-62

4. Muscle contraction energy

Athletic disciplines demand from an athlete a high energy consumption during the performance of an activity. As a consequence of consuming energy, certain work occurs. There is no greater strain for a body than strain during heavy muscle work. Actually, if heavy muscle work would last longer, it could be deadly. Here is one example in athletics: if a man has high temperature which could be deadly, body metabolism increases for about 100% above normal. Comparatively, metabolism of an athlete who runs marathon increases for about 2000% above normal (Guyton, Hall & Saunders, 1999).

To better understand this issue, we will take a look at a manner securing and consuming energy. Human organism functions like a machine which uses certain fuel, i.e. energy to work. They gain that energy in a form of chemical compounds, transforming it into free energy that performs mechanical work. The main source of energy is carbohydrates, fats and proteins which secure that energy for muscle contraction with certain biochemical processes (metabolism). The main source is the highly energetic compound adenosine triphosphate (ATP), consisted of nitrogen base of adenine, pentose sugar of ribose and triphosphate group (Pavlović, 2014). The first phosphate group is tied to ribose with a stable bond making the compound adenosine monophosphate (AMP). This compound is not rich with energy. By adding another phosphate group, another stable bond adenosine diphosphate (AMP+P=ADP). By bonding the last phosphate group, an unstable, easily broken bond occurs, adenosine triphosphate (ATP) but which is rather rich with energy. While releasing one phosphate radical, ATP frees 7-9 Kcal or around 30-36 KJ (kilojoules) of energy per one molecule and that energy is transferred to a new compound, creatine phosphate (CP) (Bajić and Jakonić, 1996; Stojiljković, 2003). The amount of ATP in muscles, even in trained athletes, is enough to maintain maximum strength for only around 5-6 seconds, which can be enough for a 50 m sprint (Guytop, Hall, Saunders, 1999).

All these bonds are reversible, and their transfer is performed with help from certain enzymes. It means that ATP can be dissolved to ADP, ADP to AMP and again return to the prior state of ATP depending on energy. In muscle cells, amounts of ATP are limited, so they have to be restored constantly. Another compound found in muscle cells which is capable to be bonded to a phosphate group is creatine (C). When a cell is in standstill, ATP gives one phosphate group to creatine and phosphorizes it, the result of which is creatine phosphate (CP). During muscle work, creatine phosphate is dissolved and again frees phosphate radical which is bonded to ADP through enzymes and again creates ATP (Yakovljev, 1983; Volkov, 1986; Sahlin, 2010). In the moment of relaxation and receiving the phosphate radical, a huge amount of energy is released and is used for muscle contraction, and also transforms into other shapes of energy, thermal, mechanical, bioelectric. This energy is also gained by dissolving carbohydrates (CH) using glycolysis and Krebs cycle processes, fat and protein. Regarding CP reserves are limited, it can secure energy that can last for 8-10 seconds, so it represents the main energy source for extremely fast and explosive activities in athletics such as 100 m sprint, jumping and throwing disciplines (Guyton, Hall, Saunders, 1999). Namely, renewing creatine phosphate is happening fast, and in the first 30 seconds achieves 70% and in the period from 3 to 5 minutes 100%. In more intensive disciplines that last approximately 40 seconds (200 m, 300 m, 400 m sprint), ATP-CP composition first secures energy, and after 8-10 seconds includes the lactic acid composition (Janssen, 2001).

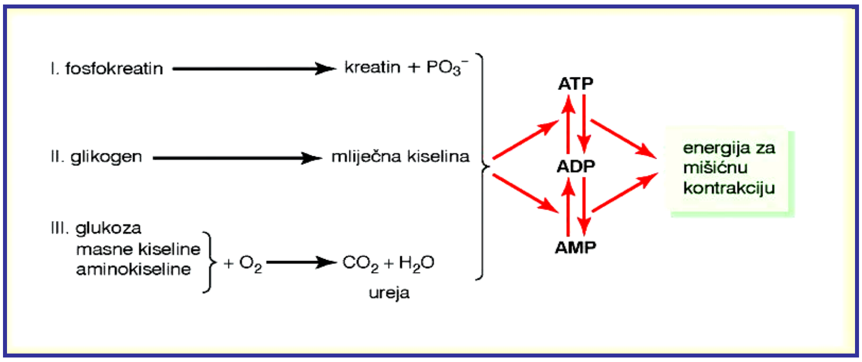

Figure 5: The transport of energy

Inside it, glycogen from muscle cells and liver is dissolved, releasing energy for resynthesis of ATP from ADP+P. Due to lack of oxygen, a side effect occurs, which is well-known as lactic acid. During high intensity activities, it causes accumulation inside the muscle which causes fatigue and ultimately the end of physical activity. Renewing this lactal composition demands longer period of time, it can last for days and depends of the type of training and nutrition of the athlete. For example, with moderate intensity activities (interval training), to renew 40% of amount 2 hours have to pass, for 55% 5 hours and for 100% 24 hours are needed. Parallel to this, it is necessary to extract lactic acids from blood, which needs more time, 10 minutes to remove 25%, 25 minutes for 50% and an hour and 15 minutes for 95%. Unlike anaerobic composition, aerobic composition is dissolved by glycogen in the presence of oxygen producing little or no lactic acid, enabling the athlete to continue the activity. Aerobic composition is the key energy composition for disciplines that last between 2 minutes and 2-3 hours, 1500 m, long track (Nikolić, 1995).

Table 5: The energy for some track and field events (Nikolic, 1995)

Discipline (m)	Energy transport (kJ)	Discipline (m)	Energy transport (kJ)
100	231	3.000	1.176
200	294	5.000	1.890
400	420	10.000	3.150
800	546	30.000	7.560
1.500	714	42.195	10.500

Table 6: Activities maximum intensity varying duration and processes providing energy for these activities (Janssen, 2001)

Duration	Type of process	Ensuring of energy	Note
1-5 sec	anaerobic alactate	ATP	does not create lactate
6-8 sec	anaerobic alactate	ATP + CP	does not create lactate
9-45 sec	anaerobic alactate + anaerobic lactate	ATP + CP + muscle glycogen	big lactate production, with an extension of the duration of the activity is reduced lactate production
45-120 sec	anaerobic lactate	muscle glycogen	
2-4 min	anaerobic lactate + aerobic	muscle glycogen	
4-10 min i dalje	aerobic	muscle glycogen + fatty acid	with an extension of the duration of the increased fat content

Table 7: The relative proportion of aerobic and anaerobic processes resynthesis of ATP in the overall energy balance of disciplines (Bajic and Jakonić, 1996)

% the aerobic release of energy	% anaerobic release of energy	The limit time contest (min)	Distance (m)	The character of work
100	0	135,00	42195	**Aerobic**
90	10	29,00	10000	
80	20	14,00	5000	
70	30			
60	40	8,00	3000	**Aerobic Anaerobic**
50	50	4,00	1500	
40	60	2,50	1000	
30	70	1,75	800	**Anaerobic**
20	80	0,75	400	
10	90	0,35	200	
0	100	0,15	100	

Regarding participation of aerobic and anaerobic processes of resynthesis of ATP in balance of athletic disciplines, we can see inverse relationship of these abilities (Fig. 7). Aerobic processes comprise long track activities (5,000 m to marathon) and here they have an 80% (AE) : 20% (AN) ratio, unlike running disciplines (1,000 to 3,000 m), where the ratio is 40-60% (AE) : 60-40% (AN). At the end, sprinting type disciplines (100 m to

800 m) have a ratio of 30% (AE): 70% (AN). Knowledge of these ratios of AE and AN potentials is crucial in planning training as well as energy intake through food.

5. Conclusion

This paper analyzed basic postuplates regarding functioning of skeletal muscles while performing physical activities with the genesis of certain processes origin in the organism on a relation CNS – muscular system. Bioelectric and physiological changes process has been defined from the cell level all the way to the huge muscle system. Understanding how the organism functions from the first nerve impulse to the last response of a muscle regarding muscle contraction is important in order to learn, observe, plan and manage in a training process with young athletes. Also, defining muscle contraction intensity and strength will largely enable clearer understanding of muscle system functioning and eventual undesired consequences that can occur as a consequence of unprofessional work of an individual. The importance of energy of muscle contraction is also emphasized in performing mechanical work and its renewability. Energy function of muscle activity is significant for balance of aerobic and anaerobic processes in energy balance of athletic disciplines and overall muscle work.

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