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PSYCHOMOTOR PATTERN FOR NEUROLOGICAL ASSESSMENT OF REFLEX IN KARATE AND TAEKWONDO

Manual muscle test under load – general model[1]

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Abstract: A reflex is an involuntary reaction of the nervous system to intrinsic and extrinsic stimuli. In athletes, it is largely damaged, which presents a serious problem. The psychomotor pattern for the neurological assessment of reflex in karate, taekwondo and other martial arts is based on the principles of physiology, neurology and biomechanics. Pattern can be defined as an inseparable entity of the physical (motor), psychological (mental-emotional) and energy factor, during manual muscle test under load used to assess muscle tonus, which is the subject of this paper. The aim of the paper is to determine neurological reflex activities of athletes' muscles when they are subject to load in order to fully exploit their potential. Investigating the reaction of the peripheral nervous system was based on the assessment of examinees' reflexes, among which were active athletes N = 50 and random sample of examinees N = 50, as well as on data comparison. The results indicated the damaged muscle innervation in 46% of athletes and 50% of random sample of examinees. The conclusion is that muscle tone virtually does not depend on whether someone is engaged in sport or not, and on the other hand, it sends a warning that it is necessary to balance the nervous system. Therefore, by restoring biological feedback, an adequate reaction of the nervous system improves health and athletes' training process. The authors provide a model of pre-exercise testing, which has the basic role of preventing muscle tone and a key role as a guardian of natural human functioning.

Keywords: *psychomotor pattern, examining reflexes, neurodynamics, karate, taekwondo*

INTRODUCTION

„Man manages movement, but not muscle tonus“ (Васильева, 2018).

The backbone of this paper is functional neurology based on the latest scientific research in medicine, biomechanics and psychology. The psychomotor pattern for neurological assessment of reflexes in karate, taekwondo and other martial arts is based on the laws of physiology, neurology and biomechanics. The psychomotor pattern for neurological assessment of reflexes for manual muscle test under load is based on the neurophysiological basis of muscle contractions and the motor reflex system, including the myotatic reflex as

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well as the inverse myotatic reflex. The pattern can be defined as an inseparable whole of physical (motor), psychological (mental-emotional) and energy factors, during manual muscle testing under load to assess muscle tone, which is the subject of this paper. The pattern has a primary functional role in establishing proper muscle innervation and the load testing itself. During the decade-long search, first of all, by Russian neurologists, the cause of the problem was discovered: it is impossible to detect a dysfunctional muscle with standard neurological testing at rest. Medical kinesiology, headed by the leading Russian academician, neurologist Dr Ludmila Vasilyeva, provides solutions for the neurodynamics of the body (Васильева, 2013). In order to move forward, according to Bojanin (2016), "in the very basis for accepting new knowledge, it is necessary to change one's opinion".

The main problem is the lack of a universal psychomotor pattern for manual muscle testing under load. Bearing in mind the fact that man is, above all, a visual being, the question arises, how to know where the muscles "do not work" if they do not give away clinical pain. This includes neurological examination. How to observe the respondent - before, during and after testing. It is necessary to assess the physical, mental and energy signs - neurodynamic status. Neurological examination is the basis in establishing a psychomotor pattern for neurological assessment of reflexes under load in karate, taekwondo, other martial arts and sports in general (Ахмерова et al., 2015).

Psychomotor pattern for neurological assessment of reflexes is essential. Why? Because the psychophysical factor is inseparable. The pattern itself is an inseparable whole and is based on that principle. It contains three tests: *physical* (motor), *psychological* (mental-emotional) and *energy* test. The psychomotor pattern is an inseparable physical, mental and energetic whole of normalization and activation of reflex patterns of the muscles of the peripheral nervous system. It implies prevention, which is reflected in the stabilization of the body before the reflex pattern is damaged and before the pain syndrome is experienced. We can't help but ask the basic question: *Do muscles provide answers to our questions?* If the answer is "*yes*", the question arises: "*how*"? By using muscle as an indicator (basic principle) (Васильева, 2018). In order to come up with an answer, it is necessary to start with the fact that the nervous system is one of the most complex and mysterious structures of the human body. Science has given us many answers separately, but as a synthesis of physiology, neurology, biology, biomechanics, psychology, we have the medicine of the future - medical kinesiology, which opens new horizons and provides adequate solutions. A new method, neurodynamic modeling of movement is another step in the development of "dynamic proprioceptive correction". By adhering to the laws of biomechanics and neurodynamics, the approach to manual muscle testing was further deepened, which enabled an increase in the efficiency of the use of proprioceptive correction method, which consists of static and dynamic movements (exercises).

The authors of this paper believe that the problem does not lie in the standard approach to testing and non-testing and scientific truths, but in our beliefs and certain patterns and perspectives. Therefore, the innovative approach in karate and taekwondo, as well as others martial arts is only the application of new findings and knowledge in order to adapt the nervous system to the load. The reflection of functional neurology is of vital importance for the formation of a general *Psychomotor pattern for neurological assessment of reflexes*, under load during manual testing of muscles in static condition and during movement. The problem considered in this paper is partially unknown in our practice from the aspect of manual muscle testing under load for neurological assessment of reflexes, and on the other hand it is largely unknown among sports professionals in general.

"In applicable kinesiology, movement reflex is assessed (manual assessment of the reflex ability of the nervous system under load in order to adequately react to mechanical, chemical and emotional influences). This is of great importance for sports rehabilitation, since the reaction of the nervous system is assessed not at rest, but under load" (Ахмерова et al., 2015, p. 8)[3]. Examination of biomechanical movements is not only a logical-methodological process, but also a specific psychological and energetic process (Savić, 1997). Recent research greatly changes our recent attitudes and recent knowledge about the functioning of the locomotor system and the influence of the psyche, thus enriching karate as a synthesis of anatomy, physiology, biochemistry, kinesiology and psychology (Savić, 2011). "Finally, movement analysis has developed greatly thanks to the application of new methods in the field of neurophysiology and electromyography, and is based on basic anatomical and mechanical laws that give extremely significant results in all biomechanical analyzes

[3] All citations of foreign authors (references) were translated by the autor of the paper.

applied in all sports" (Bubanj, 2000, p. 7). Here it is very important to understand the laws of nervous tissue biomechanics. It is forgotten that the nervous system is not a separate system. It has its own diagnostic criteria and its own individual methods of treatment and, most importantly, methods of rehabilitation. "In order to assess how an athlete's body is adapted to competitive and training load, it is necessary to dynamically assess the ability of the nervous system under load to adequately respond to physical, chemical and emotional influences" (Васильева, 2013, p. 10).

"According to K. Semenov, the method of neurodynamic modeling of movement is another step in the development of "dynamic proprioceptive correction". In it, adherence to the laws of biomechanics and neurodynamics deepened even more, which enabled an increase in the efficiency of the use of proprioceptive correction techniques. An essentially new and important idea was the implementation of movement in a closed kinematic chain" (Симутина & Захаров, 2017, p. 156). For the normal functioning of the nervous system, it is necessary to process a significant flow of sensory information, transform it and implement it in the form of optimal motor actions (Симутина, 2021). Elena Simutina made a great contribution to the development of the stabilization system through the formation of a complex kinesiological chain and antigravity mechanism. Through the practical use of neurokinesitherapy and the application of the method of neurodynamic modeling of movement "Hand-Brain", uses manual muscle testing under load, in static condition and during movement. The most interesting action of walking does not lie in its mechanics, but in its extra-mechanical features - its physiological structure of innervation. Bernstein formulated the concept of "movement system". He was obviously the first to draw attention to the fact that in the construction of motor actions, the convergence of all cognitive processes and types of thinking takes place. His conception of the motor task as the mental basis of action paved the way for the study of higher levels of consciousness in human motor activity (Бочаров, 2010). Bernstein drew attention to his experimental results of the neurological-physiological mechanism of movement by dividing the mechanism of movement into two phases, explaining the difference in the mechanisms of muscular response to load.

"Kinesitherapeutical effect of kata[4] elements on atrophic changes in muscles caused by post-fracture immobilization of the arm... From the healthy arm, which in this case performs a gyaku-zuki blow, impulses from the receptors of muscles, tendons and joints reach the central nervous system, from which trophic (stimulating) impulses are emitted into the muscles of the immobilized arm in a manner that is insufficiently explained in science, which alleviates the process of atrophy, and shortens recovery time. *Apparently, "even without the permission" of the CNS, which in this case acts on the principle of "self-protection, reaching the injured arm and there, although very weak, strong signals are trying to realize previously formed motor pattern, despite the fact that they are very weak"*[5] (Jorga et al., 1985, pp. 58-59). "Our body is a self-regulatory system. Therefore, it is necessary to react properly to the effects of the external and internal environment for health. If provided with accurate signals, the nervous system will react correctly, economically and quickly" (Васильева, 2018, p. 14). "What is important for us to know in karate is in the sphere of the so-called "Feedback". Scientists (neurologists, physiologists, above all), examining what is important for the efficiency of the conceived and then performed movement (in karate technique), concluded that it is necessary to have constant control over these movements. In order to achieve full control of movement and performed movement, constant sensory information is needed, such as feedback on the results of the movement that takes place. This feedback of sensory information about the movement and position of the body is called **proprioception**" (Bednij, 1975, in Mudrić & Simić, 2020, p. 197).

"The stimulus caused by the receptors spreads and reaches the central nervous system via sensory nerves, where it is transmitted to the motor nerve fiber and through it to the muscle, which immediately becomes a state of stimulation after receiving a sufficiently strong impulse, i.e. based on this, it is obvious that human movements are reflexive in nature" (Bubanj, 2000, p. 49).

Today's standards of training and exercise do not have a unique basic approach to understanding the human being, the organism as a single whole. We must not forget that every person is in the external environment and in oneself a whole. Too much attention has been dedicated to the division of body parts,

[4] Kata – in Japanese: form, composition, shape, etc.

[5] Part of the quotation is of vital importance in the study of the functioning and non-functioning of the nervous system, which was one of the main subjects of study of Russian scientists in the 1980s, where the results were identical. In the meantime, Ludmila Vasilyeva and her colleagues have been giving us long-awaited and unexpected factual answers since the beginning of 2000s to date.

neglecting the basic laws of biomechanics, and especially functional neurology. Thus, the tone of the muscles was not taken into account, above all, when under load. According to the authors of this paper, in our country and beyond there is no manual muscle testing under load, which reveals the reflex nervous system. That is, information coming from the muscles to the brain either reaches or does not reach and we either receive or do not receive feedback. Thus, the nervous system provides us with a response whether the body works or does not work optimally. A certain movement-technique of karate, taekwondo or in any other martial art, as in any other branch of sport, has an almost identical problem. Why? Because we deal with a certain part of the body (motor movement) either in the technique of attack or defense, as well as in movement, or psychological state, emotions and we deal with it, which the author of this paper believes to be utterly wrong.

"To understand the role of movement in the process of mental development of children, and in solving problems arising from the disharmonious course of neuropsychological development, we must have insight into the developmental process of the body and psychomotor in the context of awakening human mental functions and patterns of mental functioning" (Bojanin, 2016, p. 24). "Muscles have proved to be the most reactive structure, stereotypically responding by weakening and hypotension to imbalances in any part of the system" (Шмидт, 2004, p. 6). "In a recent article of the German tennis magazine (09/20) about the tennis world number one Novak Djokovic, the kinesiology test is described under the title "Delicate helpers ", and it has been shown that kinesiological test results can be objectified by the EMG method" (Buck, 2020, p. 2). "Muscle function should be taken literally, because the manual muscle test is the only neurological (neuromuscular) function test that is still available in medicine" (Garten, 2018, p. 8).

At the end of the introduction the authors point out an opinion of Ludmila Vasilyeva: **"Sometimes people need life to prove something new"** (Васильева, 2018, p. 9). And as a synthesis of this paper, the authors use the words of Svetomir Bojanin: **"Every scientific truth is only true until it is overturned by the discovery of new truths"**[6].

The subject of the psychomotor pattern for neurological assessment of reflexes in manual muscle testing is overcoming the assessment of reflexes at rest by assessing the reaction of the nervous system through statics and dynamics of the musculoskeletal system under load. It allows us to understand the biological connection of the body. It detects muscles that do not engage in movement properly, changes in muscle tone in different segments of the locomotor system, mental and energy ones.

The aim of the psychomotor pattern for neurological assessment of reflexes in manual muscle testing is prevention, which is reflected in body stabilization, assessing the maladaptation of the nervous system, establishing functional balance and its goal is to adapt inadequate physical-motor, mental-emotional and energy states (reactions) to external and internal situations (environmental influences) and restore muscle innervation. The aim of this paper is to determine the neurological reflex activity of athletes' muscles under load in order to make better use of their potentials.

METHOD

Method based on medical kinesiology

In today's theory and practice of manual muscle testing, neurological assessment of reflexes in static condition and during movement has not been used. Therefore, the *psychomotor pattern for neurological assessment of reflexes for general testing of muscle tone under load* in static conditions and during movement is an innovative implementation in pre-exercise process in karate, taekwondo and other martial arts. This implementation has a very significant impact on the health condition of the athlete and better use of their potential (Васильева et al., 2017).

The test was conducted on 50 active athletes (Group 1): 33 males and 17 females from different clubs, and 50 random examinees (Group 2): 27 males and 23 females from different cities. The respondents were divided into five age groups: first: 6-11 years; second: 12 - 14 years; third: 15 - 17 years; fourth: 18 - 50 years and fifth: over 50 years. The survey lasted for nine months (from July 2020 to April 2021), and the professional program IBM SPSS Statistics 25 was used to process the statistics.

[6] Author lecture of Svetomir Bojanin, 2015.

Manual muscle testing under load

The psychomotor pattern for the neurological assessment of reflexes under load implies compulsory physiological examination of normal muscle innervation prior to testing. A prerequisite for proper testing is whether the reaction of the nervous system is adequate. Before testing, perform three checks, as an inseparable whole, as follows:

1) physical (motor),
2) psychological (mental-emotional) and
3) energy check.

Before starting the test, it is necessary to examine the reaction of the nervous system. The reaction can be adequate, hyperreactive and hyporeactive. If an examinee demonstrates hypertonicity, hypotonicity, or inadequate reactions, they cannot be tested until these are eliminated (Васильева, 2013). The examination implies checking the muscles that give feedback on how the body reacts. Muscle as an indicator must meet certain requirements before the neurological assessment of the reflex. In this case, the deltoid (middle) muscle is used. The requirements are reflected in the basic principle to which the muscle should react in the following order: normal tone - the muscle responds well to force; after muscle contraction (along muscle fibers) it shows weakness; after stretching the muscle (along the muscle fibers) it shows strength. After this check, we can acknowledge that we are dealing with a normal, functional muscle as an indicator. What follows is a psychological (mental-emotional) check in the following order: for example, in case of a normal tone - when asked "*What is your name?*", and the examinee responds: "*My name is … (their real name),* the muscle indicates strength. When the examiner *repeats the question*, and the examinee *does not give their real name*, the muscle indicates weakness. In another example, in case of a normal tone - the muscle reacts well to an imaginary (mental image)[7], positive, beautiful and joyful life situation, indicating strength; in an opposite situation, to an imaginary negative, stressful, painful situation, the muscle reacts poorly, showing weakness. After this reaction, the muscle is established as an indicator. The following, third check is the energy check[8]: which, just like the second one, follows the first physiological check when we already have the indicator muscle. When the examiner moves his fist from the head to the abdomen (medially) directly in front of the examinee's body without contact, the examinee's muscle shows weakness; in the opposite direction, from abdomen to head, it shows strength. In this way, adequate work of the nervous system has been established. This is the way the muscle works and provides physiological feedback for further testing. Thus, we have an indicator muscle[9].

Then, we move on to the general model of manual muscle testing under load.

The methods for functional neurological assessment of reflexes are applied with the following basic positions:

Basic positions for general manual muscle testing under load:

- orthostatic position,
- sedentary position and
- supine position.

Basic elements of MMT under load: starting position, fixing, movement test, gravity, and manual load.

Basic instructions for testing under load

Examinee's position: Passive arm on the side, stretched out next to the body. The arm that is being actively tested is raised forward to shoulder height (flexion at the shoulder joint) at a 90° angle, elbow stretched, hand with stretched fingers and palm down.

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[7] Imagination (mental imaging) is a process that is based on the principle of biological electric currents and can disperse neurotransmitters into synapses in appropriate places in the brain. Thereby, it profoundly changes our moods, feelings and actions. Functional neurology gives us answers as to whether the body agrees with what we imagine (say) or not. This check requires sincere cooperation with the respondent, who must be ready to find out the outcome.

[8] Energy testing includes the human biofield, aura, electromagnetism. According to Sheldon Deal, electromagnetism is a property of the electromagnetic conductivity of all tissues of the human body, the nervous system, the skin, the muscles, etc. Electromagnetic balance is created through mechanical, chemical, emotional and energetic processes in the body, forming functional connections with each other and thus uniting organs and systems into a single whole.

[9] Muscle as an indicator - this process requires basic knowledge of physiology and anatomy.

Instructions for examiner: Stand on the side of the arm being tested. One hand is on the shoulder of the subject - for stabilization, and the other hand is placed over their hand just above the wrist. The test position of the hand of the examiner and the subject is at an angle of 90°.

For the testing method, the authors apply one of the **Methods of Manual Medicine in Sports Rehabilitation**, which was published at the First Moscow State Medical University (Ахмерова et al., 2015).

Initializing testing

At the signal of the examiner who provides resistance (isometric contraction), the examinee should offer appropriate resistance upwards. Without interruption, the examiner after 2.5 - 3 seconds of isometric contraction gives the second signal to the examinee to increase the resistance force upwards. The examiner opposes the examinee with isometric contraction by offering resistance in order to push the arm down, with an instantaneous stretching of the muscles by activating the myotatic reflex. The examinee's goal is not to allow the examiner to push the arm down by isometric contraction, providing resistance and activating concentric muscle contraction to instantaneous stretching (Ахмерова et al., 2015). It should be emphasized that testing movement with lunges is performed by the same arm with the same leg forward and the opposite arm from the leg forward (very similar to the position of the arms in karate: similar to *oi zuki* and *gyaku zuki*, and in taekwondo: *bandae jirugi* and *baro jirugi*). Normal muscle innervation when testing with lunges d is when the examinee shows strength when the opposite arm is extended from the leg, and weakness when the same leg and the same arm are forward.

Measuring

Assessment - muscle innervation is assessed in two ways, both good and bad: First, *good (strength)* - the examinee provides resistance, normal innervation, the muscle tone exists, as well as reflex. Second, *bad (weakness)* - does not provide resistance, innervation is impaired, weakness or muscle failure is detected. Muscles can be *hypotonic* - a muscle can be weak and not working at all and *hypertonic* - a muscle can be so strong that it does not respond to muscle contraction and stretching.

Potential errors

- initial position of the examiner or examinee,
- limb angle during testing, if the 90 degree angle is not preserved throughout testing,
- inadequate position of examinees, including synergists,
- the examinee holds their breath during the test,
- inadequate position of the examiner's body in relation to the tested arm,
- lack of fixation on the examinee's shoulder,
- the examinee touches a part of their body,
- error at the point of contact, the examiner touches the wrist of the examinee,
- it is not strength that is tested, but muscle strength (force), etc.

Note: In the testing process, functional hyporeflexia indicates the preservation of the first phase and the absence of the second phase of isometric contraction (unlike the standard testing method).

If there is a disorder in the standing or sitting position, it is the *somatic nervous system* (SNS) and if there is no neurophysiological reflex in all three positions, it means that it is the *vegetative nervous system* (VNS).

RESULTS

Testing reveals which peripheral nervous system (PNS) is in question. Knowing that the PNS is functionally divided into the somatic nervous system (SNS) and the vegetative nervous system (VNS). Based on the obtained results, we can conclude that the reflex disturbance occurred in both functional peripheral systems. Test results: neurological assessment of muscle tone under load in orthostatic, sedentary and supine positions, subjects were divided into 2 groups:

Group 1 (G1) - Out of the total number of male and female examinees, the following indicators were determined: in the orthostatic position 21 (42%) displayed normal innervation, and 29 (58%) impaired innervation-weakness; in the supine position 27 (54%) showed normal innervation, while 23 (46%) had impaired innervation-weakness. Inspecting the test results, we can conclude that out of the total number of examinees: a total of 27 (54%) displayed normal innervation, while 23 (46%) showed signs of impaired innervation; in 23 subjects the muscle tone of the left or right arm was disturbed, or both: the somatic nervous system 14 (28%) and the vegetative nervous system 9 (18%).

Group 2 (G2) - Out of the total number of male and female respondents, the following indicators were determined: in orthostatic and sedentary position 16 (32%) showed normal innervation, and 34 (68%) had impaired innervation (weakness); in the supine position 25 (50%) displayed normal innervation, 25 (50%) showed impaired innervation-weakness, and of the total number 7 examinees (14%) had impaired innervation of both left and right arm. Taking a look into the test results, we can conclude that out of the total number of examinees: a total of 25 (50%) had normal innervation, while 25 (50%) suffered from impaired innervation; in 25 subjects, muscle tone was impaired, namely: 18 in the somatic nervous system (36%) and 7 in the vegetative nervous system (14%).

Impaired innervation was revealed during testing, and since there is no physiological-neurological reflex in two positions – orthostatic or sedentary, it indicates that it is the s*omatic nervous system*; when all three positions are involved, the *vegetative nervous system* is in question.

G1–Active athletes and G2 – Random examinees are presented in Table 1.

Table 1. *Person's analysis of descriptive frequency*

G1 Neurological assessment of the PNS: Normal tone – Impaired tone

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strength: Normal tone	27	54.0	54.0	54.0
	Weakness: Impaired tone	14	28.0	28.0	82.0
	Total weakness: Impaired tone	9	18.0	18.0	100.0
	Total	50	100.0	100.0	

G2 Neurological assessment of the PNS: Normal tone – Impaired tone

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strength: Normal tone	25	50.0	50.0	50.0
	Weakness: Impaired tone	18	36.0	36.0	86.0
	Total weakness: Impaired tone	7	14.0	14.0	100.0
	Total	50	100.0	100.0	

In Group 1, weakness of the muscles of the peripheral nervous system was detected in 23 (46%) examinees, namely: 14 examinees (28%) had it in the somatic nervous system and vegetative nervous system.

In Group 2, 25 (50%) subjects were found to have muscle weakness, namely: 18 (36%) in the somatic nervous system, and 7 (14%) in the vegetative nervous system.

Correlation between variables - Neurological assessment of muscle tone under load – strength and weakness in G1: Active athletes and G2: Random examinees.

Probability samples are displayed in Table 2.

Table 2. *Results of Pearson's correlation of total score of G1 and G2 of normal tone and impaired tone*

		G1 Neurological assessment of PNS: Normal tone-Impaired tone	G2 Neurological assessment of PNS: Normal tone-Impaired tone
G1 Neurological assessment of PNS: Normal tone-Impaired tone	Pearson Correlation	1	.383**
	Sig. (2-tailed)		.006
	Sum of Squares and Cross-products	29.520	10.520
	Covariance	.602	.215
	N	50	50
G2 Neurological assessment of PNS: Normal tone-Impaired tone	Pearson Correlation	.383**	1
	Sig. (2-tailed)	.006	
	Sum of Squares and Cross-products	10.520	25.520
	Covariance	.215	.521
	N	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

The Table 2 shows that there is a strong correlation of 0.383 at the level of 0.01 between the correlations of the variables on the number of G1 and G2 examinees on whom this coefficient was calculated. In addition, a partial analysis was performed with an isolated effect of the age category, where the correlation is 0.359. The effect of age is related to the age categories, and a separate analysis was performed for each category. The obtained results of the significance analysis the most significant positive correlation of the effect of age in the third category (from 15 to 17 years) - coefficient 0.730 with probability Sig. 0.062, while the level of significance of the negative linear connection is of medium intensity in the fifth category (over 50 years) - coefficient -0.316 of significance Sig. 541 where significance is greater than 0.05.

Also, the correlation between G1 and G2 was examined in orthostatic, sedentary and supine position, with neurological assessment of muscle tone under load, on the total result of muscle tone: strength (normal tone) and weakness (impaired tone) of PNS and they are presented in Table 3.

Table 3. *Results of Pearson's correlation for G1 and G2 in case of normal and impaired tone in orthostatic, sedentary and supine position*

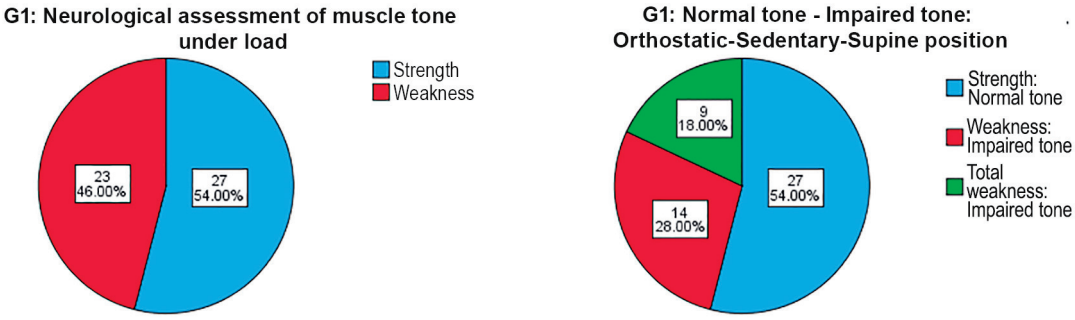
		Active athletes G1 Muscle tone, strength-weakness	Random examinees G2 Muscle tone, strength-weakness
Active athletes G1 Muscle tone, strength-weakness	Pearson Correlation	1	.281*
	Sig. (2-tailed)		.048
	Sum of Squares and Cross-products	12.420	3.500
	Covariance	.253	.071
	N	50	50
Random examinees G2: Muscle tone, strength-weakness	Pearson Correlation	.281*	1
	Sig. (2-tailed)	.048	
	Sum of Squares and Cross-products	3.500	12.500
	Covariance	.071	.255
	N	50	50

*. Correlation is significant at the 0.05 level (2-tailed).

Pearson's correlation coefficient is 0.281 with significance at 0.05.

Analyses of G1 – Active Athletes

Graph 1. and 2. *Pearson's analysis of graphic presentation of distribution*



Graphs 1 and 2 show the results of descriptive statistics of significance according to gender, a sample at the level of neurological assessment of muscle tone under load of the total score of weakness and strength and depending on position.

Pearson's correlation analysis: Relationship between variables - Neurological assessment of muscle tone under load, strength and weakness, and Normal tone-Impaired tone: Orthostatic-Sedentary-Supine positions are shown in Table 4.

From Pearson's coefficient we see that there is a strong correlation between the assessment of muscle tone in orthostatic, sedentary and supine position with the neurological assessment of muscle tone under load on the overall result of muscle tone: strength and weakness of the PNS. That is because Pearson's linear correlation coefficient is r = 0.902. Next, it was checked whether the effect of age has an impact on the mentioned variables.

Table 4. *Results of Pearson's partial correlation between G1 and G2 variables*

Partial Correlation				
Control Variables			G1 Neurological assessment of muscle tone under load	G1 Normal tone – Impaired tone: Orthostatic-Sedentary-Supine
Age	G1 Neurological assessment of muscle tone under load	Correlation	1.000	.898
		Significance (2-tailed)	.	.000
		df	0	47
	G1 Normal tone – Impaired tone: Orthostatic-Sedentary-Supine	Correlation	.898	1.000
		Significance (2-tailed)	.000	.
		df	47	0

When we isolate the effect of age from the partial analysis, we see that there is a very strong correlation, the coefficient is 0.898.

Then, the effect of age related to age categories was studied. Each category was isolated separately and an analysis was performed in all five categories. The result is that in the third category, the effect is the age of the respondents from 15 to 17 years most significantly correlates and amounts to 1,000.

DISCUSSION

This paper refers to the study of neurological and physiological reflex using the MMT method under load (general model), where testing enables the identification of muscle tone in active athletes and random examinees.

"Using the manual method for assessing the activity of the myotatic reflex (stretching reflex) of skeletal muscles - manual muscle testing, it is possible to conduct an express assessment of the functional state of the muscle: tone and excitability (normotonia, hypotonia and hypertension, normo-excitability, hypoexcitability and hyperexcitability)" (Крашенинников, 2013, p. 212). The nervous system responds adequately to mechanical, chemical and emotional influences when assessing movement reflexes. Manual assessment of the reflex ability of the nervous system under load is of fundamental importance for sports rehabilitation (Васильева, 2013). Breathing is also of vital importance for MMT under load. "The activity of the Dorsal Group of Respiratory (DGR) neurons lasts about **two seconds** in total, during which the duration of inspiration is maintained. After two seconds, the activity of the inspiratory group of neurons ceases and their inhibition occurs. As a result, impulses are no longer sent from the inspiratory group of neurons **to inspiratory muscles**, and inspiratory muscles relax, which causes expiration. Inhibition of DGR neurons lasts about **three seconds** and is maintained during expiration. The ventral group of respiratory neurons (VGR) consists of inhalation and exhalation neurons whose functional role is to innervate respiratory muscles during exhalation and as an aid to inspiration. VGR neurons are activated during physical exertion" (Đurić et al., 2018, p. 177). The significance of the aforementioned knowledge basically reminds us of the functional role and duration of certain breathing processes. It is important to remember that both under load (during contraction) and muscle relaxation during testing, their duration is three seconds. Also, we must not overlook the fact that examinees must not hold their breath during the testing process, because, according to the law of neurophysiology, respiratory myofascial chains are activated while holding the breath (air) during MMT under load.

For this research, the authors of this paper used data collected by testing active athletes and random samples from different towns. All obtained data were entered and processed in IBM SPSS Statistics 25. The comparison of weakness data from the total number of 50 active athletes - G1 and 50 random examinees - G2 100% of respondents with the results of neurological manual testing under testing load of active athletes 46% and random examinees (50%). The difference in normal tone is only 4% in favor of active athletes. This fact reminds us that there is virtually no difference. It is important to draw attention to the impaired vegetative nervous system: 9 examinees among active athletes (18%), and 7 among random examinees (14%). The difference in normal tone is 4% in favor of Group 2. This problem should be seriously addressed, because the normal innervation of the muscles, the hypotonicity of the muscles, practically does not depend on whether you are actively involved in sports or not. On the other hand, based on the obtained assessments of the vegetative nervous system, the situation is very alarming, because these are people with total weakness and they are in a serious problem. According to the authors of this paper, they should not exercise until the primary cause is discovered and the weakness is eliminated. Based on studies conducted in Russia, there is an indication that the death of athletes on the field, in arena, or during training, is caused by impaired vegetative nervous system.

Also, the somatic nervous system is not to be underestimated, there are 14 examinees with the problem of muscle weakness in group 1 (28%), and 18 in group 2 (36%). This speaks of a more favorable outcome of Group 1 by 8%. However, we must not neglect the fact that an inadequate reaction of the nervous system causes a violation of the coordination of work of a certain movement, i.e. a certain group of muscles, so it is necessary to restore the physiological reflex arc, muscle tone. It is interesting that both groups of subjects did not show muscle hypertonia (which does not mean that they will not in some other study). During the test, the case of muscle hypertonicity (general tension) did not appear, but it should be emphasized that there is no reaction to provocation in muscle hypertonia, because it occurs with damage to the central nervous system and is a structural disorder and not functional.

Data obtained by manual muscle testing under load of PNS muscle tone were obtained by variance analysis. The obtained results suggest that the sex of the subjects is not statistically significant for the muscle tone (reflex) of the peripheral nervous system ($F = 0.408$, $p = 1{,}000$). Pearson's linear correlation coefficient between the age of the examinees in G1 and G2, shows a strong correlation of 0.383, as well as a strong partial analysis of 0.359, while, according to Cohen's criterion (Cohen, 1988), this is a moderate correlation. Also, the effect of all five age categories was investigated: the first: 6 - 11 years; second: 12 - 14 years; third: 15 - 17 years; fourth: 18 - 50 years and fifth: over 50 years. The effect of age is most significantly related in the third category with a coefficient of 0.730, and in the fifth -0.316. When the correlation is positive - the movement of variables is conducted in the same direction. This means that increasing one variable affects increasing another and decreasing one affects reducing another variable. The correlation is negative when an increase in one variable affects a decrease in the value of another variable. The results obtained by using a p***sychomotor***

***pattern for neurological assessment of reflexes (tone),* during manual muscle testing under load** indicate an imbalance in the body that indicates two main problems with impaired peripheral nervous system, somatic and vegetative one.

"The contraction of skeletal muscle itself occurs in response to nerve impulses, which come to the muscle through special nerve cells - motoneurons. Muscles together with the nerves that innervate them form the human nervous-muscular apparatus" (Bubanj, 2000, p. 49). Inadequate reaction of the nervous system causes a violation of the coordination of movement, i.e. a certain group of muscles.

Therefore, this movement-technique of karate, taekwondo and other martial arts and any branch of sport is facing the problem of the existing functional connections, whether it is a somatic or visceral motor reflex. Both types of reflexes occur before the information reaches the brain. It should be particularly emphasized that the most important of them is the visceral motor reflex, because each internal organ is reflexively connected with the tone of a certain skeletal muscle. When a person has impaired internal organ function, certain muscles lose tone and simply do not get involved in movement. "Functional muscular hypotension, hypertension and excessive lightness-total weakness (hyperphasification) - functional (reversible) disorders of the organism, occur in conditions of neurological disorganization, which occurs when there is a lack or excess of afference (mechanical, chemical or energetic)" (Васильева et al., 2017, pp. 13-14). "The unconscious emotional component takes place in every somatic pathology. Using homeopathic complexes, the doctor gets a reliable and affordable means for deeper correction of the organism" (Гитбиндер, 2009, p. 33).

Various devices and tools were used to assess muscle strength. However, MMT is the most informative method, as each device can estimate only the total amount of force, and the researcher's hand is able to distinguish the type of contraction (concentric, eccentric, isometric) to capture muscle fiber involvement as applied force changes in order to establish positive reactions and other characteristics of muscle function, which are unattainable for the apparatus. Manual muscle testing, conducted under certain conditions, allows not only to determine the presence of muscle weakness, but also the cause of its occurrence (Шмидт, 2004). **The results of manual muscle testing in the load process were confirmed electromyographically, by the functional diagnostic method of the PNS** (Ахмерова et al., 2015). "It is inappropriate to observe a person from the aspect of separate body parts, individual organs and muscles, and the perception in the complex interaction of all organs and interconnected systems is neglected. Why? Because it is crucial to understand the biomechanics of movement and how the nervous system works. It is very important to find muscles that do not engage properly in movement and other muscles that do all the work (contract together). Muscles whose innervation is impaired, lose tone (lose the force of contraction) and do not participate in maintaining staticity" (Васильева, 2013, p.11). "Any violations in the activities of the human body cannot be isolated and exist independently. An organism can exist only if there are interconnections of different systems with each other and with the environment. All changes in the activity of the organism or the influence of external factors lead to a complex reaction of adaptation to part of all organs and systems in order to achieve maximum efficiency and effectiveness, the formation of functional chains that form functional rings with a compensatory role" (Васильева & Борисова, 2007, p. 5).

In line with the previous statement, *all reference papers are based on the final comparison of the results of testing after MMT under load, with testing during treatment and after treatment of athletes. Therefore, the comparison of the research results of this paper with the results of other relevant research studies is unknown to the authors.*

However, what can be done is a comparison with MMT under load, which was used as one of the diagnostic methods in order to rehabilitate athletes. Testing provided an insight into muscle innervation and their functional role in the state of PNS in detecting muscle weakness. With this innovative approach and adequate rehabilitation of a large number of individuals and small groups of elite athletes and Olympic representatives of the Russian Federation, their health condition visibly improved, as well as their competitive results. Studies have been published in the Proceedings of the All-Russian Scientific and Practical Conference with International Participation in Moscow (2013); at the Novokuznetsk Institute for the Training of Physicians at the Department of Neurology; the importance of neurological testing of MMT under load was emphasized (Шмидт, 2004); as well as at the First Moscow State Medical University I. M. Sechenov (Ахмерова et al., 2015). The research was conducted at the Department of Rehabilitation, Sports Medicine and Physical Education of the Russian State Faculty of Medicine, and included athletes from various sports (hockey, football, tennis, alpine skiing, judo, sambo, taekwondo, karate, etc.). Three research phases referred to: 1) injuries or lack of specific

psycho-physical abilities (one of the MMT tests under load), 2) diagnosis by specialists and 3) rehabilitation according to our methods (Russian). Based on the obtained results, the largest number of innervation impairment and injuries of the musculoskeletal system occurred on the lower limbs (in some types, up to 40%). After rehabilitation, the following results were obtained: pain in problem areas was stopped; muscle innervation was restored, as well as motor functions of damaged segments of athletes, and the range of motion in problematic joints was increased.

Based on the obtained results, we can conclude the following: the research of the authors of this paper has one thing in common compared with the research of others, and that is the way of neurological testing of muscles and reflex assessment using MMT under load (general model). It should be kept in mind that MMT under load was used with a combination of other diagnostic methods in order to rehabilitate athletes.

Medical kinesiology draws our attention to the fact that when an organ begins to hurt (no pain is felt), a certain muscle stops working. Therefore, neurological MMT under load assesses the activity of the nervous system. Based on the law of neurology, a hidden problem of muscle tone is revealed (no pain is manifested), because the weakness of that muscle is an indicator for finding a weak connection between the systems. This is only possible if perceived in the complex interaction of all organs and systems with each other. Organism should be viewed as a single whole of systemic functioning, and not just as a specific segment. This tells us that we just need to seriously "play", with understanding and practical action - to put together a whole. So, by discovering secondary problems, we must come to the main cause of nervous system disorders, when the primary problem is ascertained - by solving it, secondary ones are also solved, this is a universal principle.

In the end, we can state that the research presented in this paper is just the beginning of a new approach in the process of testing athletes, as well as improving their capabilities and more fully exploiting their potential.

CONCLUSION

Basically, the application of a psychomotor pattern for neurological assessment of reflex under load may play a functional role in establishing proper muscle innervation. Further testing is needed to find out the cause of the indicator muscle weakness and to establish the neurophysiological reflex. And especially finding those muscles whose innervation is impaired, that lose tone and do not participate in maintaining statics, and clinically do not manifest themselves in anything, presenting hidden syndromes. The practical significance is reflected in the given psychomotor pattern for neurological assessment of reflexes during manual muscle testing under load, where the physical, mental and energy states of the organism are combined. This greatly contributes to a new approach in the methodology of working on the training of athletes, in order to more fully exploit their potential. From a theoretical point of view, it may be worth considering the existence of an essential harmony between holistic and standard scientific approaches, for the purpose of the practical role of the mentioned way of testing through which human aspects would develop, i.e. the nervous system would be balanced for preventive purpose, providing restored muscle tone, biological feedback and the path to the development of psychophysical potentials. Thus, the health condition and learning process (exercise) of the athlete improves. Some other possibilities of the given pattern and the way of testing and discovering the causes and eliminating the disorders of the peripheral nervous system have yet to be discovered. Therefore, it is essential to work on functional disorders at the level when the pathology did not have time to develop. Thus, prevention should be the main goal of coaches, teachers, and instructors.

The findings of this study need to be further examined in some future studies, in order to draw a general conclusion about the effects of the proposed method in the assessment of neuromuscular function in sport. Therefore, additional research is needed to confirm the results of this paper.

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