NERVOUS INTEGRATION OF VOLUNTARY MOVEMENT

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Abstract
Designed as a true cyber scheme, execution of volitional movements is a synergistic combination of different sensory and motor factors which is reflected in muscle contractions, adequate control over the intensity, hierarchy, chronology and spatial location of body or different parts of the body.
All body biomechanical activities results from a double command which simultaneously produces the contraction of two muscle groups with antagonistic action. Those are the flexors and extensors. The first group contract and produce the desired movement, the second group provides relaxation and modulates movement. The movement would lose precision and safety, also can occur excessive contractions without this synchronization between the muscles agonists and antagonists.
Voluntary movement involves a complex process of coordinated steps required not only for initiation, but also for the cessation of muscle contraction, and the intimate nature of the processes in which volitional consciousness is capable of expressing itself in terms of movement remains incomprehensible.
In the rehabilitation and sport, the accuracy of the voluntary movements is crucial. The learning and repetition for learning of one motion require a complex image of the temporal and spatial succession and nervous integrationof the elementary movements that must be executed in a special order to achieve the desired action. Those succesion are the base of rehabilitation and sport and must be well understude in order to achive the ideal voluntary movement.
Key words: *muscle contraction, nervous integration, voluntary movements*

Introduction

The muscle is the active effector part of the system that realizes a movement. This is how the body reacts to the constant changes in the environment, all range of external attitudes is feel in the functionality of central nervous system that can ultimately reduced to a single fundamental phenomenon that is the movement.
For point-to-point movements, the model provides predictions on (1) movement trajectory, (2) equilibrium trajectory, (3) muscle control inputs, and (4) antagonist muscle stiffness, as well as other variables. [1]
The striated muscle is the actualy effector device of this system that has two fundamental properties: excitability and contractility, also guarantee that the electro-chemical influx that is perceived at his level is transformed into mechanical energy through a complex processes.
The various movements of the body are carried by the muscles closely related to the nervous system that is based on integrates internal/external information. After the integration of those informations the brain is emitting commands for the muscles that are end effectors and finally do the required and learned movement. For many years thereafter the role of the motor cortex was relegated to that of a simple map of muscles and muscle activity patterns by which the rest of the cerebral cortex controlled spinal motor neurons. [2]
Franz & McCommick [3] highlighted there is a tendency in the brain to economise cognitive resources, while at the same time optimising behaviour. Further, the brain is continually monitoring sensory and cognitive information to glean essential associations used to efficiently guide behavior. [4]
The motor system can learn new behavioral strategies or new reactions to familiar stimuli to improve behavioral outcomes, and it can learn new skills to cope with predictable variations and perturbations of the environment.Thus the neural control of voluntary movement involves far more than simply generating a particular pattern of muscle activity. [2] Many aspects of the neural response may be quite ‘non-muscle like’ even if muscle commands are the final output. [5]
In 1997, Ning Lan talk about the multi-joint arm movements performed by humans, the coordination strategy for a set of redundant muscles and the consequent invariant features of movements that are not well understood. [6] Also the Ning article speek about the fact that extensive experimental studies have been carried out to identify biological control strategies of movements.

There are several types of muscle fibres that differ with regard to their functional, biochemical and morphological properties. [7] Nevertheless, muscle fibres belonging to a particular motor unit are all identical and are specialized to carry out the tasks demanded from them by the motoneurones that activate them. [7]

The heterogeneity of the muscle fibers is the base of the flexibility which allows the same muscle to be used for various tasks from continuous low-intensity activity (e.g., posture), to repeated submaximal contractions (for example, locomotion), and to fast and strong maximal contractions (jumping, kicking). [8] In addition, the structural and functional properties of the fibers, which are generally referred to as fiber phenotype, can change in response to hormonal and neural influences, nerve-activity being a major determinant of the fiber type profile. [8]

Needham (1971) [9] provides a comprehensive account of the history of muscle contraction and metabolism and quotes Berzelius (1807) for the discovery that the muscles of an exhausted stag contained lactic acid.

Skeletal muscle accounts for approximately 50% of total body weight, and is known to be the largest tissue in the human body, mainly responsible for force generation, movement and breathing. [10, 11]

After Best and Garret skeletal muscle comprises the largest tissue mass in the body, accounting for 40–45% of body mass [12, 13]. It is responsible of locomotion and also for the changes in body size and shape of the internal organs, so:

a) the muscle transform the chemical energy into mechanical and thermal energy. In order to fully appreciate the physiology of skeletal muscle, you must know how muscle transforms the food we eat into the muscular action that produces force and motion. This flow of energy is called skeletal muscle energetics and it focuses on the creation and use of adenosine triphosphate (ATP). [14]

b) the mechanical effect is realized by muscular contraction that manifest also in pressure on cavitary organs, also by the resistance to changing of the posture of a body or different body parts (specialy the postural muscles) or for carry out active movements (walking, running, jumping etc.)

c) actomiozionic complex consists the structural basis that couple the excitation with contraction in muscle fiber d) ATP (adenozintrifosforic acid) is the direct power source necessary for the contraction named by Engelhard "universal energy currency of living matter". ATP is a complex *nanomachine* that serves as the primary energy currency of the cell [15]. A nanomachine is a complex precision microscopic-sized machine that fits the standard definition of a machine. ATP is the “most widely distributed high-energy compound within the human body” [16]. AllenD. G et all from 2008, have cite many studies that have reported that cytoplasmic [ATP] does not drop below ~60% of the resting level during either imposed stimulation or voluntary exercise. [17]

e) the muscle contraction is triggered by a physiological stimulus (nerve impulse), stimulus that represent the information.

The human body is a complex machine that poses many sub-systems interacting each other and a main control to make efficient this interaction: the nervous system. [18]

The various muscle functions are controlled by signaling pathways that allow the muscle fiber respond to changes in the metabolic and functional demands of the body. Indeed, examples in the world of sports, therapy, surgery, and trauma support the idea that skeletal muscle is one of the most adaptable tissues in the body. [19]

Some forms exercise training, such as strength training and resistance training, can produce an increase in skeletal muscle mass, known as muscle hypertrophy [20]. These interactions suggest that the dynamic regulation of skeletal muscle mass is not simply a balance between synthesis and protein degradation, but a finely regulated process. [19]

The motor system was born, not made, and many of the characteristics of the human motor system reflect its history. [21] The ability to store motor memories enables the motor system to select a wide variety of movements in a highly flexible manner. People can select actions from a large repertoire of skills that have been previously learned, depending on context. [21]

Force and movement depend on muscle proteins, principally myosin and actin, both of which form strands within the muscle fibers. Molecules of myosin store kinetic energy as a result of metabolizing adenosine triphosphate (ATP), and muscle activation converts this chemical energy into mechanical force and work. Muscles generate force through a cascade of electrical and biochemical events, beginning with the release of acetylcholine by motor neuron synapses at the neuromuscular junction. [21]

Nerves from the motor neurons are also called efferent fibers which carry signals to the end organs. Sensory or afferent neurons carry sensory

signals from these organs to the CNS for processing.

Striat skeletal muscle that is involved in voluntary motion, should be framed in general metabolism of the body, which influences and by which it is influenced. The contractile activity is mainly dependent in terms of source energy, muscle is the main producer of lactic acid that is consider the "metabolic waste" which in human represent an important energy substrate for cardiac muscle. The skeletal muscle is the main producer of CO2 in the body also as the main source of heat from the body.

Lactic acid that appear after the anaerobic glycolysis should not be seen as a negative factor but also as a possible source of energy, although in certain situations may occur that increased acidity potential destabilizing affects muscle function and metabolism. Lactic acid is produced continuously, even at rest, so when training athletes, in cool-down period of training are indicate carbohydrate supplements that restores glycogen accumulation.

Considered as an organ, the striated muscle is made of elementary fibers in their turn joined in fascicles by connective tissue. The muscle fibers, which represent 85% of the striated muscle is wrapped in a thin sheath of connective tissue called endomysium, which bond tight between them. The muscle fibers are arranged in parallel and grouped in bundles by 20-50 fascicles with a diameter of 0.5-1 mm, surrounded in turn by a rich connective tissue, called internal perimysium.

The entire striate muscle is wrapped in a tissue sheath (epimysium). The epimysium composed of a thick layer of collagen fibers is fibrous elastic tissue and allows muscle to contract and move while maintaining its structural integrity; it also separates muscle from other tissues and organs.

From the surface of epimisium protrude depth in the muscle septa of connective fibers which separate in different clusters each constituting as a whole internal perimisium. From this emerge thinner fibers of connective tissue, so single muscle fibers partly constituting the endomysium.

The fibro-conjunctiv tissue is represented by collagen fiber, elastic, by fibroblasts, histocite, fat cells and the tendons, all those structures binds to muscles to the bones that they put it in motion.

Striated muscle contraction is closely related to Central Nervosus System, striated muscle is an organ that works only under control peripheral nerve. Therefore, the muscles are innervated by rich motor, sensory and autonomic nerve fibers. The best metabolism of striated muscle depending on the integrity of its innervation, (neurotrophic effect).

Two aspects of motor control have been traditionally considered separately from each other. The first relates to the nature of physiological variables that are used by the brain to control muscles. The second relates to the problem of motor redundancy [22]: How does the brain select particular solutions from infinite sets afforded by the redundant design of the neuromotor system at all levels of its analysis? [23]

In most skilled sensory-motor tasks, the body acts as a multivariable continuous control system synchronizing movements with the behavioural of the environment [24].

An important movement control strategy used by the central nervous system (CNS) is the activation of multiple muscles acting in concert with each other to achieve a specific movement [22, 25]. Studies indicated that cortical activity related to sensory response and perception is modified by movement executing mechanisms. [26]

Coordination of the movement by the motor cortex provides both the start, support of motion and the finish of voluntary movements, just following the established patterns. First the movement is the design in cortical area. Next the sensorimotor information from the cortex (regarding the spatial environment need for the movement, time and its sequences, the necessary effort required to execute them). The next of step is the transmission down of the efector outgoing messages thru the central and peripheric motor path to the muscular system.

The osteo-articular mobilization occure by the transmission of mio-artro-kinetic proprioceptive information mainly to the cerebellum. The cerebellum intervenes to motor control with a share alongside the Reticular Form to modulate alpha and gamma motoneuron activity.

Such coordination has a specific purpose and it is ensured by a reflex mechanism, partly borned with and partly perfected in the period of development of the child by various motor skills gained as character automatism or "dynamic stereotype". [27]

Motor fibers representing axons of spinal motoneurons or motor cranial nuclei are myelinated fibers. Axons link to skeletal muscle fiber is made thru a synapse modified has presynaptic segment, a synaptic cleft and a post-synaptic segment. The gap between the button terminal and the muscle fiber membrane is called the synaptic space and the folds of the post

synaptic junctional area increases the area of each terminal synaptic knobs depression lies on the surface of a muscle fiber (called "synaptic gutter") At the bottom of synaptic gutter the muscle fiber shows numerous folding forming subneural clefts which serves to increase the surface area on which the neurotransmitter acts.

Each terminal nerve ending supplies single muscle fiber, so each nerve fiber or a single axon. In the post-synaptic membrane, there are numerous receptors for acetylcholine

When the action potential reached the axon at the button level it cause an opening of Ca^{2+} channel ionic and the entry of Ca^{2+} in the termination presynaptic (in a millisecond, thru a single opened channel pass hundreds of Ca^{2+} due to the electrical gradient-attracted by the negative charges on the inside of the membrane, and also because the extracellular concentration gradients are larger, approx. 1-2mM).

The alteration of the genetic control of protein synthesis by membrane transport system (chanel diseases) caused by inherited mutations of ions channel provides a unique insight into the mechanisms of many neurological diseases. However, they also provide new informations about the fundamental biology and function of ion channels and about the neurons and muscles.

For example, mutations in the genes: CHRNA2, CHNRA4, CHRNB2 changes subunits α2, α4 and β2 of nicotinic receptors in the postsynaptic membrane and are involved in epileptic syndromes idiopathic and mutations in the genes: CHRNA1, CHRNB1 changes subunits α1 and α 2 of nicotinic receptors is associated with congenital myasthenic syndromes. [28].

Striated muscle has a very active metabolism which corresponds with a rich blood supply is also a typical operating level.

Training and effort improves oxidative capacity by increasing aerobic capacity, also increases the proportion of fast-twitch fatigue-resistant fibers when the intensity is begger then 80% Vo2max.

Nowadays motor synergies are studied using a mathematical approach that identifies patterns of muscle recruitment, incorporating the onset, duration and magnitude of muscle activity. [29]

After stroke it can be difficult to identify patterns of muscle activity due to the loss of strength and control combined with disordered command signals from the brain. In addition, movement patterns that can be clearly distinguished in healthy people become smaller and less distinct after stroke. For example when walking the foot may not be lifted off the ground and swung forward (reflecting two separate muscle synergies) but may be shuffled forward without leaving the ground after stroke in a single muscle synergy. [30]

*Integration is the process when the s*timuli that are received by sensory structures from different parts of the human body are communicated to the central nervous system where that information, based on the already know experience, is processed and analised. Stimuli are compared with, or integrated with, other stimuli, memories of previous stimuli, or the state of a person at a particular time. This will leads to the specific response. [31]

In humans, even from birth it occure an improvement in execution of some mouvements, that happen in time because training determine a change in the motor commands.

The specific coding of movement parameters in the neurons that compose internal models have a significant, measurable influence on behavior. That influence can be observed in how our brain learns to predict forces in control of reaching movements. Training to make reaching movements in a force field results is a specific, highly reproducible pattern of force generalization to other movements. [32]

Improvement in performance occurs because training results in a change in the motor commands. One possibility is that movements improve because subjects co-contract antagonist muscle groups. [32]

Conclusion

Voluntary movement involves a complex process of different steps that need to be coordinate not only for initiating, maintaining and finish of muscle contraction. The intimate nature of the processes in which volitional consciousness is capable of expressing itself in terms of movement remains incomprehensible.

To run a simple voluntary act there is a well-defined sequence: the initiation and development of voluntary movement transmitted to effectors; there is a complex picture of the temporal and spatial sequence of basic movements to be performed to achieve the purpose, that is an" ideal draft of the action".

Authors' contributions. What each author contributed equally to the study and writing of the article.

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