

MUSCLE STRETCH AND NEURAL COORDINATION IN SHOTOKAN KARATE: INSIGHTS FROM A THEORETICAL APPROACH

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Abstract

The education of flexibility inscribed in this pattern of logic implies the identification of the reporting element for establishing the rhythm or algorithm at the point zero of the process, the investigation of the initial parameters at the first point, and the establishment of a limit of evolution that can be framed within a predefined time unit at the second point. As with any intervention involving changes in biological parameters of the human body, flexibility training must, at ground zero, be related to the natural limits of the biosystem represented by unconditioned reflexes. In this case, the unconditioned reflex that regulates the process of nerve-muscle communication and vice versa is the muscle stretch or myotatic reflex, whose physiological role is to maintain muscle tone, regulate balance and thus prevent potential injuries caused by sudden or forceful muscle stretching.

Key-words: *muscle stretch, flexibility, Shotokan Karate.*

INTRODUCTION

The stretch reflex regulates the degree of elongation of muscle fibres, allowing a balanced muscle tone between agonist and antagonist muscles. Any natural movement of the body triggers an elongation of the muscle fibres of the muscle group on the opposite side. For example, if an individual bends forward, the fibres of the leg muscles will lengthen, triggering the equivalent contraction of the stretching effect. If a neuromuscular spindle is elongated suddenly or forcefully, it triggers the inverse myotatic reflex, whose physiological role is to prevent muscle fibres and tendons from tearing. In this situation, instead of causing a muscle contraction, stretching induces the opposite state, i.e., relaxation, avoiding loading the muscles beyond their state of

resistance. In conclusion, the basic logical scheme or the pattern of any flexibility training algorithm lies between the functional limits of the body on the two axes of expression of the myotatic reflex: the impulse that stimulates stretching followed by contraction and stretching followed by relaxation.

The methodological parameters theoretically predefined by the investigations carried out in the biological, medical and sports fields are based on these limits imposed by the unconditioned reflex interpreted in the direction of its conditioning and represent the guiding axes of any attempt at programming.

Stretching is the field that is now internationally recognised as a representative of how it has differentiated, defined and developed the possibilities of stretching movements involving muscles, joints and the nervous system, which can lead to flexibility training and increased range of movement.

METHODOLOGY

The theoretical approach in this study was structured to analyse the interplay between muscle stretch and nerve-muscle communication, framed within the context of Shotokan Karate practice. We conducted a comprehensive review of existing scientific literature related to muscle stretch, nerve-muscle communication, and their interdependent processes.

RESULTS

Stretching, somatics and biofeedback

Stretching has been recorded as the status quo during research to identify procedural approaches to restore flexibility and elasticity of the skeletal and muscular systems by Thomas Hanna as well, a philosophy professor, neurologist and movement theorist who has invented the term *somatics*. Hanna's research, carried out in the informational context of the 60s and 70s of the past century, is now widely supported by both neurological and physiological arguments. The researcher's hypothesis,

following neurological studies, was that all life experiences lead to physical patterns in the body that may or may not support the maintenance of somatic balance, depending on the limitations they impose.

Hanna is also the author of the sensorimotor amnesia and sensorimotor awareness concepts. He believes that life routines that generate physical or behavioural patterns have the negative effect of sensory-motor amnesia, which essentially involves changes in self-perception, which can be translated by the inability of people to project themselves in their environment through the lens of natural limits. In other words, daily habits force the nervous system to build synaptic networks that can be perceived as structural limits of the body, although their nature is purely functional, the nervous system being capable of building new synapses continuously and constantly throughout life.

By being connected to the environment, the sensory-motor system is constantly reacting to external pressures through the activity of specific muscle reflexes. Subject to the effect of repetition, they cause conditioned muscle contractions which in turn cause joint and muscle contractions, which limit the body's natural movements. This state of dysregulation of the neuro-muscular control function, which consists in the diminution or lack of voluntary control of certain natural movements, has been named sensory-motor amnesia by Hanna, while also adding that it affects the self-image, the image of one's own emotions and capabilities: "Sense-motor amnesia is a state that occurs universally in the human species as a predictable result of long-term stress conditions. Constant repetitions of stress stimuli cause loss of volitional awareness of certain areas of the body musculature, usually predominantly those in the area of the centre of gravity, such as, for example, the musculature of the junction of the thoracic cage and pelvis musculature" (Hanna, "*What is somatics?*", 1986, pp. 349,350). The return to the initial state takes into account the identification of the functions of neuro-muscular control, and the author of the study reached the zero point of the cause-effect relationship, the pandiculation, considering that the exit from the vicious circle or feedback loop closed by the sensory-motor amnesia can be made by sensory-motor awareness of the function of the pandiculation, to which he finds technical correspondences, creating a method that was the basis for the establishment of the

Novato Institute for Somatic Research and Training: "Hanna Somatic Education uses a specialized technique called pandiculation to reset muscle length and improve coordination" (https://hannasomatics.com/about_somatics/history_and_founder/).

Hanna's method is essentially based on the principle of biofeedback discovered by physician Edmund Jakobson in 1921. Through his studies and microvolt measurements, he demonstrated that the mind communicates with the body, and the body communicates with the mind through electrochemical nerve inputs. He also observed that muscle relaxation causes the mind to relax, and that muscles are involved in the thinking process, with thoughts generating muscle contractions or relaxations. The context of the 1920s was favourable to the scientific confirmation of these theories thanks to the emergence of electrophysiological instruments (in 1924 Hans Berger invented the electroencephalogram, the first form of brain electricity measurement), encouraging Jakobson to create a device that could measure the smallest electrical action potentials in fibres or nerves. Thus, the neuro-voltmeter was created, demonstrating that the mind works both centrally and peripherally. Nowadays, as a result of investment in neuroscience (a field of knowledge also generated by Jakobson's discoveries), devices that electromagnetically measure joints, muscles, the heart, the eyes, etc. have been developed. Wanting the results of his research to reach the general public, Edmund Jakobson published the book *You must relax* in 1934, which is today considered the main source of inspiration for all fitness and Pilates programmers who seek scientific explanations, avoiding correlations with yoga or karate, which are considered closer to Eastern than Western culture.

Thomas Hanna, however, does not fructify information from the previously mentioned fields of knowledge. His interdisciplinary specialisations (theology, philosophy, neurology) and his relationship experience with Moshé Pinchas Feldenkrais led to the creation of a perspective that in contemporary terminology, could be called 3D or even 5D if we integrate Feldenkrais' knowledge in the field of physics (he was a physicist, student of Marie Curie and assistant of Jean Frédéric Joliot-Curie) and in the field of martial arts (he practised martial arts, having as mentors Jigaro-Kano and Mikinosuke Kawaishi). In his works, *Somatics: Reawakening the Mind's Control of Movement, Flexibility, And Health* (1988) and *What is Somatics?* (1995), Thomas

Hanna argues his hypotheses interdisciplinary by creating an angle of information reception that places the reader in a subjective relationship with their own body from the perspectives of the first person and the second person and in objective relation from the perspective of the third person.

By circumscribing the possibility of activating the sensory-motor awareness of the soma domain, which is, in Hanna's view "the body as perceived from within by the first person" (Hanna, 1986), believing therefore that through learning somatics, man can regain full control over neuro-muscular functions, which in the translation of the flexibility education system would imply total freedom of relationship with the natural limits of the flexibility of the human body. Thus, through voluntary and conscious training, new synaptic networks can be built, which will restore the body's natural flexibility, inhibited over time due to the repetitive behaviours that created sensorimotor amnesia.

Correlating the arguments that substantiate the relationship between the involuntary reflex of stretching the body, pandiculation, and stretching, with those that demonstrate the possibility of returning to the natural effects of the activation of pandiculation through sensory-motor awareness and with those that demonstrate how neurons in the motor area of the brain act, we have identified the possibility of creating a new method of educating flexibility through the basic functions of Shotokan Karate to which we have associated, at the instrumental level, the Dartfish 360 S and Mobe Med applications which trigger, at the theoretical level, regardless of the degree of motivation or reflexive capacity of the practitioners, the first-person perspective.

Stretching, the nervous system and conscious control

Our vision affirms the existence of an anatomophysiological framework that confirms two possibilities in a state of major convergence:

- the possibility of improving flexibility from a technical point of view by applying scientific principles in a program that has the effect of increasing sports performance;
- the possibility of remodelling the body along the lines of the natural flexibility specific to human nature.

These two objectives can be achieved while respecting both the anatomophysiological characteristics, which, as mentioned above, define the relationship between the nervous and muscular systems and the order in which the specific balance of communication between the two systems implies. Of the researchers concerned with understanding and defining communication between the nervous and muscular systems, Moshe Feldenkrais is the one who has emphasized their importance of order. With a dual perspective as a karate practitioner and physical scientist, he emphasised the primacy of the nervous system in shaping the body: "Movements mean nothing. I'm not looking for flexibility of the body, but of the nervous system. What I seek is to restore human dignity in each person" (Verin, 1978). This level of awareness has made it possible to understand the long-term effects of both the dominantly passive or withdrawn behaviours of people living in a stressful, hostile environment and the dominantly active behaviours of people living in a favourable environment, conducive to freedom of expression and affirmation.

Thus, Feldenkrais observed the existence of two bodily patterns determined by these two forms of pressure of the living environment and the possibility of body remodelling by redefining the mental attitude of individuals towards the environment. His method is also based on static or dynamic voluntary muscular contractions, known today as stretching, accompanied by breathing exercises and the realisation that most bodily dysfunctions are the consequences of the posture adopted as an unassumed reaction to the stress of the living environment. In other words, Feldenkrais' research brings the idea of the relationship between the quality of an athlete's lifestyle and his or her bodily capabilities into the system of data supporting the effects of stretching, forcing us to integrate informational and behavioural elements that involve the creation of these mental links for each practitioner into the flexibility improvement program.

This learning method is based on the importance of self-image, the plasticity of the nervous system and its learning faculties.

Feldenkrais talks about organic learning, i.e. the relationship between sensory-motor experiences and the development and growth of neural connection networks. For him, movement is the best mirror of an individual's life, the best index of nervous system activity, as well as a pretext for self-awareness. This way of looking at the body and

mind as a whole, movement being the mirror of the functioning of the central nervous system, allowed the method to reconnect the structures of the human being as a whole to be functionally well integrated, i.e. capable of individual choices/decisions" (Carmen Șerbănescu, *Metoda Feldenkrais*, 2015, p. 22).

Once again, surprisingly, the empirical research that Shotokan Karate has enjoyed so far proves that the system was created on fundamental principles, as we can find sufficient control tools on this segment within it. Dignity and self-respect, vigilance and focus on the attitude that demonstrates the awareness of action as a form of expression in both attack and retreat are fundamental axes both in training and in the evaluation of a karateka that athletes learn as behavioural principles, referring to them as standards and criteria for competitive credit. Therefore, the scientific data on the interactions between the osteo-muscular, nervous and self-awareness planes have a technical and procedural counterpart within the Shotokan Karate system and encourage us to believe that stretching supported by breath control and control of attitude and posture will lead to improved flexibility to the point of conscious control of joint amplitude.

Types of stretching

Neuromuscular facilitation

Passive neuromuscular facilitation was developed by Herman Kabat, a neurophysiologist, in the late 1940s. Using the model of the neuromuscular activity described by Sir Charles Sherrington, he laid the foundations for treatment using neuroproprioceptive facilitation techniques. The patients for whom this type of treatment was intended were those suffering from post-polio syndrome, who until then had been treated one movement, one joint and one muscle at a time. Kabat's formula is his own: "Every human being, and therefore also the patient, has latent motor possibilities, which can be stimulated and activated by appropriate facilitations." (<https://xdocs.ro/doc/rolul-tehnicilor-de-facilitare-neuroproprioceptive-n-recuperarea-fizica-loywmxer6m83>). Today, the PNF has been taken up by all medical and sports fields involving body remodelling in this segment.

Depending on the objectives pursued, the authors of movement programs for the development of flexibility, use the information whose bases were created and developed in the Kabat-Kaiser Institute. An important aspect of the method is the possibility of creating and organizing movements according to the nature of the stimuli:

- proprioceptive stimuli;
- exteroceptive stimuli;
- telereceptive stimuli.

Stimulation may target a single group of stimuli or a combination of several. Exercises involving touch achieve proprioceptive and exteroceptive stimuli. Voice commands and movement patterns activate telereceptive stimuli, such as hearing and vision.

Depending on the nature of the stimuli, programmers may use facilitators or method-specific manoeuvres aimed at amplifying or reducing the intensity of the feedback:

- Proprioceptive elements: stretching, resistance, telescoping or traction;
- Exteroceptive elements: light temperature tapping or paravertebral tapping;
- Common proprioceptive and exteroceptive elements: manual contact, pressure on long tendons;
- Telereceptive and interoceptive elements: visual patterns, auditory commands, carotid sinus stimulation.

The PNF method provides practitioners with movement patterns that emphasize the application of maximum resistance throughout the entire range of motion. The authors of the method have concluded that the best types of movement are diagonal and spiral movements because they allow maximum elongation of the muscles so that the myotatic reflex is applied to the entire range of motion. The method-specific movement patterns follow the following logical patterns:

1. The initial stimulation of the strong muscles (this allows the nervous influx to radiate to the weak muscles and to generate a positive perception from the practitioner's psychological point of view);
2. The realization of the sequence of active-free, active-assisted, active with resistance or passive movements;

3. The choice of movement positions that allow the patterns to be performed easily and without force.

The ballistic stretch

The medical dictionary defines ballistic stretching as: "Stretching or warm-up that uses the momentum of a moving body or limb in an attempt to force it beyond its normal range of motion by jumping into or out of the stretched position, using the stretched muscles as a spring to get out of the stretched position; ballistic stretching is not considered helpful and can lead to injury; it does not allow the muscles to adapt and relax into the stretched position, but rather can cause them to tighten by repeatedly activating the stretch reflex." (<https://medical-dictionary.thefreedictionary.com/ballistic+stretching>). The medical definition creates the limiting framework from the point of view of ensuring the health of practitioners, the margin of risk being conditioned both by the particularities of each sport itself and by their anatomophysiological and volitional particularities. Integration into a martial arts program, including Shotokan Karate, involves validating the practitioner's availability on all three levels to perform the ballistic movements specific to the field. The program's author is obliged to take into account this double hypothesis of relationship with the practitioner when designing the program:

- biologically predefined limits in a picture of possible negative effects normalized to the general coordinates of the human body;
- the individual limits of practitioners monitored by continuously recording their evolution with the help of classical (communication and data recording on a routine basis) and modern (logs provided by the archive of chosen technologies for recording progress) testing tools.

The positive effects of ballistic stretching recommend this method particularly to practitioners of sports that involve complex jumping, including martial arts. The fact that athletes' proprioception involves the imagistic integration of movements that require the specific effort of ballistic stretching reduces the risk point, since the method is included in the states of progress that its advantages imply, namely:

- more stretching of the muscles than in other standard stretching techniques;
- improved tendon elasticity;
- reduced Achilles' tendon stiffness;
- improved blood circulation;
- reduced possibility of muscle soreness.

Dynamic stretching

Dynamic stretching is a method similar to ballistic stretching, the difference being in the way the exercises are performed. The movements involve moving the limbs and trunk in a controlled and slow manner, therefore without resorting to the force and sprints typical of ballistic stretching. In this way, it is possible to perform the exercise within the range of motion of the joint. The movements defined by dynamic stretching are performed by actions of the limbs in a certain direction in a controlled and slow manner, aiming at the gradual exploitation of the entire amplitude of the joint. The speed of the movements is controlled so that the effect on the myotatic reflex causes the muscle to react by contracting rather than relaxing.

Dynamic stretching is repetitive and progressive in nature. Traditional practice recommends dynamic stretching in the stage of preparation for physical activity, as it has the following effects:

- helps increase body temperature;
- increases the transmission speed of nerve signals;
- stimulates the muscles and the enzyme cycle;
- accelerates energy production.

The central axis of dynamic stretching manifestation is the relationship between agonist and antagonist muscles. The neuro mechanisms involved in the relationship between these two types of muscles was conceptualized by Sir Charles Sherrington (1857 - 1956), considered the philosopher of the nervous system. Active stretching movements apply the following neuromechanisms:

- Reciprocal inhibition that manifests itself through the sequence: while the agonist muscles contract, the antagonist muscles relax, their contraction being inhibited to create the balance necessary to maintain the health of the muscles;
- Muscle spindles that are manifested by the ability of the sensory nerve endings in the muscle to detect the change in the length of the muscle and its rate of change.

Static stretching

Static stretching is a method that involves lengthening the muscles with the application of a low force and for a long time (on average, 30 seconds). Static stretching has a relaxing and lengthening effect on muscles, which increases range of motion, decreases muscle and tendon stiffness, and also reduces the risk of acute muscle injuries. It is a slow, controlled movement with an emphasis on postural awareness and body alignment. It is suitable for all types of sports or physical activities in general.

Traditional practice recommends performing static stretching exercises before actual training or sports competition to improve muscle performance and minimize the risk of injury, and describes the method as having a low risk of injury. However, more recent research does not maintain the same perspective, listing among the negative effects, roughly the same long-term risks that most exercises that involve constant pressure on the body's conditioned reflexes. Among them, according to a study presented by physio-pedia.com, one can find:

- The decrease in the viscoelastic behaviour of muscles and tendons only in the short term, without long-term effect;
- the decrease in the excitability of the motor neuron through the inhibitory effect in the Golgi tendon organ and through the activation of the recurrent Renshaw loop (recurrent inhibition);
- the decrease in motor unit activity;
- the decrease in the activity of the muscle spindles, which results in a decrease in the activity of the myotatic reflex. (https://www.physio-pedia.com/Impact_of_Static_Stretching_on_Performance#cite_note:-0-1)

CONCLUSIONS

The differences between the particularities of these methods, as noted from their description, do not concern the principles of operation and interaction of the bone, muscle and nervous systems, but the extent to which the use of these principles in a rhythm, a cadence, with a speed or a force of certain types can induce the expected effect. Since the effects are aimed both at increasing performance and maintaining health or returning to health, the methodology of stretching or flexibility is approached theoretically or practically in various fields of knowledge: physiotherapy, neurology, biomechanics, most sports fields, etc. The informational level generated by technology forces any study author of this topic to face the vastness of research results in all these fields where flexibility is defined and interpreted in relation to the criterion of interest regarding the transformation or modification expected or already produced in the basic system of the field. Thus, the palette of accessible elements in order to test effects in relation to Shotokan Karate is considerable, concepts such as: pre-contraction stretching, post-facilitation stretching, biomechanical model, sensory model, neural model, passive-static stretching, static-active stretching, stretching isometric, offering various perspectives of how the human body manifests itself during the process of muscle contraction-relaxation under mechanical or mental pressure.

We believe that the principle that is imposed in the methodological approach of flexibility in order to make a program is the creation of personalized algorithms with double valence: the anatomical-physiological and psychological particularities of the practitioners and the temporal and objective particularities of the program.

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