IOSUD - UNIVERSITY „DUNĂREA DE JOS" GALAȚI

Doctoral School of Socio-Human Sciences

DOCTORAL THESIS

Study on the improvement of performance in shotokan karate by edu-cating flexibility with the use of emerging technologies

PhD candidate,

Marius Cojocaru

Scientific leader,

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SSEF Series: Sport Science and Physical Education No 7

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KEY WORDS

KARATE	FLEXIBILITY	TRAINING
TECHNOLOGIES	EMERGING	ISOINERTIAL
PERFORMANCE	KUMITE	KATA

Contents

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Abd. - abduction
Add. - adduction
AM - motor action
Art - joint
CAP - chapter
C.S. - sports club
cv - coefficient of variability
CV - spine
dev - development
Dr - right
EMG - electromyography
Ex.f. - final execution
Ext. - extension
F - feminine
FEFS - Faculty of Physical Education and Sport
Fig.- figure
Fl. - flexion
FNP - passive neuro-muscular facilitation
F.R.A.M.- Romanian Federation of Martial Arts
F.R.K. - Romanian Karate Federation
gr. - grades
Gr. exp. - experimental group
Gr. mar. - mar. group
In. - forward
I.N.C.S.- National Research Institute for Sport
I.S.I.- Institute for Scientific Information
L1-L4 - lumbar vertebrae
Lat. - lateral
m - meter
Mez - mesococcycle
M.I. - lower limb
M.S. - upper limb
M.T.S.- Ministry of Youth and Sport
Nr.- number
pag.- page
Per. - Period
Per. comp. - competitive period
Per. precom. - precom. period
Per. preg. - preparatory period
Pf - final position
PF - physical preparationP.I. – poziție inițială

PT - theoretical training
PTC - tactical training
PTH - technical training
PTH - TC - technical-tactical training
Rot. int. - internal rotation
Rot. ext. - external rotation
S - subjects
Sec - seconds
CNS - Central Nervous System
CNS - Nervous System
S.K.D.U.N.- Shotokan Karate Do of United Nations
Stg - left
Tab.- Table
tehn. - technique
Tehn. Em. - emerging technology
F.T. - final test
T.I. - initial test
TH. - technical
TH-TC - technical-tactical
TMG- Tensiomyography
U.N.E.F.S- National University of Physical Education and Sport
va.- anterior view
Val.ref. - reference value
Val. T. - test value
vp. - posterior view
SIPS - posterior superior iliac spine
S.I.A.S. - anterior superior iliac spine
<º - Angle

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INTRODUCTION

Sports based on martial arts have always been considered attractive by individuals of all ages, and have been practiced even in times when they were not legally allowed. In the contemporary context of the increased attention which people are paying to personal development, the interest towards these sports has impressively grown.

In Romania, according to statistically analysed data from the local federations in the year 2019, the martial arts rank second only after football, counting 38,733 athletes. As reported by the Institute of Educational Sciences, since 2017, the Ministry of Education has also integrated a school curriculum for practical sports training with karate as a specialization into the offer of optional school subjects, thus clearly responding to an educational need voiced by both parents and students.

The existence of a large number of aspiring practitioners to the predetermined levels of competitive performance, pushes all those involved in the process of theorizing, training and organizing competitive events into treating the limits that the practice of a martial art implies with the utmost responsibility.

As a coach, 3rd dan black belt and physical education teacher, I have been directly confronted with this concern throughout my professional career, and I've carefully analysed anatomophysiological parameters, and the extent to which changing correlations between them can influence individual performance. Thus, we have identified the manifestation of a limit in terms of muscular amplitude. The limit, which seems to manifest randomly in various cases, is imposed by joint flexibility. The practitioners seemed to refer to this limit as a bodily particularity, tying the specific movements of Shotokan Karate to personal limits that inhibited their improvement. This triggered the concern to create a training context that would become effective, not only in relation to the improvement of flexibility itself, by training the specific muscle groups of each joint, but also in relation to the way in which the practitioners related to their own bodily limits, the latter being, in our view, the main cause of these inhibitions. These two lines of investigation were also supported by general research findings specific to the improvement of certain functional parameters of the body, which demonstrate that the effect of a workout stops when the training itself has also stopped, in the absence of a mentally supportive factor. This idea, moreover, is deeply rooted in martial arts culture and can be found in the specialized literature under any form of approach: "We must first understand with the mind, then we must practice" (Taisen Deshimaru, 1982, p. 136).

In the specialized literature one can find definitions and premises about the positive influence of high flexibility on sports performance, but without seeing actual demonstrations in a concrete study. Also, within the country's doctoral schools, researches have been supported in the field of Shotokan Karate but flexibility in this context has not yet been addressed. Therefore, after having defined this research's niche, we would like to make known (and to implement) emerging technologies in the measurement of static and dynamic flexibility, therefore concretely demonstrating the influence of flexibility on a sports' performance, on the quality of execution of leg techniques and on the number of points obtained with the upper and lower limbs in sports competitions.

HIGHLIGHTING THE INTERDISCIPLINARY AND TRANSDISCIPLINARY NATURE OF THE CARRIED-OUT RESEARCH

While examining the sports system, which now includes martial arts, one may find an informational diagram represented by educational structures within competitive systems. These are further integrated into entertainment systems and ultimately encompassed by national or international political and media systems. These systems are present not only through traditional written or broadcast press, limited by language and national borders, but also through the latest Internet and modern technologies.

As a result, the present no longer allows research approaches to be confined to a single area of knowledge, since emerging technologies and the Internet have made it possible to navigate freely within these informational diagrams. Transdisciplinary and interdisciplinarity are the key words in the new research context, which are becoming ubiquitous in the field of education.

Any study from any field of knowledge, in the present context, must respect the principle of emergence imposed by contemporary technologies. Investigating the anatomophysiological aspects that condition the performance increase in a sport, by means of virtual global libraries, involves confronting multiple scientific visions. Any action that involves taking control of a function of the human body is conditioned by accepting the interconnections that contemporary research defines as implicit. Thus, an athlete's performance, although it seems to be the prerogative of the predefined system of the sport he or she practises, becomes at the same time a problem that can be approached from a biological, psychological and sociological perspective, because one cannot control their own body in a volitional way, and therefore ignoring any of the three dimensions. This approach has been impossible in the absence of emerging technologies, because no research could track how an issue has been investigated in various fields of knowledge without going through the complete bibliographies of too many fields of knowledge at once. Nowadays, search engines have got access to huge virtual libraries and are an excellent support for constructing a complete bibliography on any investigated issue, thus unlocking the possibility of understanding the implications of any attempt to improve a system in depth.

By integrating our endeavours into the present context, we have discovered how flexibility, as a defining anatomophysiological function for the way joints condition the range of movement, is biologically interconnected with the understanding of the bio-physical implications, psychologically interconnected with the understanding of the feedback of one's own body, and sociologically tied with the understanding of the biological effects of interaction with the living environment.

Although the vastness of the data representing the theoretical fields to which the study has pushed us to look into has certainly got an inhibiting appearance, the reliable methods made available by academic research and the speed of technological search engines have allowed us to identify the nodal points that have formed the argumentative basis on the possibility of improving performance by educating flexibility in cadets and juniors both from a theoretical and from a practical point of view.

THE CURRENT STATE IN THE SPECIALIZED LITERATURE

By being both a sport and an art, Shotokan Karate has developed, in time, some concepts that today can be found in a complex academic system, which includes both the fields of investigation specific to the academic sports environment (biology, biophysics, sports psychology, kinesiology, biomotry or motor anthropology, sports psychology), as well as fields from other areas of knowledge such as art, philosophy, neurosciences, contemporary psychology, computer science and automation. The sports perspective itself is undergoing a process of redefinition, with the boundaries between the performance, maintenance and curative areas involved in the human relationship with the movement of the body disappearing from the contemporary vision of academic program authors. An example of this is the field of physiotherapy, which is claimed by both sports and medical universities. Physics, computer science and automation are now providing support for studies of the human body's motor skills, with a wide range of measurement and control instruments based on cutting-edge scientific discoveries in sensors and biofeedback systems which enable communication with the human body via waves which influence the circuits of the nervous, endocrine, respiratory, blood and muscular systems, sonically, thermally and also tactilely.

Our research hypothesis led us down this challenging and overwhelming path, making us pick the direction of this investigation with academic discernment. We thus identified two possible ways of relating to the specialized literature:

1. The possibility of identifying the fundamental principles that support the hypothesis of the study;
2. The possibility of bringing a relevant amount of statistical data resulting from related studies into agreement with the hypothesis of this paper.

In the belief that any academic endeavour retains its scientific accuracy only if it relates to a sufficient number of principles that validate its own hypothesis, we chose the first possibility, while keeping in mind that it will also require a transdisciplinary approach down the road.

In conclusion, the research does not follow the traditional path of investigating European or international papers and journals. In relation to this field, our interest lies in identifying the possibility of uncovering studies applied directly to the hypothesis. The result of the investigation has therefore brought to light some data on particularities and reactions from athletes pertaining to the investigated age segment and general measurements, in the context of the limits of range of motion in joints, data which has been found through high-end equipment.

We started from the goal itself, which is to increase performance by educating flexibility, and we have created the logical scheme of the factors involved in this endeavour, following with our research of the literature made available by the limitless instruments of today; finally, we have used the scientifically validated principles that theoretically confirmed the possibility of achieving our goal, regardless of the field of knowledge in which the validation occurred.

Thus, it was possible to gather data confirming that the movements involved in educating flexibility can be triggered both through the nervous system, by transmitting and appropriating information through which Shotokan Karate practitioners become aware of their body's potential, and also through the physical system, with stretching used as a technical benchmark.

PART I - THEORETICAL BACKGROUND ON FLEXIBILITY TRAINING IN SHOTOKAN KARATE CADETS AND JUNIORS AND THE VERIFICATION OF THE POSSIBILITIES FOR MEASURING AND ASSESSING FLEXIBILITY USING EMERGING TECHNOLOGIES

CHAPTER 1. THEORETICAL APPROACHES TO FLEXIBILITY

1 Theoretical limits of the concept

Every field of human knowledge is like a universe in the making as long as the flame that created it is taken up by some of the representatives of each generation of individuals, as the ritual of the Olympic flame explicitly demonstrates. The taking up of the flame can be achieved only if those who dare to do so understand how it is to be maintained and what the shining idea whose reverberation has the power to inspire all those who approach it is.
Our research has identified, as the source of the flame that sustains the Shotokan Karate system, the metaphor of the "pine wave", chosen by Master Ginchin Funakoshi. We believe that it was the master's intention to show that, although continually under the influence of feedbacks from stimuli coming from the external and internal environment, man has the ability to make choices in full accord with himself and his specific living environment.
The study triggered by this conviction continued in the direction of identifying the features that make this reality possible, both in the concreteness of human nature represented by the anatomy and physiology of the human body and in the dimension of psychological and neurological manifestations. The element that we have identified as the defining element in this respect is flexibility, interpreted both from an anatomophysiological perspective and from a neurobiological and psychological perspective as well.

1.1. Flexibility from a biological perspective

The traditional view of flexibility integrates the concept into the skeletal system, defining it as the main element of joint functionality. From a biological point of view, the joint (also known as articulation) is not a constituent element of the body, but a place: the place where two bones meet. Semantically, the idea is also to be found in the root of the Latin word *ar-*, which means *to be together*. In Romanian, the word *încheietură* ('joint' but also 'lock') is also used for articulation, which directs the meaning towards the shape and individuality of the bones, emphasizing once again that joints are not concrete elements. Joints are the meeting points of bones and cartilage that enable bodies to move in three ways:

- on their own, with conscious command under the directions of the central nervous system;
- by unconscious command under the directions of the autonomic nervous system;
- by external command through consent or pressure.

1.2. Flexibility from a physical and biophysical perspective

The field in which joints find their perfect counterpart in terms of perceived role and limits is physics. Within the concepts of this discipline, the joint is a lever of order 1, 2 or 3, depending on its nature, with the point of application of the active force being located between the resistant force and the fulcrum. Physics limits the understanding of the concept by referencing the fundamental element that gives the joint its immediate reality: namely, force. Thus, the lever is defined as a rigid element that can perform a rotational movement around a fixed point called the fulcrum. Three forces act on this element, in the case of the joint:

1. a resisting force (the force to be overcome);

2. the active force (the one by which the resisting force is overcome);
3. the reaction from the fulcrum.

Because the fulcrum is fixed, its reaction does not perform mechanical work, so the displacements only belong to the points of application of the resisting and active forces. The lever serves to amplify either the force or the displacement.

The scientific perspective conferred by physics makes it possible to reconceptualize the biophysical reality in the broad field of sporting activities, applied to the principles of Shotokan Karate, which involves achieving performance by taking control of these three forces:

- The active force is represented by the amplitude difference between the movement pattern memorized through daily activities when the performance begins to improve and the pattern considered to be a possible maximum that the athlete keeps as a personal remodelling goal;
- The resisting force is the absence of the synaptic circuit or behavioural pattern that the nervous system needs in order to project spontaneous movement and is perceived as a negative emotion;
- The reaction at the fulcrum is the sensation of pulling or squeezing which, if not controlled judiciously by both coach and practitioner, can bring a sensation of pain.

Figure 1. Symbol of the Shotokan Karate style as found on the Tora No Maki *cover.*

1.3. Flexibility from a biomechanics and kinematics perspective

The possibility of educating flexibility is conditioned by increasing the range of motion in each of the joints involved in the composition of a technique. From a scientific point of view, this is made possible by the in-depth knowledge of the anatomophysiological patterns of each joint and by how they can be attained through sequences of movement and pressure that enable the practitioner to progress within a given time and in a context where the risk of injury is zero. The weight of the data that is controlled by the coach, as the author of the programs, and by the practitioner must be balanced on the axial cause-effect principle. While the coach's decisions constitute the background of causality, being conditioned by the detailed knowledge of all the objective elements and factors that can influence the process of body remodelling and neuroplasticity of the practitioner, the practitioner must be guided towards observing the effects of the coach's decisions. Although we are convinced that in the educational context of the 21st century the necessary condition in the training of coaches is the correlation of the hierarchy of martial arts ranks with the academic hierarchy, we believe that the realistic approach to the way Shotokan Karate is practiced globally and, implicitly, nationally, forces us to summarize the need to control scientific information in the construction of a program at the level of interdisciplinary compendium. The basic elements of the synthesis are represented by the biomechanics of the osteoarticular system and the muscular system, which involves the understanding of the functionality of bones, cartilages, ligaments, joints and muscles, and in particular the fundamental principles that ensure the awareness of the effects of the pressures generated by training on the bodies of the practitioners:

1. Bones remodelling capacity: "Bones, regardless of their shape, are in continuous remodelling, i.e. adaptation to Wolff's law (every change in the shape and function of a bone or only in its function is accompanied by well-defined changes in its internal architecture and, secondly, in its

external conformation according to mathematical laws), through two biological processes, namely: destruction or resorption and rebuilding or production of bone mass" (E. Budescu, *Biomecanică generală*, 2013, p.45);
2. The biomechanical functioning of joints is influenced by the anatomical shape of the articular surfaces and the thickness of the cartilage layer which, being aneural, non-lymphatic and avascular, does not regenerate;
3. The articular ligaments, resistant and inextensible, are sufficiently flexible to allow the execution of movements, their stiffness varying non-linearly with force. Ruptured ligaments may heal spontaneously or surgically, but the scar site will become the point of least resistance for a new rupture;
4. The functioning of the joints is influenced by their structure and their kinematic and dynamic manifestation as an "anatomical assembly that ensures - between two or more bones - the transmission of movement, the transfer and dissipation of forces due to gravity or the muscular activity of the human body" (E. Budescu, *Biomecanică generală*. 2013, p. 70). The number and nature of possible movements in a joint is predefined: flexion-extension, lateral movements rotation and circumduction, abduction and adduction;
5. The amplitude of movement is determined by the distance between the joint ends allowing voluntary oscillatory or pendular movements within the limits of joint movement;
6. The role of the muscles in movement is to mobilize the bone levers and keep the joints connected: "The osteo-muscular component represents the active (driving) part of the muscle force, it is present in the balance equation of the bone leverage, and the articular component represents a passive part of the muscle force, it contributes to the preservation of the joint connection" (E. Budescu, *Biomecanică generală*. 2013, p. 81).
The double perspective on the joints is materialized at the configurative level in a map of the human body made up of more than 300 points (number of joints) in which movement can be inscribed in circular arcs by reference to landmarks located in one of the three planes in which the body can be projected (sagittal, frontal or transverse). This demonstrates the existence of an infinite number of matching possibilities, although the number of possible motions at each point is finite.
Educating flexibility is conditioned by the internalization of this map by each practitioner. At the structural level, it can be achieved by knowing and understanding the limits of movement of the 11 groups of joints:

1. Joints of the hand
2. Elbow joints
3. Wrist joints
4. Axillary joints
5. Sternoclavicular joints
6. Vertebral joints
7. Temporomandibular joints
8. Sacroiliac joints
9. Hip joints
10. Knee joints
11. Leg joints

The nature and position of the joints in the human body is shown in the adjacent picture and table (source: https://www.mdpi.com/1424-8220/19/11/2629/htm)

Figure 2.Synovial joints

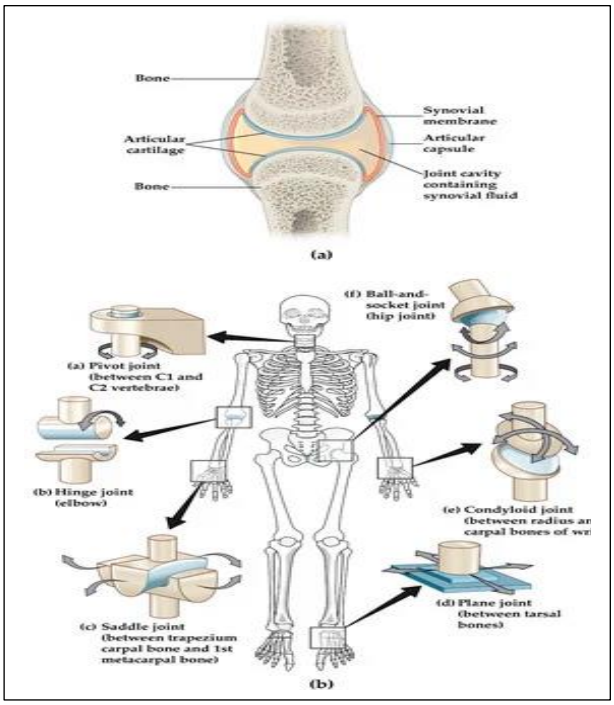


Figure 3.Different types of movements

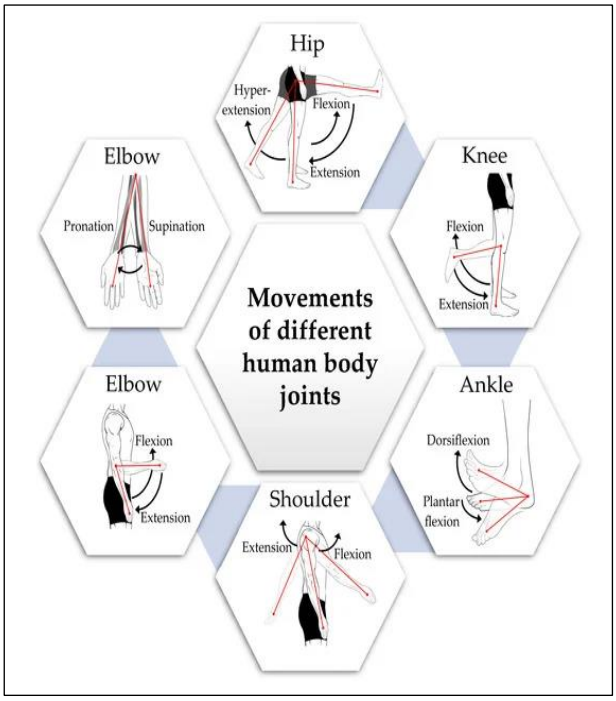


Table 1Types of synovial joints.

Joint type	Common movement	Example
Pivot	The rotation of a bone around another bone	Upper part of the neck
Hinge	Flexion/extention	Elbow/knee/ankle
Saddle	Flexion/extention/adduction/abduction/circumduction	Thumb/Hallux
Plane	Gliding movements	Intercarpal/tarsal bones
Condyloid	Flexion/extention/adduction/abduction/circumduction	Wrist
Ball and socket	Flexion/extention/adduction/abduction/rotation	Shoulder/hip

At the kinematic level, education is conditioned by an understanding of how the three major systems involved in the construction of movement interact: the nervous system (provides command and control), the muscular system (receives the commands of the nervous system and produces the motor force necessary for movement) and the osteo-articular system which realizes the movement within the limits imposed by the systemic typology.
Flexibility training is a process which places the trainer's decision in relation to the potential of the human body, to the stage or momentary limits of the practitioners and to their aspirations in terms of taking control of reaching anatomophysiologically predefined limits.
Any decision involves referring back to the system in which the movement is continuously and constantly integrated, as a result of the interaction of the body's internal forces (nerve impulses,

volitional feedback, muscular and articulatory feedback), the forces of the external environment (gravity, inertia, atmospheric pressure, etc.) and the forces of the relationship between the two environments.
The evolution of movement in the body's internal environment follows a fixed algorithm: nerve impulse - muscle contraction - bone leverage - joint mobility. It is necessary that on each of the elements of the movement sequence, the pressure weight or energy weight be measured or counterbalanced in such a way that the organic feedback stops at the point where the new limit of joint mobility is built without affecting the integrity of the element involved (nervous system, muscles, bones, ligaments, cartilages). We consider that the agreement between the limit of the practitioner and the evolution potential that can stimulate or inhibit the movement which implies an increase in joint mobility, is achieved by the objective recording of the application (Dartfish 360 S or Mobee Med). This removes, from the circuit, the classic cutoff that forces the practitioner to report having exceeded the stage limit in anticipation of the undesirable effect: namely, pain, which is the main cause of inhibiting progress and, in the case of practitioners who are overconfident in their stage limit, this is the body's natural response to pain.
The algorithm involving the use of technology targets the movement that is defined by dynamic flexibility. The second type of flexibility, static flexibility, is to be controlled in order to generate the expected feedback without reaching the pain point, by algorithmizing muscle contraction times using both predefined statistical graphs and individual logs through which practitioners can monitor their personal limits, thus creating personalised graphs.

1.4. Factors that condition the manifestation of flexibility

Like all other characteristics of the living body, flexibility is a pro-facto constant which is expressed individually on a scale between zero and the maximum possible variant according to the action potential of the type of joint. Any program meant to train it is actually conditioned by the recording of the body's characteristics at the time of onset in order to identify the parameters that encourage the development, and to know the factors that may support or hinder the achievement of the objective.
The measurement of flexibility is currently an aspect which has authoritative instrumental scientific support in order to confirm the particularities which allow a person to be integrated into a program aimed at changes which will affect the skeletal, muscular and nervous systems.
The nature of the factors that support or limit the increase in flexibility is complex, requiring an awareness of the fact that, in this context too, the human being is evolving in relation to his or her internal biological system, which is continuously and constantly influenced by emotional reactions caused by the confrontation between information from the external environment and feedback from the habitual internal environment as a result of behavioural patterns acquired through direct bodily or linguistic experience.
In relation to the internal biological system, the factors whose observation requires conscious monitoring can be classified into two categories: **internal-general and internal-particular or individual**.

1.5. The methodology meant to develop flexibility: Stretching.

The primary, literal, etymological meaning of the word *method* is *way* or *path*. Approaching a process or transformation from a methodological perspective involves both accurately fixing the starting point and the point of arrival in hypothetical terms and establishing the rhythm/algorithm/steps which enable the element undergoing change to be maintained within the parameters of the individual systemic balance. The education of flexibility inscribed in this pattern of logic implies the identification of the reporting element for the establishment of the rhythm or algorithm in the point zero of the process, the investigation of the initial parameters in the first

point, and the establishment of a limit of evolution that can be framed within a predefined time unit in 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.
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, stretching, instead of causing a muscle contraction, 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 recognized as a representative of the way in which it has differentiated, defined and developed the possibilities of stretching movements involving muscles, joints and the nervous system, movements that can lead to flexibility training and increased range of movement.
Moreover, stretching has been assimilated by the culture of the fields of maintenance and body care in our country, at a point in the evolution of the concept which, due to the level of procedural integration, has not allowed the identification of a synonymous word or concept in Romanian. This fact eliminates the possibility of correlating the idea of the concept with the field in which it was originally produced, and through scientific investigation in the autochthonous culture it has forced us to investigate its evolutionary path in other cultures. Paradoxically, the term, although identifiable at an encyclopaedic level as a definable and applicable concept of an interdisciplinary nature, found in both physical education, sport and medicine, does not enjoy a history in the culture of Anglo-Saxon languages, which recognizes its conceptual value through scientific connotations. This reality has forced us to admit the emergence of the concept at a technical-procedural level and its integration at a theoretical level only as an element of relation to other concepts that aim to concentrate the physiological, psychological, physical, neurological and chemical forces that it involves. Our investigation has started, as in other cases, by using the method of returning to the point of creation as a resort. Thus, we accepted the conditioned reflex, which makes stretching possible, as the starting point and investigated the pathway to the unconditioned reflex involving muscle stretching. Given that the object of the investigation is essentially an ability of the living organisms, we resorted to identifying the basic function it represents: the unconditioned muscle stretch reflex, known in the literature as *pandiculation*. Therefore, we have correlated stretching with *pandiculation*.

Stretching and pandiculation

The term, for which we did not find a registered correspondent in the Romanian dictionary, can be translated, however, on the basis of the specific principle of taking over scientific terms from a foreign language (*pandicula* is of Latin origin), into *pandiculare* or *pandiculație*. We will use the form *pandiculație*.

"Pandiculation is the involuntary stretching of soft tissues that occurs in most animal species and is associated with transitions between cyclical biological behaviours, especially the sleep-wake rhythm (Walusinski, 2006). Yawning is considered a special case of pandiculation that affects the mouth musculature, respiratory system and upper spine (Baenninger, 1997). When, as is often the case, yawning occurs simultaneously with pandiculation in other body regions (Bertolini and Gessa, 1981; Lehmann, 1979; Urba-Holmgren et al, 1977), the combined behaviour is referred to as the yawning-stretching syndrome (SYS). SYS has been associated with the arousal function because it appears to reset the central nervous system to the awake state after a period of sleep and prepare the animal to respond to environmental stimuli (Walusinski, 2006). This work explores the hypothesis that SYS may also have a self-regulatory role with respect to the locomotor system: to maintain the animal's ability to express coordinated and integrated movement by restoring and regularly resetting the structural and functional balance of the myofascial system", according to Luiz Fernando Bertolucci in his article *Pandiculation: nature's way of maintaining the functional integrity of the myofascial system*, published in 2011 in the National Library of Medicine. Bertolucci's research presents the link between the involuntary stretch reflex (through which the central nervous system is switched from the parasympathetic to the sympathetic autonomic nervous system) and the respiratory system, when the body moves from sleep or relaxation to wakefulness. We have chosen this perspective on pandiculation, first of all, because it reinforces, from a scientific point of view, the importance of practiced breathing control, also found in Shotokan Karate, as an effect of empirical research carried out throughout the evolution of the field, in relation to any command to activate the muscular system: "For martial arts, breathing is the most important factor, because the way to develop power in the hara and the way to concentrate energy in the lower abdomen is through correct breathing. " (Amălinei, 2006).
The second argument that led us to analyse the relationship between pandiculation and stretching from this angle is the fact that the author of the study emphasizes the order of movement times in the pandiculation algorithm as a biological pattern of stretching. The central nervous system switches the organism from the parasympathetic to the sympathetic autonomic nervous system through an involuntary breathing reflex, oscitation (yawning), which is currently studied within the discipline of hasmology, which provides an objective, scientifically substantiated perspective on this involuntary reflex. Although, throughout the evolution of the species, the reflex has been interpreted primarily from a social perspective, research has not been slow to reveal an awareness of the order required in the algorithm for maintaining muscle tone appropriate to the context of the relationship with the environment. Nowadays, oscitation is defined, its causes and effects are known and can be interpreted in relation to any of the systems investigating the relationship between the nervous system, the respiratory system and the muscular system. Technically, oscitation is composed of a long, deep breath, followed by a short plateau and a rapid exhalation, and involves closing the eyes and opening the mouth. It may be accompanied by stretching of the limbs and trunk and contraction of the tensor tympani. In pandiculation it occurs consistently at the beginning of the day and at the end of the day, being triggered in the morning by decreased muscle tone or increased nerve tone, and in the evening by the reversal of this balance. This has led to the correlation of this reflex with the function of cooling the body temperature in the overstressed area and warming it in less stressed areas. Hasmological studies demonstrate the activation of the reflex even in life situations characterized as boring, repetitive, uniform. The effects of activating this involuntary reflex necessarily involve a return to a state of alertness in relation to environmental stimuli, regardless of their nature, which once again highlights the importance of correlating each conscious action on the body muscles with a synchronized respiratory action. The scientific revelation of these intrinsic links to the proper functioning of the body harmonizes amazingly with their revelation through empirical research by martial arts masters who have given special importance to breathing and alertness (Zanshin): "Breathing is the most important thing in martial arts. First of all, it must establish a slow, strong and natural rhythm, for breathing is a vital function in man... Breathing must be natural and never forced. It should begin with a short, natural inhalation from the solar plexus, followed by a long exhalation, pushing down, below the navel, the intestines." (Deshimaru, 1982)

1.5.2. 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 prism 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 specializations (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 practiced 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 relation subjectively with one's own body from the perspectives of the first person and the second person and in objective relation from the perspective of the third person. In other words, Hanna helps people realize that they can relate to their own bodies in three ways:
- through proprioception, in the first-person singular (I), looking at the body and self-consciousness as a whole;
- in the third person through information taken from other people who have knowledge about the body and human nature, which they accept and respect, as if the body were differentiated from self-consciousness;
- in the first-person plural (we), through conscious self-observation, which implies the possibility of voluntary actions on one's own body and following the feedbacks that the body expresses both as a reaction to environmental stimuli and as a reaction to one's own conscious actions.
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 Mobee Med applications which trigger, at the theoretical level, regardless of the degree of motivation or reflexive capacity of the practitioners, the first-person perspective.

1.5.3. 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 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 emphasized 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 realization 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 real 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 the 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.

1.5.4. Types of stretching

The literature in the field currently records four methodological categories of flexibility education that aim to respect this type of bodily feedback correlated with movement:

1. Passive neuromuscular facilitation (PNF)
2. Ballistic stretching
3. Dynamic stretching
4. Static stretching

1.5.4.1 Neuromuscular facilitation

Passive neuromuscular facilitation was developed by Herman Kabat, a neurophysiologist, in the late 1940s. Using the model of 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. Proprioceptive, as well as exteroceptive stimuli, are achieved through exercises involving touch. Telereceptive stimuli, hearing and vision, are activated by voice commands and movement patterns.
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.

1.5.4.2. 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.

1.5.4.3. 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 main axis of manifestation of dynamic stretching is aimed at the relationship between agonist and antagonist muscles. The neuromechanisms involved in how the relationship between these two types of muscles works were 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.

1.5.4.4. 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)

The major 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.

CHAPTER 2. THEORETICAL ASPECTS OF SHOTOKAN KARATE TRAINING

2.1. Technical preparation

The technical word has been so influenced by its use in tool making in the industrial age that it has strayed far from its original Greek meaning: art, skill, craftsmanship. Its counterpart in the Japanese language, used in martial arts, is waza and in any translation it benefits from the reference to the technical word, with the meaning of art. Technical preparation from a sporting point of view is aimed at this meaning of the word. Through technical training, athletes individualize their identity, build their mental and physical system necessary to express themselves in the field they choose. Although, in appearance, technical training represents a sequence of movements related to a systemic position that are acquired through repeated exercise in conditions specific to the performance of competitive activities, in essence, it has a ritual character and definitively changes the self-perception of the one who chooses to become a performance practitioner of sport.
According to Guy Sauvin, quoted by Neculai Amălinei (2006), "any Karate technique can be broken down into four sequences:

1. The reparation;
2. The trajectory;
3. The point of impact;
4. The return.

As in any combat sport, the fundamental element of technique application is decision. The practitioner is trained to be aware of the 2 axes of bodily relationship with the opponent: attack and defence and the possible actions associated with these two postures:

A. Attack:
    a. Blow;
    b. Reaping;
    c. Throwing.
B. Defense:
    a. Blockage;
    b. Dodge;
    c. The fall to the ground.

Actions are designed according to predefined trajectories in association with each technique:

A. Simple actions:
    a. Front (Mae);
    b. Back (Ushiro);
    c. Lateral (Yoko);
    d. Semicircular (Mawashi).
B. Complex actions:
    a. From the inside to the outside (...)
    b. From the outside to the inside (Soto)

Also, the ways of applying the actions are predefined and associated in the names of the techniques:

- Direct (Choku)
- Penetrating (Kekami)
- Percussive (Keage)

Another dimension embedded in the names of the techniques is the level at which the shot is projected:

- Up (Jodan)
- Medium/Middle (Chudan)
- Down (Gedan)

In this coherent and fixed system of relations with his own body and with the opponent, the Karate practitioner projects his movement according to his natural weapons, around which all techniques are organized:
1. Fist (Zuchi);
2. Palm (Shuto);
3. Arm (Ude);
4. Leg (Keri/Geri);
5. The sole of the foot (Keri/Geri).
The application of the techniques is conditioned by the choice of the **position** (**Shisei**) suitable for the action. In Karate, Shisei, although it does not fall within the definition of the technical concept involving movement, is the basis of any technique. Stance receives special attention, because in this stage of the technique that appears to be stillness, the karate practitioner mentally structures the internal movements of their body to be able to hold a fighting position. In the tradition of the sport this guard position requires the Zanshin state where the body is relaxed but the mind is alert. From a neurobiological point of view, this reality translates into conscious control of the commands of the hormonal system. People untrained to understand and relate to these possibilities of the human body cannot consciously command the activation of the adrenaline and noradrenaline stress hormones, their bodies only having the ability to react to situations that the brain interprets as dangerous. The key element, in terms of the structure of Karate techniques, from this perspective, is giving the position to the movement intentions expressed by the opponent without expressing one's own movement intention. In other words, a karateka is technically trained to move in two rhythms or cadences:

- The rhythm of the relationship with the opponent's techniques;
- The rhythm of the relationship with their own techniques.

The idea of the bivalent rhythm, apparently concordant, essentially discordant, is explicitly defined by the Japanese sword master Miyamoto Musashi in the work The Book of Five Rings: "...*Hyoshi* exists in many forms; it is very important to know concordant hyoshi, then discordant hyoshi, and distinguish between large and small hyoshi, slow and fast, interval hyoshi and discordant hyoshi. The latter is essential, for without it the sword cannot be safe. In battle, knowing the opponent's hyoshi, I will use a hyoshi that he does not think of and win, causing the void hyoshi to appear from the wisdom hyoshi." (Miyamoto Musashi, 2000, p.29)
All techniques in Shotokan Karate are theoretically designed to make it possible to win the fight in one shot. In practice, this intention becomes possible through very good timing control.
Timing is a multifaceted concept in terms of the number of fields of knowledge in which it is used, but whether we find it in dance, theatre, film, photography, chemistry, economics, neuroscience or life sciences, the definition implies the idea of rhythm synchronization the translated data from one medium to another. A technically well-trained karateka measures his performance by his ability to synchronize his breathing with the muscle tension specific to the action by which he will force his opponent to accept defeat. In essence, the timing, in a Karateka, represents the adjustment of the speeds with which the breath leads the sequence of images with the learned positions and techniques, a sequence triggered by the analysis of the relationship with the opponent at the pace necessary to take the decision of action in the form of the final blow.
The study of karate techniques must respect certain stages, which Guy Sauvin (1986) quoted by Neculai Amălinei (2006) centralizes in the following way:
1. The Japanese name of the technique and the corresponding translation into the language of the practitioner;
2. General considerations on the technique;
3. Descriptions of the way force is applied in the technique and the parts of the body that transmit this force;
4. Descriptions of the technique (basic form);
5. Variants of the technique;
6. The specific details and advantages of the respective technique;
7. Combinations, mode of defence, instances for applying the technique;
8. Educational exercises, muscle control and the development of specific mobility.
Unlike other sports, martial arts enjoy the possibility of an accurate inventory of techniques, a fact that is due to the maintenance of the tradition that requires keeping the names of the techniques

in the original language. The application of a technique is conditioned by the type of reception command. The highest reaction speed of the human body, especially when the context is of the combat type, is the reaction to auditory commands. By internalizing the suite of movements that make up a technique in relation to a linguistically well configured voice command, the practitioner ensures the best reaction speed. The Karate coach builds the reality of the technique, as demonstrated by Sauvin's description of the stages, physically by demonstrating the sequence of movements and verbally by the detailed and exact descriptions of the form, variants, advantages, disadvantages and ways of composing each technique.

2.2. Tactical training

All sports, whether individual or team, currently enjoy both theoretical and technological support for setting up highly accurate tactical systems. However, the perspective on this type of training is dual: the tactic being approached at a systemic level in order to create patterns or schemes that optimize the chances of achieving an anticipated success or at a psychological level by building conceptual benchmarks specific to strategic thinking. In the case of martial arts, although both types of tactical training are practiced, the formation of strategic thinking is a sine qua non objective in the evolution of a karateka with deep roots in Japanese culture, especially used in the training of samurai.
Miyamoto Musashi, in his work *The Book of Five Rings*, written in the first part of the 17th century, captures the essence of tactics in the Japanese vision in terms that are as concise as they can be: "The way of hyoho strategy is the Free Way. The Hyoho Way is the natural way. Naturally, like a miracle, a rhythm is achieved in a fraction of the time. You naturally attack and defend yourself.'' (Miyamoto Musashi, 2000, p. 22)
At the heart of the view on the nature of tactical thinking is the idea of fully accepting the human nature from the perspective of control used in order to survive. Musashi insists in his work on the acquisition of behaviours specific to tactical thinking so that they can be practiced at any moment of life, not only during combat. Without possessing amount of scientific data that currently confirms his hypothesis, he realizes that the number of bodily reactions that members of our species have at their disposal is limited and predefined, and that if for various reasons, any one of these behaviours is inhibited (is not practiced), then one can actually erase his chances of activating tactical thinking.
Through the application of this perspective to Shotokan Karate and through the analysis of the technical training by reference to the number of actions and directions previously presented, it is easy to confirm the hypothesis configured by Japanese culture: what would be the chances of a karateka to think of the most appropriate strategy for the moment, if he was to eliminate from his system the possibility to block/dodge or if he would avoid side movement, for example. In essence, tactical thinking and flexibility completely overlap at the level of decision-making because the body is totally subordinated to the decision to project the movement in the maximum degrees of amplitude, as long as the movement is perceived in the "attack and defend" style. If thought is inclined in even the slightest degree towards attack or defence as being the dominant action, tactics lose that coherence which makes the miraculous seconds used to secure victory possible, whether in a combat situation or in a peaceful relationship between people.
Consequently, the main difficulty of tactical training does not consist, as one might think, in the physical or somatic conditioning, but in the mental conditioning. All of man's initiatives are conditioned by the way he perceives himself in relation to others, and these projections are usually conditioned in the family, in the first three years of life by parental authority and confirmed or denied by the educational environment outside the family. The 21st century no longer offers people the natural framework of relationship with adversaries or enemies that Musashi has experienced in the 16th and 17th centuries. The present obliges the family and society to inhibit behaviours specific to the attack, both physically and verbally, these being defined as social aggressiveness, regardless of the context in which they are applied, without counting in the sports context. The hypothesis of the manifestation of tactical thinking in real life is currently, at least in a public or private social context, prohibited by law. Therefore, most parents educate their own children in such a way that fighting behaviours are inhibited from childhood. The mission of karate

trainers seems, in this context, impossible. In reality, through training, primary beliefs can be disinhibited and strategic thinking can be educated in relation to the possibilities made available by the sum of the techniques mastered and the limits of the regulations. Surpassing this level and acquiring the real and full behaviour of tactical thinking is achieved, however, only by the great masters.

2.3. Psychological preparation

In psychological training, "the essential problem, regardless of the type of sport, is finding the best psychological means to influence the athletes' psyche to achieve maximum performance."(https://vdocumente.com/psihologia-sportului-2012.html). M. Epuran (2001), quoted by D. Deliu (2008), believes that psychological means must be directed towards "the formation of a system of attitudes and behaviours with an operational and regulatory character" (D. Deliu, 2008, p. 152). Considering the fact that mental preparation is conditioned by the understanding of human sensory reactions' limits, we believe that the state of mental comfort necessary for performance in Shotokan Karate is a derivative of the control of the relationship void between stimulus and sensor and that this can be applied using the technique of the redenomination that influences vestibular and proprioceptive-kinaesthetic sensitivity.
The technique of redenomination is approachable from the perspective of Thomas Hanna's vision of somatics. The author differentiates the triple possibility of an individual's way of relating to him/herself, in connection to the limits involved by the nervous system: subjective through the first person (I know who I am and what I can do), objective through the third person (I am and do what I say about myself that I am and can do - doctors, psychologists, mentors) and subjective through the second person (the body acts according to laws that the individual accepts as inherent and believes that he cannot be responsible for his own actions). The somatic nervous system, made up of sensory and motor neurons, commands the movements and position of the body according to the perceptions of the sense organs (tactile, visual, auditory, olfactory). Information received from the environment is spontaneously decoded and activates, through neurotransmitters, the autonomic nervous system through one of its basic components (sympathetic or parasympathetic) depending on the general or specific codes. Hans Selye (the author of the concept of stress, with the two modes of manifestation: distress or eustress) describes the two types of reactions that define the general codes of manifestation of human bodies under the influence of hormones: withdrawal or action reaction. An example in this sense: "an individual who walks down the street and hears the noise of a car explosion, reacts under the pressure of general codes as follows: in 14 thousandths of a second, the jaw muscles contract; in around 20 thousandths of a second, the muscles of the eyebrows and eyes and the trapezius muscle (descending fascicle) contract, while the shoulders raise and the head projects forward. After 60 thousandths of a second, the elbows flex and the hands close. This descending nerve influx then reaches the abdominal muscles, which then contract, compressing the ribcage and leading to a decrease in respiratory movements; knees bend and toes turn inward; the perineal muscles contract; the body has a withdrawal reaction in the danger phase, as if to regain its fetal position. This cascade of influxes has a descending direction, emanating from the corticospinal bundle. Thus, this mechanism escapes the conscious control of the cortex. This is our primitive protection instinct whose motto is: "Retreat, you will think later!" (Carmen Șerbănescu, 2015, p.4)
Specific codes are represented by each individual's empirical or academic cultural experience. Based on the previously presented case, a man trained to defend, protect, be responsible for public order or simply, trained to react to danger through the action reaction reflex will show the following behaviours: the opening of the eyes, extension of the head, lowering of the shoulders, extending of the upper limbs, opening of the hands, a forward bringing of the chest, relaxation of the abdominal muscles and the diaphragm, with the simultaneous increase of the respiratory rate, relaxation of the perineum (and sphincters), contraction of the buttocks and external rotation of the lower limbs, hyperextension of the knee and the extension and pronation of the leg.
The redenomination involves specific coding according to the limits of the general coding, so that the individual subjectively can approach in the first person, in the general way, any life situation and more specifically any situation in the Shotokan Karate system.

In essence, the entire classical theoretical and practical scaffolding of the training system that the great masters of martial arts have built is based on the manipulation of the human system of reception-emission in an open feedback loop, and the application of the principles even without the integration of the data provided by science, currently, triggers the psychological competences needed to achieve performance to a lesser or greater degree. To the extent in which the conscious involvement of the athlete in the process of his evolution is followed, we consider that the integration of this information is mandatory.

2.4. Moral-ethical training

Shotokan Karate, by definition, like any martial art, places practitioners, from a biological point of view, outside of social networking, therefore outside of any system of rules that are not directly related to techniques, tactics and strategies of fighting for survival. Psychological training, through the technique of redenomination, generates the possibility of self-control and acceptance of the moral-ethical system of the sport community by appropriating its principles. Maintaining the behavioural codes from Shotokan Karate outside of its territory, can be achieved only by referring to individual moral-ethical codes, codes imprinted through religious or civic education, in the family and in school, which implies the creation of interdisciplinary correspondences.
Of all the dimensions involved in the training of athletes, the moral-ethical dimension is the one whose relationship with the practitioner enters the paradoxical, since it essentially requires the athlete not to assert the powers which he acquires through training in any outside context other than the dojo, powers which are a profound expression of the human personality. The conditions are specific to combat sports, sports that continue to affirm the need for the human body to use its basic functions in a social time that eliminates this possibility, any kind of physical aggression being prohibited by law.
Our research opens new perspectives on moral-ethical training by the fact that improving flexibility by using the methods and strategies defined above implies changing the way Shotokan Karate practitioners relate to their own physiological reactions. A karateka trained in this way is no longer obliged to inhibit his reactions in socially challenging situations of the fight-or-fly type, because he will acquire the ability to make the choice of maintaining a state of balance by integrating the need to secure his own body in relation to his own systems. In words that would literally reproduce the state specific to the manifestation of full flexibility, this can be expressed as follows: *in a state of alertness, my body can only be attacked by my decision to unconsciously respond to environmental challenges*.
The history of Shotokan Karate and, in general, the histories of martial arts are full of facts describing this power of the great masters, a power manifested in real life, in conflict situations. In the absence of an understanding of the inner workings of the human body and how these men had been trained to relate to themselves, the facts seemed hyperbolized by mythical or legendary aura. The present, however, makes it impossible for any trainer to ignore the reality of scientific discoveries about human nature and, implicitly, the solutions made available by these discoveries.
In conclusion, moral-ethical training can get out of the paradoxical as long as the emphasis is shifted from the force implied by physical actions to the force implied by mental actions through the training of the flexibility of thought at the same time as the training of musculoarticular flexibility.

CHAPTER 3. DESCRIPTION OF SOME EQUIPMENT MEANT FOR STUDYING FLEXIBILITY

The confidence necessary to take conscious control of the potentialities of one's own body has been accomplished, over time, by various means. The archetypal means is conditioned by the nature of the pre-existing relationship between the communicator/giver and the receiver, with a natural transfer from parent to child, from older brother/sister/boyfriend to a younger one. All the archetypes involving schooling and mentoring have been constructed on the basis of this functional reality at both an anatomophysiological and a psycho-social level. However, the sine qua non condition can only be accomplished through the level of the mentor's additional data load, not on the level of the transfers necessary for the disciple to integrate the data, since the natural emotions generated by the way in which human sensors allow the recording and translation of information disrupt to a greater or lesser extent the reception of contextual information. In other words, in order for a Shotokan Karate practitioner to evolve in accordance with the maximum potential of his/her body, according to the patterns recommended by the master/trainer, the specific emotional agreement of the natural relationships defined above is necessary. The coach's level of competence cannot emotionally precondition the transfer of information, and generating the emotional context by means specific to the coach-practitioner relationship involves major risks:

- It affects the time of any program, generating large discrepancies between the evolutions of individuals in a pre-selected group in terms of basic potential;
- It is correlated with aggressive behaviour, in the case of negative emotions associated with any type of physical pain generated by the pressures required to get out of the state of comfort (traditional training abused this possibility as pain endurance was interpreted as a mark/symbol of personal endurance level; nowadays, the current legislation on the rights of minors excludes this possibility).

On the one hand, the traditional solution for creating the emotional context necessary to increase the level of confidence in one's own potential is when competition is practiced under training conditions which respect the standards imposed by the evaluation grids of official competitive circuits. Even this solution has its limits subjectivized by the small possible number of competitions and the degree of confidence in self-feedback.
On the other hand, modern solutions provide coaches with devices with a very high degree of possibility in creating the emotional context, as they are created for this purpose (increasing the number of scorers and records confirming progress or success). The main element by which contemporary technologies become supportive of projects to improve the limits of human potentials acquired by memorizing behavioural schemes is the possibility of entering the scheme of the individual's relationship with himself on the basis of contact sensors that allow the projection of data about the general or stage configurational limits of his own body.

3.1. Posturotest (Sensor 2020) for postural analysis

The typology of the methods that can have the effect of improving performance by developing flexibility is conditioned, according to the theoretical results of the research, by the awareness that mentality and habits determine the occurrence of sensory motor amnesia that limits or blocks movement in one area or another of the body's joint system. Knowledge of these limitations is fundamental for the creation of the general or individual algorithm of reactivation of these areas. In this context, we considered it fundamental to integrate a *posturotest* into the research.
The apparatus consisting of a FreeMed baropodometric platform, a webcam and the computerized software FreeSTEP Full, provides diversified functional information about the motor activities of the entire musculoskeletal system. The Posturometer is a specially designed, electronic, objective, non-invasive body posture measuring device. The FullStat provides data on

the assessment of posture and back shape together with the associated mobility of the spine, pelvis and rib cage.

3.2. Mobee Med for flexibility analysis

For the analysis of flexibility, we consider the MobeeMed application to be suitable. The analysis is performed using a compact sensor-based device, which is also used to conveniently control the software. The main element that has determined this specific choice is the possibility to access interactive instructions on how the movement can be performed so that it can be followed in real time. The results (range of movement, symmetry and harmony) are presented in a clear and concise manner. The overall package is complemented by progress displays over time and context-specific exercise recommendations.
The app represents the necessary and sufficient tool to subjectivize the mirror neuron system by triggering the meditation-specific reflexivity that is traditionally acquired in long-term exercises by a relatively small number of practitioners. The practitioner can observe his or her body subjectively and objectively at the same time, the interaction and the patterns created to generate the evolution, applied on one's own body creating the string of images that have the effect of increasing the degree of confidence and resetting information erased by sensory motor amnesia. The analysis method is particularly easy to learn and requires no special prior knowledge. The fundamentals derived from using MobeeMed are:

- The availability of functional mobility tests with general and sport-specific measurement profiles;
- The possibility to create your own measurement profiles;
- The possibility to establish an interactive relationship;
- The existence of analysis device;
- Live motion animation;
- Live comparison with reference values;
- Customizable results reports are available;
- The ability to generate muscle information and daily relevance information;
- The existence of reports displaying progression with animated exercise recommendations;

3.3. Dartfish 360s software for dynamic flexibility analysis

The Dartfish software enables video analysis by capturing, analysing and sharing training videos. The footage is recorded directly on the platform, with events being tagged in real time, with a built-in capture system and the ability to import footage from other sources on a wide range of devices. Designed to provide the possibility for complex analysis of whole or clipped footage as required by the stage, the software allows the highlighting of any elements that the coach deems important, with the service allowing notes to be sent via the cloud for access by any interested practitioner.

3.4. DESMOTEC emergent equipment

This emergent device used in isoinertial training, consists of two stations (Desmotec D. Full and Desmotec V. Full) and is equipped with a series of accessories (belts, ropes, harnesses, handles, disks) and a rotating system that controls the motor actions according to the gravitational force. Training with Desmotec enables muscle groups to work at maximum force at any angle because the resistance adapts in real time, the force used during concentric motor action causes the rotary system to accelerate.
Desmotec acts like a yo-yo mechanism - the external resistance being represented by the inertia of a wheel which is decelerated/accelerated by the muscular force (the system maintains a constant inertia in both the concentric and eccentric phases).
Desmotec used in isoinertial training increases muscular endurance, improves range of motion, increases the performance of extensor muscles, improves flexibility of tendons and ligaments.

CHAPTER 4. CONCLUSIONS OF THE DESK RESEARCH

The increase of performance in Shotokan Karate is conditioned by the ability of the practitioners to maximize the natural potential of the body system limited by the way in which the joint systems manifest themselves: physiological (muscular, skeletal, nervous), informational (ideas, conceptions, prejudices, etc.), and psycho-sociological (relations with the physical and social environment, conditioned by the body's feedback system).
Shotokan Karate, as a martial art and competitive sport, requires the practitioners to build a psychosocially based agonistic behaviour as the sum of reactions triggered by the territoriality instinct that manifests itself in the presence of environmental resources, a possible mate or a personal shelter.
The agonistic behaviour triggered by the environmental variables mentioned above triggers the release of specific hormones in the body that take control of the nervous system, commanding the muscular system to spontaneously manifest specific bodily positions of distress, action/fight, retreat/ flight, submission, etc.
Our research demonstrates that movements that are naturally triggered spontaneously by the pressure of the external environment can be triggered in a controlled way during training by internal psychological pressure generated by information acquired in specific contexts of formal education.
The main lever of conscious movement control is people's ability to de-focus or relate both objectively and subjectively to their own body. In the case of Shotokan Karate, this involves consciously taking ownership of the karateka's identity and the path by which the practitioner assumes the evolution towards predefined performance standards, pointing towards taking control over the overall flexibility of the body.
The evidence base for objective reporting is provided by information that in the past only people with professional experience or expertise had access to on the basis of direct experience, but nowadays technology provides access conditioned on the one hand by people's interests and motivations and on the other hand by their biological (age) or intellectual capacity to understand the information.
Subjective reporting to one's own body is done through voluntary action commands on the nervous system (imagination/meditation), the muscular and skeletal system (stretching) and the respiratory system (awareness and breath control techniques).
Supporting the effort required for voluntary action on the nervous system (imagination) can be made more effective by images recording personal development made available by applications created for this purpose (Mobee Med, Dartfish 360S).
Our research demonstrates that the assumption of conscious control can be triggered by any of the three basic systems: nervous, respiratory or musculoskeletal, depending on the developmental dominance of the practitioner.
We have also identified enough arguments to support the fact that the ages between of 14-18 (Shotokan karate cadets and juniors) is the right age to take conscious control, because it is the age of self-knowledge and self-image establishment, of evolutionary stabilization from a physical point of view. It is at this age that all the territorial instincts are activated and the lack of experiences of coherent manifestation of impulses provides the optimal framework for implementing the conditions that ensure the balance between the capabilities provided by agonistic behaviour and the moral and ethical values involved in practicing a sport and a martial art in the specific conditions of the beginning of the 21st century.
From our point of view, the research’s value goes beyond the field of Shotokan Karate by asserting a new perspective on the approach to performance in sport: the perspective of a transdisciplinary approach when it comes to the limits of the human body.
In an attempt to identify the natural forces of the body that allow the improvement of flexibility, we let ourselves be guided by the abundance of information that global research makes available through emerging technologies, by accessing the phenomenon investigated from all the perspectives that cover the human body when it is in action: biological, biophysical, psychological,

neurological, sociological, anthropological, following the fundamental axes that allowed the congruence of data in the point sought: the scientific translation of the metaphor through which the author of the Shotokan Karate system tried to define the possibility of achieving peak performance, namely *the pine wave*. Therefore, we identified the human body's ability to consciously and voluntarily shape its behaviours by training the nervous, respiratory and musculoskeletal systems in harmony, using any of these three dimensions as the dominant action. Due to the need to maximize the control of performance evolution, we have chosen the muscular-bones- system and the respiratory- nervous system directions, with the evolution being tracked by recording progress data on joint amplitude.

CHAPTER 5. OPERATIONAL FRAMEWORK OF THE PRELIMINARY RESEARCH

5.1. Premise

The verification of apparatus, equipment and ways to enhance flexibility in Shotokan Karate practitioners is a necessity for the success of our preliminary research.
In the preliminary study we aimed to highlight new methods of educating, measuring and evaluating flexibility using emerging technologies.
We admit that carrying out preliminary research with the help of emerging technologies (laboratory equipment, state-of-the-art equipment), will lead to the improvement of the cognitive baggage through the complexity and accuracy of the data, a fact that will make it easier for us to approach the subsequent fundamental research.

5.2. Purpose

The purpose of the preliminary approach is to verify the use of laboratory apparatus and equipment to highlight the flexibility and select the appropriate technology for our fundamental research.
After selecting the devices and software that will be used in the fundamental research, it is imperative to establish the methodology for highlighting and analysing the flexibility.
In order to improve the sports performance of Shotokan Karate practitioners by developing flexibility, after using an original training program, it is necessary to consider the way of highlighting the program, the means and methods used for this purpose.
At the same time, we aim to improve our knowledge of apparatus, equipment, methods and training tools with which to increase the possibilities of highlighting, measuring and educating flexibility. Moreover, we want to note the emerging technologies that can be used for the purpose of research and improvement of sports performance.
We recognize the fact that the improvement of specialist knowledge has a favourable effect both for coaches (sensei) and for beginners, advanced athletes, with the purpose of increasing performance at all levels of training.

5.3. Objectives

- Highlighting several possibilities for measuring and evaluating body flexibility.
- The familiarization with emerging technologies to be used in highlighting flexibility.
- Establishing a methodology for the selection of athletes who will participate in the fundamental research.
- The need to implement an original flexibility education/development program in order to improve sports performance using emerging technologies.

5.4. The hypotheses of the preliminary research

1. By applying an opinion questionnaire regarding the analysis of the impact of the development of static and dynamic flexibility on technical quality, on sports results and also on the quality of life of athletes practicing Shotokan Karate, carried out on a considerable number of specialists in this field, we will be able to obtain information that

underlines the need to develop a methodology for measuring, evaluating and improving flexibility in order to achieve sports performance.

2. Using the Mobee Med equipment we can identify the degree of mobility of the joints, measuring the angles and amplitude of movements for the shoulders (scapulohumeral joint), the upper limbs (the elbow and hand joints), the hips (the coxa-femoral joint), the lower limbs (the knees and ankles).
3. Using Dartfish 360 Software we can obtain accurate and complex data regarding dynamic flexibility specific to Shotokan Karate techniques for mae geri (forward kick), yoko geri (side kick), mawashi geri (circular kick) and ushiro geri (back kick).

5.5. Tasks

- Research periodization;
- Carrying out studies regarding the highlighting of flexibility with the help of various devices and equipment;
- Establishing research samples;
- Establishing tests and control norms;
- Carrying out measurements and tests;
- Statistical processing of the results;
- Graphic representation of the preliminary research results;
- Interpretation of preliminary research results;
- Elaboration of preliminary research conclusions.

5.6. Research methods and techniques

The methods and techniques used in the preliminary approach are the ones which are generally valid and the ones customized according to our theme.

CHAPTER 6. ORGANIZATION OF THE PRELIMINARY RESEARCH

6.1. RESEARCH ORGANIZATION

For the purpose of the preliminary research, we conducted several studies to finally establish the flexibility assessment methods and range of motion measurement tools. We aim for the research to provide a didactic and practical support to athletes, coaches and those who want to assimilate and deepen the information regarding the measurement and evaluation of flexibility.

6.1.1. Preliminary research methodology

The chosen methodology was made up of a series of characteristic stages, in order to carry out fundamental scientific research, stages that are staggered chronologically and can be highlighted in the appendices.

6.1.2. Place, time, research subjects and collaborators

For the study that used the Mobee Med equipment needed to measure and evaluate flexibility in karate, the data are as follows:

- **Place**: Superfit Medical Center – Bucharest
- **Time**: January 2021.
- **The subjects** of our investigation were three athletes registered at the Kazumi Sports Club affiliated to the Romanian Karate Federation, the S.K.D.U.N. department.
- **Collaborators**: Director of the Superfit Bucharest Clinic, doctor Damian Șerban, physiotherapist Aguciu Mădălin, University Professor dr. Claudiu Mereuță.

For the study that used the Dartfish 360S software needed to measure dynamic flexibility and flexibility specific to shotokan karate foot techniques, the data are as follows:

- **Place**: The sports hall of “Al.I. Cuza’’ - Technological High School, in Panciu, Vrancea county.
- **Time**: January 2021.
- **The subjects** of the research are three athletes registered at the Kazumi Sports Club affiliated to the Romanian Karate Federation, S.K.D.U.N. department.
- **Collaborators**: University professor dr. Claudiu Mereuță, Eng. Dr. Daniel Ganea.

For the study in which the Posturotest equipment (Sensor, 2020) was used to assess postural deficiencies, in order to select the athletes who will participate in the fundamental research, the data were as follows:

- **Place**: The Physiotherapy Office within the Faculty of Physical Education and Sport – ‘‘Dunărea de Jos’’ Galați University;
- **Time**: January 2021.
- **The subjects** were three athletes of the Kazumi Club from Focșani.
- **Collaborators**: University professor dr. Claudiu Mereuță, En. Dr. Daniel Ganea

CHAPTER 7. CONDUCT OF PRELIMINARY RESEARCH

7.1. The analysis of the necessity and usefulness of developing the flexibility of athletes practicing Shotokan Karate

7.1.1. Objectives

The analysis of the necessity and usefulness of developing the flexibility of Shotokan karate athletes was organized during February 2020 with the main objectives:

1. the analysis of the need to develop the static and dynamic flexibility of Shotokan karate athletes;
2. the analysis of the need for a specific program aimed at developing the static and dynamic flexibility of Shotokan karate athletes;
3. identifying the main joints on which the static and dynamic flexibility development program of Shotokan karate athletes should focus;
4. the analysis of the impact of the development of static and dynamic flexibility on sports results and the quality of life of Shotokan karate athletes.

7.1.2. Subjects batch

To achieve the research objectives, 48 Shotokan karate trainers from the Romanian Martial Arts Federation, Shotokan Karate of United Nation (SKDUN) department were surveyed.

7.1.3. Tool used and data collection

The data collection was carried out with the help of an online questionnaire comprising 36 questions:
- 18 questions are related to static flexibility and 18 questions are related to dynamic flexibility;
- 10 questions are related to the need to develop flexibility in the case of athletes practicing Shotokan karate (5 with reference to static flexibility and 5 with reference to dynamic flexibility);
- 10 questions are about the joints whose flexibility must be developed in the case of Shotokan karate athletes (5 with reference to static flexibility and 5 with reference to dynamic flexibility);
- 16 questions are about the impact that the development of flexibility has on the sports results and the quality of life of Shotokan karate athletes (8 with reference to static flexibility and 8 with reference to dynamic flexibility).

The fidelity analysis of the instrument used, carried out by calculating the Alpha-Cronbach internal consistency coefficient, provided the following results:
- 0.905 for the entire questionnaire, corresponding to an excellent fidelity of the questionnaire[1];
- 0.866 for the 18 items referring to static flexibility, corresponding to a good fidelity of this scale;

[1] a value of the alpha-Cronbach coefficient above 0.9 corresponds to an excellent fidelity of the scale, above 0.8 reflects a good fidelity and above 0.7 corresponds to an acceptable fidelity of the rating scale (Gliem, J., Gliem, R (2003). *Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type Scales*. Midwest Research to Practice Conference in Adult, Continuing, and Community Education)

- 0.772 for the 18 items related to dynamic flexibility, corresponding to an acceptable fidelity of this scale;
- 0.841 for the 10 items referring to the need to develop flexibility, corresponding to a good fidelity of this scale;
- 0.840 for the 10 items referring to the joints whose flexibility must be developed, co-responsible for a good fidelity of this scale;
- 0.851 for the 16 items referring to the impact that the development of flexibility has on the sports results and the quality of life of Shotokan karate athletes, corresponding to a good fidelity of this scale.

7.1.4. Statistical procedures used in data analysis

The Skewness coefficient is an indicator of the asymmetry of the distribution of scores obtained by a group of subjects on a certain evaluation scale. A perfectly symmetric distribution has a Skewness coefficient equal to zero; a distribution of scores with a longer tail to the left has a negative skewness coefficient, while a distribution with a longer tail to the right has a positive Skewness coefficient.[2]
The statistical significance of the Skewness coefficient value is as follows:

Table 2.Coefficient of Skewness

Lower than -1	a much longer tail to the left distribution	the majority of the answers are concentrated towards the maximum of the evaluation scale
Between -1 and -0,5	A longer tail to the left distribution	the majority of the answers are concentrated towards the highest scores
Between -0,5 and 0,5	A relatively symmetrical distribution	the number of low scores is relatively equal to the number of high scores
Between 0,5 and 1	A longer tail to the right distribution	the majority of the answers are concentrated towards lower scores
Higher than 1	A much longer tail to the right distribution	the majority of the answers are concentrated towards the minimum of the evaluation scale

The t-test for paired samples (paired samples t-test) is an evaluation of the statistical significance of the difference between the means obtained at two evaluations of the same group of subjects. [3]The paired-samples t-test is a parametric test whose objective is to statistically determine whether the difference between the means of two ratings is significantly different from zero. The main statistical result of the t-test for independent samples is p (in SPSS being reported as Sig. (2-tailed)), its value being interpreted as follows:

[2] Brys, G., Hubert, M., Struyf, A. (2003). *A robust measure of skewness*. Journal of Computational and Graphical Statistics (13)
[3] SPPS tutorial. Kenn State University. https://libguides.library.kent.edu/spss/pairedsamplesttest

Table 3.The t test

p>0.05	statistically irrelevant	the two averages do not differ significantly
0.01<p<0.05	relevant for a confidence interval of the 95% results	there is a chance higher than 95% that the two averages are significantly different
p<0.01	relevant for a confidence interval of the 99% results	there is a chance higher than 99% that the two averages are significantly different

7.2. Analysis and interpretation of the results

7.2.1. The need to measure the flexibility of Shotokan Karate athletes

Shotokan Karate coaches almost unanimously believe that measuring the flexibility of athletes is necessary, especially in terms of dynamic flexibility, thus emphasizing on the one hand the importance of flexibility in sports performance, and on the other hand the need to know the basic level of flexibility of athletes in order to be able to effectively plan the training and to evaluate the progress of the athletes. Our results confirm the information from the specialized literature, where it is specified that flexibility is an essential quality for athletes, thus imposing the development of the degree of flexibility that will ultimately lead to an increase in the yield, quality and economy of technical executions (Neculai, 2006).
At the same time, more than 80% of Shotokan karate trainers are of the opinion that it is necessary to transition from the classic means of measuring static flexibility (metric tape, goniometer, etc.) to the use of emerging technologies for measuring static flexibility (Mobee Med equipment, dartfish 360s software, etc.), thus emphasizing the need to digitize the assessment of the static and dynamic flexibility of athletes to increase the accuracy of the measurement.

7.2.2. The utility of a flexibility development program for Shotokan Karate athletes

More than 90% of Shotokan karate coaches surveyed agree or totally agree with the fact that the development of athletes' flexibility must be achieved with the help of a specific intervention program, through systematic and well-organized activities, even more so in the case of dynamic flexibility. This response tendency confirms the importance that must be given to the development of flexibility (static, but especially dynamic) of Shotokan karate athletes, an aspect that must be well planned as an integral and constant part of sports training. According to Amălinei (2006), the coach ensures (by designing a logical and well-thought-out training program) the progress of all the components that facilitate the sports form of a karate practitioner, including flexibility. At the same time, Shotokan karate coaches emphasize the fact that it is necessary to select athletes who can participate in specific intervention programs for the development of flexibility, both in the case of static flexibility and in the case of dynamic flexibility. Athletes must be healthy from an osteo-muscular point of view. From the perspective of the methods that can be used to develop the flexibility of Shotokan karate athletes, most coaches agree that stretching can significantly contribute to the development of static flexibility as well as to the development of dynamic flexibility.

7.2.3. The main joints targeted by the flexibility development program for Shotokan karate athletes

Shotokan karate trainers know the importance of developing the static and dynamic flexibility of all important categories of joints: the scapulohumeral joint, the spine joints, the upper limb joints and the lower limb joints. However, the more in-depth statistical analysis argues that, both in the case of static flexibility and dynamic flexibility, coaches believe that the most important thing is to develop the flexibility of the acetabulofemoral joint and the flexibility of the joints of the lower limbs. The development of the static flexibility of the spine joints and the joints of the upper limbs is also important, according to the coaches, while the development of the static flexibility of the scapulohumeral joint is secondary.

7.2.4. The impact of static and dynamic flexibility development on sports results and quality of life of Shotokan Karate athletes

Shotokan Karate coaches see flexibility as a very important element for the quality of executions, especially dynamic flexibility, the vast majority of coaches surveyed agreeing or totally agreeing that the development of flexibility (static, but especially dynamic) leads to a significant increase of the quality of executions. This evaluation is not surprising if we consider the information from the specialized literature, according to which fighters who followed a dynamic flexibility development protocol achieved performance in technical executions regarding flexibility, strength, balance (Polat, S. C., Cetin, E., Yarim, I., Bulgay, C., & Cicioglu, H. I. 2018).
At the same time, flexibility is considered to be an important benchmark for reducing the execution time of blows, dynamic flexibility being considered more important than the static one in this regard. This fact is argued by the researchers Chatzopoulos, Galazoulas, Patikas, Kotzamanidis (2014) who demonstrated that the dynamic flexibility development protocol compared to the static one led to much better results in terms of balance, agility and execution time.
The majority of the Shotokan karate coaches believe that there is a direct relationship of conditionality between the athletes' flexibility and the quality of the results obtained in the kata and kumite competitions, stating that the development of flexibility, especially dynamic, positively influences the athletes' results in both categories of competitions.
The flexibility of Shotokan karate athletes, especially dynamic flexibility, conditions, in the opinion of their coaches, both the number of points obtained with upper limb strikes and the number of points obtained with lower limb strikes.
From the point of view of sports life, a very important aspect emphasized by the interviewed coaches is that the development of athletes' flexibility significantly reduces the risk of accidents, an aspect valid for both static and dynamic flexibility. This aspect is important not only for sports results, but also for the health and safety of the athletes. Moreover, the majority of Shotokan karate coaches believe that the development of static and dynamic flexibility of athletes determines an increase in their quality of life, emphasizing the importance of flexibility not only in a sports activity, but in any activity.

7.3. The study of correlations

By analysing the results obtained according to the tables below, we have highlighted a series of positive and statistically significant correlations.

Table 4.The need to measure and develop static and dynamic flexibility.

VARIABLES	Pearson coefficient of correlation r	Probability p
The necessity of static flexibility measurement / The necessity of dynamic flexibility measurement	0.529	0.000
The necessity of emergent technologies in the measurement of static flexibility - The necessity of emergent technologies in the measurement of dynamic flexibility	0.990	0.000
The necessity to develop static flexibility – The necessity to develop dynamic flexibility	0.674	0.000
The necessity of participant selection (for static flexibility development) - The necessity of participant selection (for dynamic flexibility development)	0.958	0.000
Utility of stretching for static flexibility development – Utility of stretching for dynamic flexibility development	0.516	0.000

The correlation identified for the need to measure static and dynamic flexibility, where the probability associated with the test is $p = 0.000 < \alpha = 0.001$ (significant 99%), the Pearson correlation coefficient $r = 0.529$ (positive) means that in general respondents who consider that it is necessary to measure static flexibility believe that it is also necessary to measure dynamic flexibility (and vice versa).
In the case of the use of emerging technologies in the measurement of flexibility $p = 0.000 < \alpha = 0.001$ (significant 99%), $r = 0.990$ shows that respondents consider the digitization of flexibility measurement useful both in the case of static and dynamic flexibility.
It is necessary to develop static and dynamic flexibility because in this case the probability associated with the test is $p = 0.000 < \alpha = 0.001$ (significant 99%), $r = 0.674$ (positive).
Both in the case of the development of static and dynamic flexibility, the respondents consider it necessary to select athletes, the probability associated with the test being $p = 0.000 < \alpha = 0.001$ (significant 99%), $r = 0.958$ (positive).
Respondents who stated that the stretching method is useful for developing static flexibility considered that the same method is also useful for developing dynamic flexibility, the probability associated with the test being $p = 0.000 < \alpha = 0.001$ (significant 99%), $r = 0.516$ (positive).
Note: the study of the other correlations can be followed in the appendices.

7.4. Conclusions

The development of the flexibility of Shotokan Karate athletes has a significant impact both on sports performances and on life in general: it increases the quality of executions and decreases the execution time, facilitates better performances in both kata and kumite competitions, increases the number of points obtained both with the upper and lower limbs, reduces the risk of injuries and increases the quality of life of athletes. In most of these respects, coaches place more emphasis on the influence of dynamic flexibility than that of static flexibility.
Under these conditions, it is not surprising that most coaches consider it necessary to implement specific programs to develop the flexibility of Shotokan karate athletes, especially dynamic flexibility, including using stretching as a method of developing flexibility. From the perspective of the joints which flexibility should first of all be developed, the trainers consider it more important to develop the flexibility (especially dynamic) of the acetabulofemoral joint and the joints of the lower limbs.
At the same time, the coaches emphasize the necessity of selecting the athletes who participate in the flexibility development program. Consequently, most coaches are aware of the need for a precise and relevant assessment of the flexibility of athletes, including by using modern, digital tools to increase the relevance of the measurement.

From the practical perspective of organizing and implementing such a program to develop the flexibility of Shotokan karate athletes, we consider the following aspects to be very important:

- such a program is considered useful and necessary by the coaches, but it must be well organized and planned, it cannot be limited to sporadic interventions, it must be unitarily integrated into the whole of the athletes' training activities;
- such a program would be beneficial to aim at the development of both types of flexibility (static and dynamic), but with an emphasis on the development of dynamic flexibility, which has a greater impact on sports activity;
- participation in the flexibility development program must be conditioned by a rigorous selection of participants;
- faithful and repeated measurement of the athletes' flexibility is strictly necessary to be able to evaluate the impact and effects of the flexibility development program, the measurement being carried out mainly with modern, digital tools (Mobee Med equipment, Dartfish 360s software, etc.)

CHAPTER 8. EMERGING TOOLS USED IN THE PRELIMINARY EXPERIMENT

8.1. Mobee Med used in measuring static flexibility

We chose this modern equipment because it allows us to quickly and accurately measure the degree of flexibility in the joints. With over 100 different measurement options, Mobee Med offers a wide selection for almost all joints (except finger and toe joints).
Through different positions (sitting, sitting, lying down) you can find the optimal option for measuring the joint that interests us.
Mobee Med will help us record the values obtained from measuring the range of motion. As a digital companion, the system displays measurements recorded throughout the research period and also makes progress visible.
The analysis is performed using a compact, sensor-based device, which is also used to conveniently control the software. We can track the execution of the movement in real time and enter additional relevant information, for example data about pain if it exists or not. The results are then presented clearly and appropriately for the recipient (coach/athlete). Active-passive and right-left comparisons are used for evaluation. Progress displays throughout the study underscore the success of our research.
Properties of the Mobee Med equipment:

- 142 mobility tests using the zero neutral method;
- Extended catalogue of measurements;
- Editable reference values;
- Software operation with analysis device;
- Animation of the measured angle;
- Recording the type of pain;
- Presentation of the results in neutral-zero notation;
- Displaying the total range of motion;
- Comment function;
- Various viewing options;
- Customized, verifiable result report:
- Display progress in patient and expert mode.

8.1.1. Measurement of active flexibility at the level of the scapulohumeral joint

Shoulder flexion (anterior movement of the arm in the sagittal plane)
1. Reference values (values considered normal by different researchers):

- 180^0 Mircea Chiriac;
- 160^0 David J.Magee;
- 180^0 Tudor Sbenghe;
- Mobee Med 160^0 active.

2. Initial position (P.I.) – Standing (orthostatism), arms next to the body (in anatomical/neutral position), palm turned outwards;
3. Motor action (MA) – Bringing the left arm forward and up;
4. Final position (F.P.) – the athlete in orthostatism will complete the movement by reaching with the left arm extended next to the ear;
5. The plane in which the motor action takes place - sagittal;
6.Mobee Med gyroscope position – inner part of the arm;
7. The position of the researcher in relation to the examined athlete – on the same side of the arm.

Shoulder extension (posterior movement of the arm in the sagittal plane)

1. Reference values (values considered normal by different researchers):
   - 45^0 Mircea Chiriac;
   - 50-60 ^{0} David J.Magee;
   - 50-60 ^{0} activ, 90^0 pasiv-Tudor Sbenghe.
   - Mobee Med 50^0 active.

2. Initial position (I.P.) – Standing (orthostatism), arms next to the body (in anatomical/neutral position), palm turned outwards;
3. Motor action (MA) – Bringing the left arm backwards;
4. Final position (F.P.) – the athlete in orthostatism will complete the movement reaching with the left arm extended backwards to the limit of movement;
5. The plane in which the motor action takes place - sagittal;
6.Mobee Med gyroscope position – inner part of the arm;
7. The position of the researcher in relation to the examined athlete – on the same side of the arm.

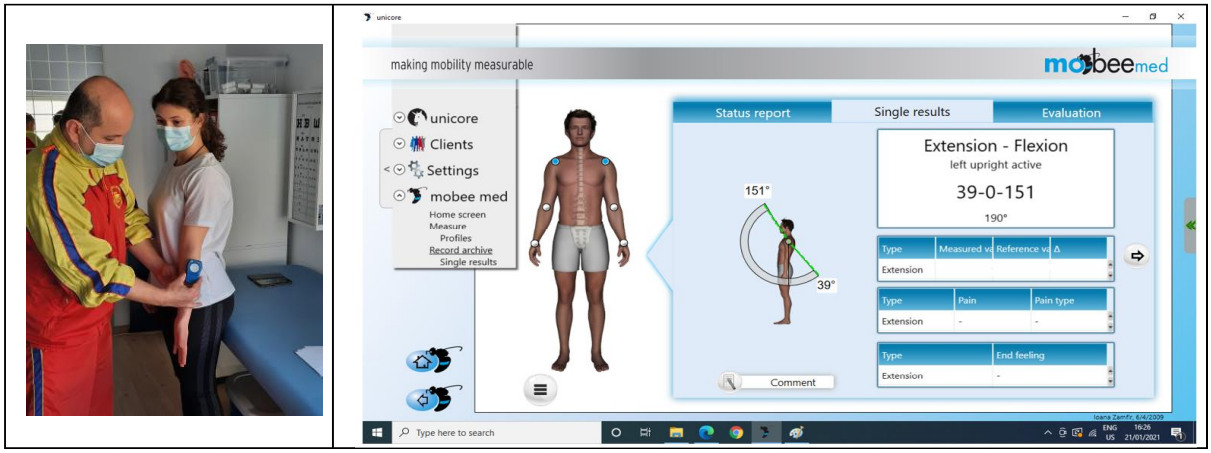


Figure 4.Flexion and extension of the shoulder

Horizontal shoulder adduction (moving the arm closer to the opposite shoulder, maintaining a shoulder flexion of 90^0)
1. Reference values (values considered normal by different researchers):
   - 135^0-140^0 Mircea Chiriac (from supine position);
   - 130^0 David J. Magee (from supine);
   - Mobee Med 140^0 (from orthostatism) active.
2. Initial position (I.P.) – Standing (orthostatism), left arm extended laterally (in 900 abduction position), palm facing forward;
3. Motor action (MA) – Taking the left arm forward and to the right;
4. Final position (F.P.) – the athlete in orthostatism will complete the movement reaching with the left arm outstretched and to the right to the limit of movement;
5. The plane in which the motor action takes place – transversally;
6.Mobee Med gyroscope position – the outer part of the arm;
7. The position of the researcher in relation to the examined athlete – on the same side of the arm.

Horizontal abduction of the shoulder (the movement of the arm away from the midline of the trunk in the transverse plane)
1. Reference values (values considered normal by different researchers):
   - 130^0 David J. Magee;
   - Mobee Med 60^0 active.
2. Initial position (P.I.) – Standing (orthostatism), left arm outstretched laterally (in 900 abduction position), palm facing forward;
3. Motor action (AM) – Bringing the left arm outstretched backwards;

4. Final position (P.F.) – the athlete in orthostatism will complete the movement reaching with the left arm extended backwards to the limit of movement;
5. The plane in which the motor action takes place – transversally;
6.Mobee Med gyroscope position – outer part of the arm;
7. The position of the researcher in relation to the examined athlete – on the same side of the arm.

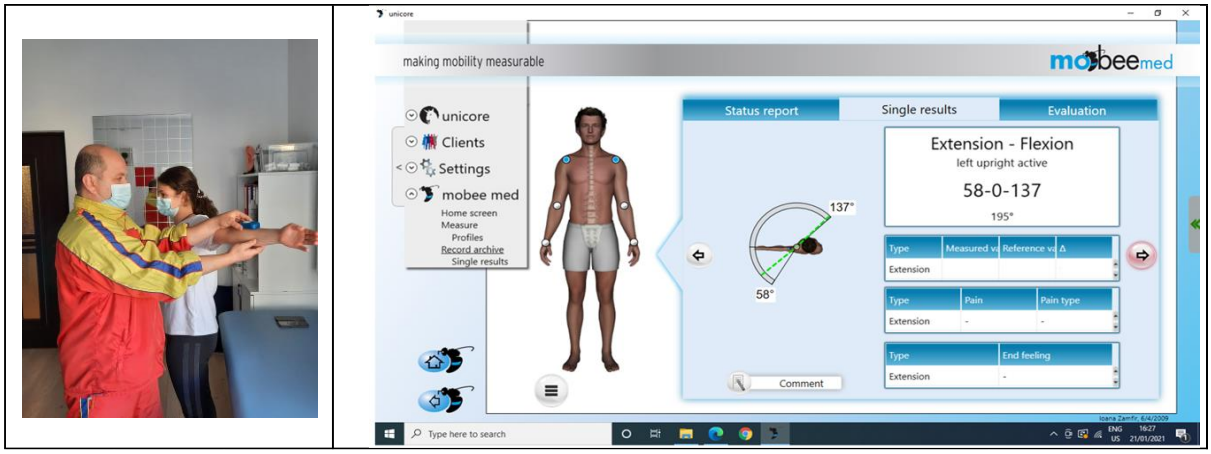


Figure 5.Horizontal abduction and adduction of the shoulder

Shoulder abduction in the frontal plane (moving the arm away from the trunk)
1. Reference values (values considered normal by different researchers):
   - 180^0 Mircea Chiriac;
   - $170\text{-}180^0$ David J. Magee;
   - 180^0 Tudor Sbenghe;
   - Mobee Med 180^0 active.
2. Initial position (I.P.) – Standing (orthostatism), arms next to the body (in anatomical/neutral position), palm turned outwards;
3. Motor action (MA) – Bringing the left arm through the upper side;
4. Final position (F.P.) – the athlete in orthostatism will complete the movement by reaching with the left arm extended next to the ear;
5. The plane in which the motor action takes place - frontal;
6.Mobee Med gyroscope position – outer part of the arm;
7. The position of the researcher in relation to the examined athlete – on the same side of the arm.

Shoulder adduction in the frontal plane (movement bringing the arm closer to the trunk)
1. Reference values Mobee Med: 20^0 active. By studying the specialized literature, we realized that real adduction is impossible to achieve due to the trunk; we can associate shoulder adduction with its flexion or extension ($50^0\text{-}75^0$ Magee); however, in order to be able to measure the adduction movement, we considered the position of the arm at an angle of 10^0, in the sagittal plane, as the initial position;
2. Initial position (I.P.) – Standing (orthostatism), left arm next to the body (at 10 degrees in the sagittal plane), palm turned outwards;
3. Motor action (MA) – Bringing the left arm in front of the trunk and to the right;
4. Final position (F.P.) – the athlete in orthostatism will complete the movement by reaching the limit of movement with the left arm extended to the right;
5. The plane in which the motor action takes place - frontal;
6.Mobee Med gyroscope position – outer part of the arm;
7. The position of the researcher in relation to the examined athlete – on the same side of the arm.

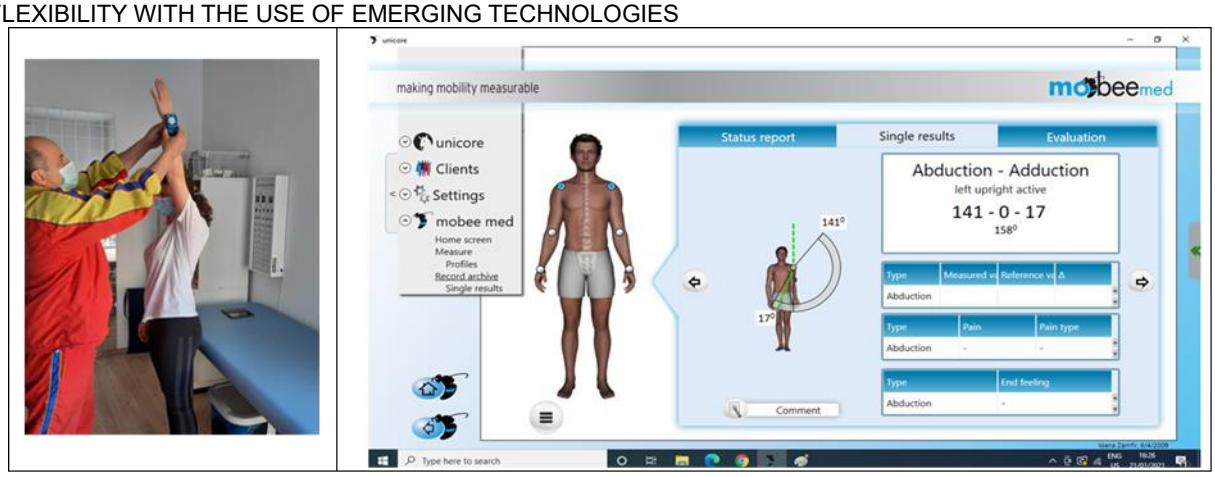


Figure 6.Shoulder adduction and abduction in the frontal plane

External shoulder rotation (movement around a vertical axis)
1. Reference values (values considered normal by different researchers):
   - 80^0-90^0 Mircea Chiriac;
   - 80^0-90^0 David J. Magee;
   - Mobee Med 90^0 active.
2. Initial position (I.P.) – Standing (orthostatism) with the left arm in flexion and abduction of 900, palm facing the ground;
3. Motor action (MA) – Bringing the left forearm forward and up;
4. Final position (F.P.) – the athlete in orthostatism will complete the movement reaching with the tips of the fingers up, keeping the flexion of 90^0, until the limit of movement;
5. The plane in which the motor action takes place - sagittal;
6. Position of the Mobee Med gyroscope – the outer part of the forearm;
7. The researcher's position towards the examined athlete – before the tested member.

Internal rotation of the shoulder (movement around a vertical axis, axis which will pass through the middle of the humeral head)
1. Reference values (values considered normal by different researchers):
   - 80^0-90^0 Mircea Chiriac;
   - 60^0 -100^0 David J. Magee;
   - Mobee Med 95^0 active.
2. Initial position (I.P) – Standing (orthostatism) with the left arm in flexion and abduction of 90^0, palm facing the ground;
3. Motor action (MA) – Bringing down the left forearm;
4. Final position (F.P) – the athlete in orthostatism will complete the movement reaching with the tips of the fingers down, keeping the flexion of 900, until the limit of movement;
5. The plane in which the motor action takes place - sagittal;
6. Position of the Mobee Med gyroscope – the outer part of the forearm;
7. The researcher's position towards the examined athlete – before the tested member.

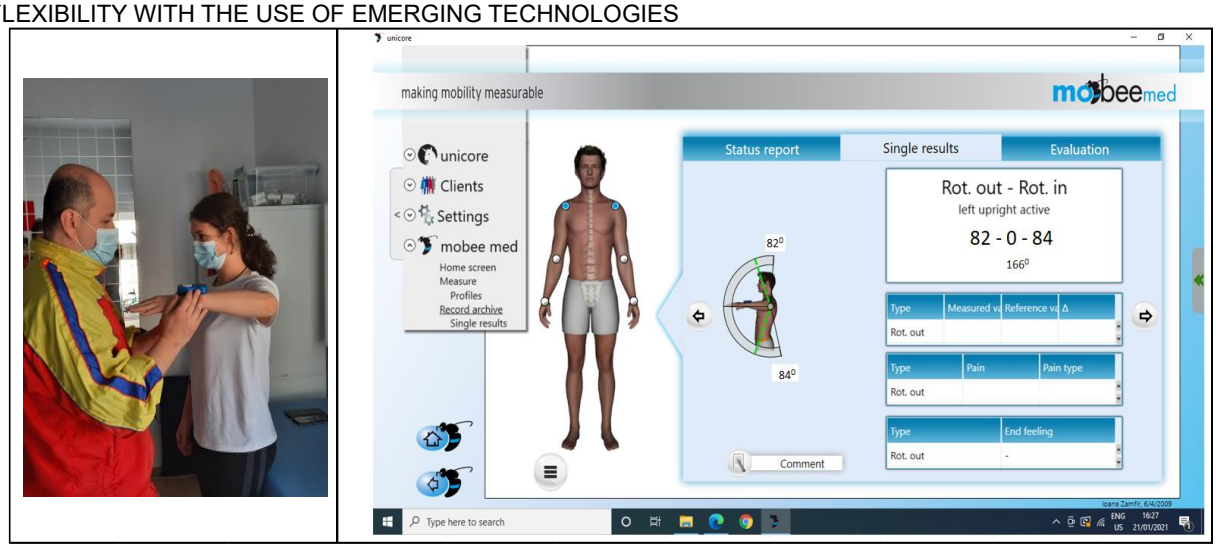


Figure 7.Internal and external rotation

Note: measurements for spine joint, upper and lower limb joint, acetabulofemoral joint can be analysed in PhD thesis.

8.2. Measuring dynamic flexibility

Control samples

1. Forward bringing of the outstretched leg

I.P. – Sitting, right arm stretched forward;
MA – The right leg is brought forward.
Methodical indications:
The trunk is straight. The leg that goes forward must be perfectly extended. By using the hand as a target raised at different levels progress can be assessed. Flexibility was also measured for the other leg.

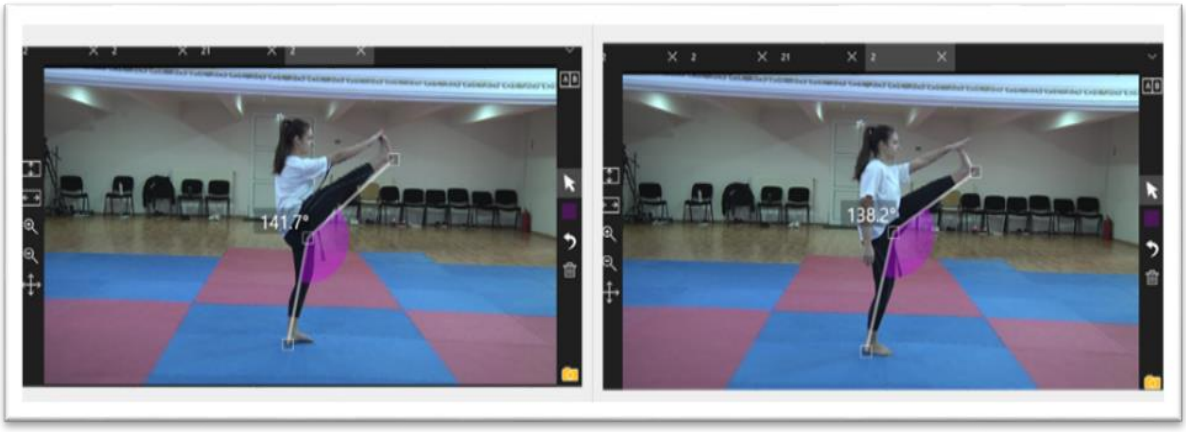


Figure 8.Forward bringing of the outstretched leg

Abbreviations: I.P. Initial position; M.A. Motor action

2. Taking the outstretched leg to the side

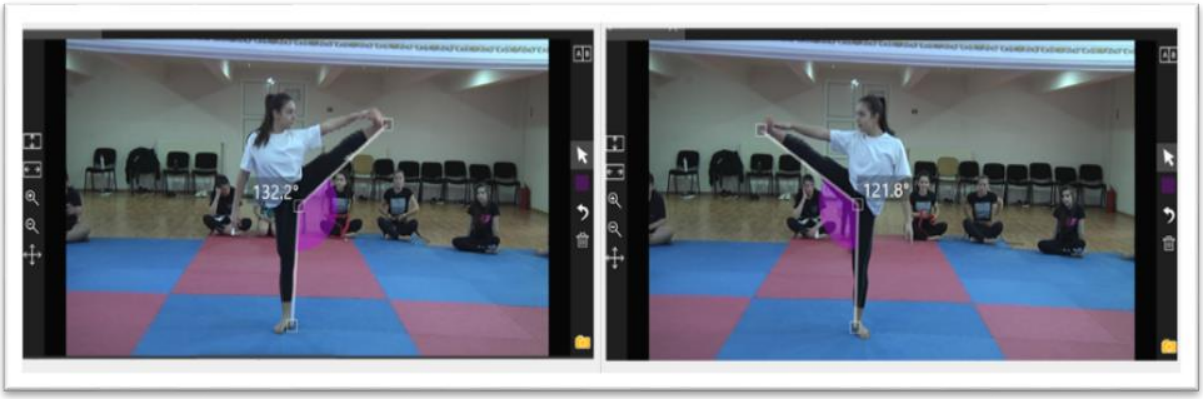


Figure 9.Taking the outstretched leg to the side

I.P. – Sitting, right arm extended to the side;
MA – The lateral right leg is carried out.
Methodical indications
This exercise is specific for a KARATE-KA. The sole of the foot that goes laterally is oriented with the toes in the extension of the SOKUTO ("sword of the foot" or the outer part of the foot), and contact with the palm is made through the side of the foot. Exercise is repeated for the right leg.

8.2.1 Measurement of dynamic flexibility specific to shotokan karate foot techniques

Control samples
1. Mae Geri
I.P. – Standing (Hachiji – Dachi)
MA – The outstretched leg goes forward, performing the Mae Geri technique (direct kick with the forward leg). Flexibility was also measured for the other leg.

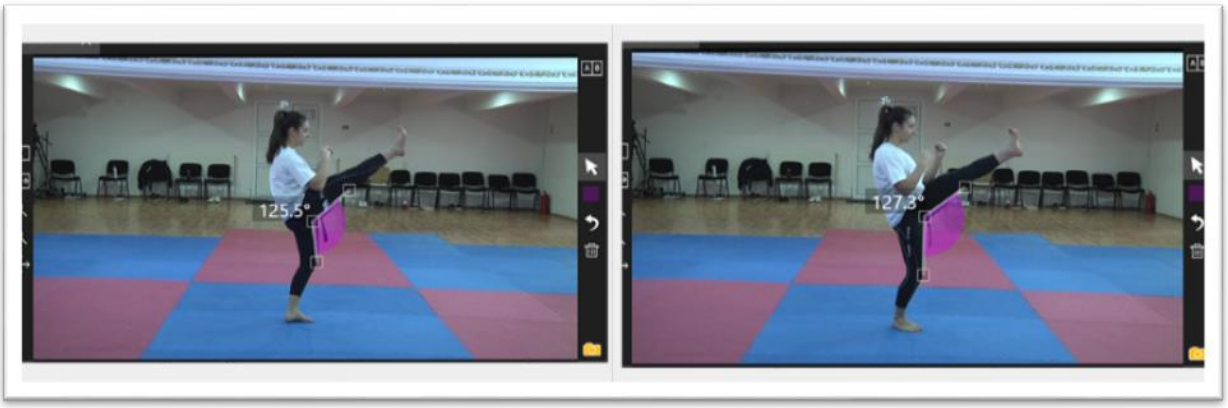


Figure 10.Mae Geri (direct forward kick)

Abbreviations: I.P. Initial position; M.A. Motor action

2. Yoko Geri
I.P. – Sitting (Hachiji – Dachi),
MA - The leg goes to the side performing the Yoko Geri technique (kick with the side leg). Flexibility was also measured for the other leg.

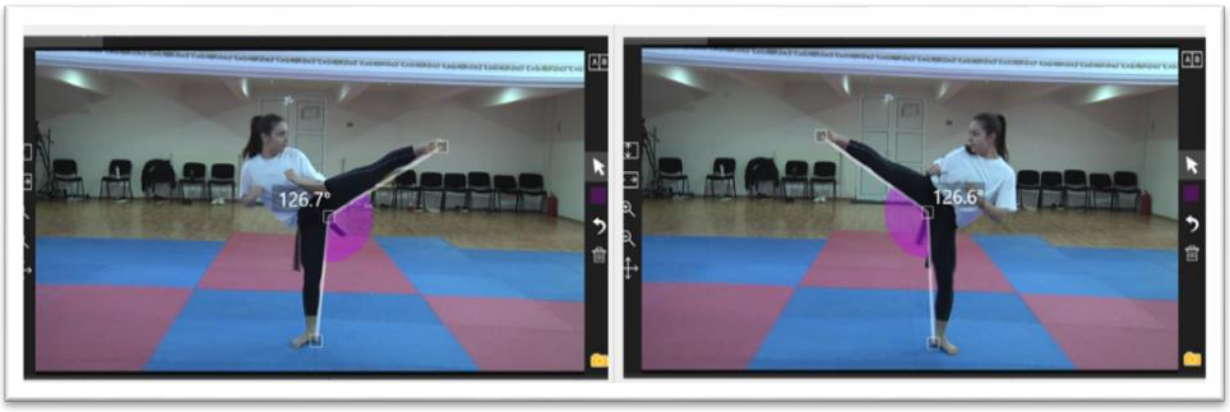


Figure 11.Yoko Geri (side kick)

Abbreviations: I.P. Initial position; M.A. Motor action

3. Mawashi Geri
I.P. – Standing (Hachiji – Dachi)
MA – The semicircular leg goes (as high as possible), executing the Mawashi Geri technique (kicking with the leg following a circular trajectory). Flexibility was also measured for the other leg.

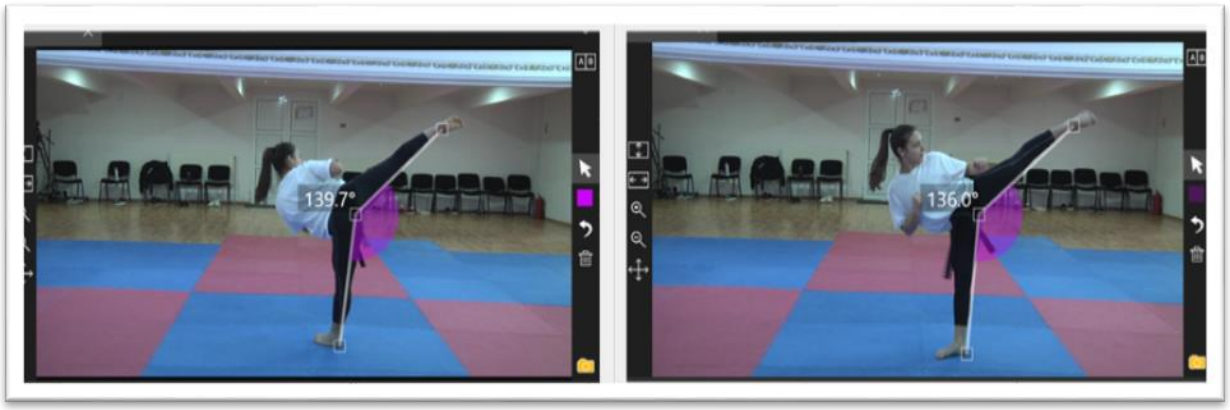


Figure 12.Mawashi Geri (Circular kick)

Abbreviations: I.P. Initial position; M.A. Motor action

4.Ushiro Geri
I.P. – Standing (Hachiji – Dachi)
MA – The leg is taken backward by executing the Ushiro Geri technique (direct kick with the backward leg). Flexibility was also measured for the other leg.

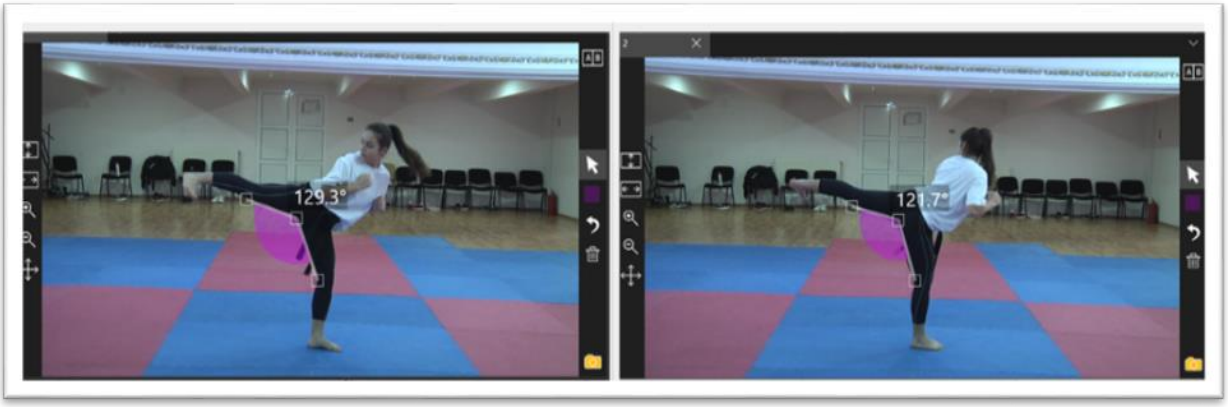


Figure 13.Ushiro Geri (direct back kick)

8.3. Collection, processing, graphic representation and interpretation of data obtained from the measurement of static and dynamic flexibility with the related software (Mobee Med and Dartfish 360 S)

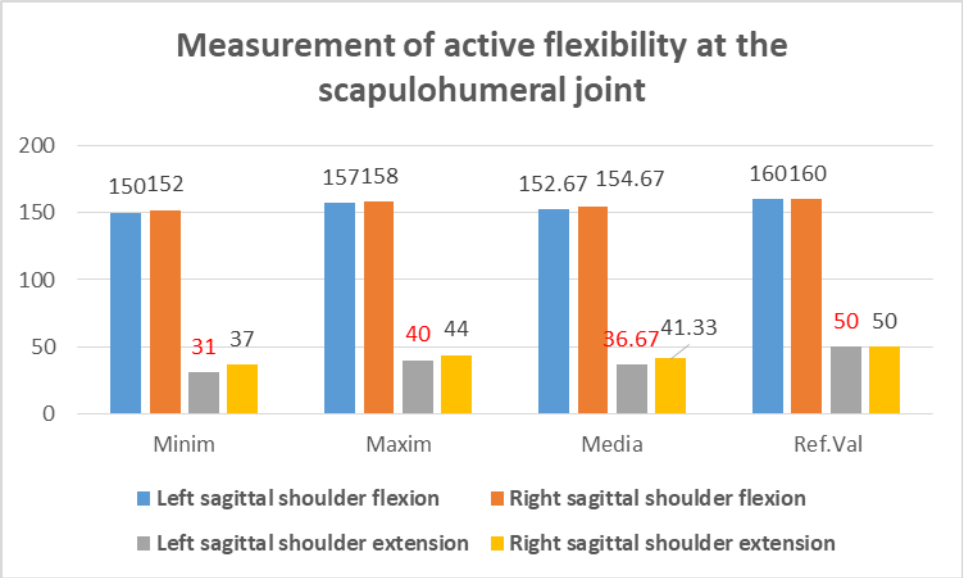


Figure 14.Flexion-extension at the scapulohumeral joint

When the flexion movement is performed at the level of the scapulohumeral joint (Figure no. 5. lifting the outstretched arm forward up), the main muscles involved will be the biceps brachii, the coracobrachialis and the anterior deltoid, and the accessory muscles involved will be the subscapularis and the anterior deltoid. In extension, the accessory muscles are the subspinous and teres minor, and the main muscles involved in joint mobility are the deltoid, teres major, latissimus dorsi, and the long head of the triceps brachii.

From graph no. 57, it can be seen that both in the case of flexion and extension, average angular values were recorded below the reference values proposed by the manufacturers of the Mobee Med equipment. In flexion 152.67^0 left-154.67^0 right against 160^0 reference value, and in extension 36.67^0left -41.33^0 right against 50^0 Mobee Med reference value. The mobility deficit in flexion is 7.33^0left -5.33^0 right, and in terms of extension 13.33^0 left -8.67^0 right, because in both actions (flexion-extension) the main and accessory muscles show reduced flexibility.

In the case of the preliminary group, after affecting the t-test for the one-sample mean compared to the reference value of 160 for shoulder flexion in the sagittal plane, because $t = -3.355$, $p = 0.079 > \alpha = 0.05$ (left shoulder flexion); $t = -3.024$, $p = 0.094 > \alpha = 0.05$ (right shoulder flexion) and taking into account that the limits of the confidence interval for the difference between the

sample mean and the reference value contain the value zero it follows that there are no statistically significant differences between the group mean and the reference value, for both the left and right sides. However, we note that the reference value is higher by 4.89% compared to the group average in the case of the left shoulder and by 3.45% in the case of the right shoulder.

Table 5.Descriptive statistics for the preliminary group regarding the assessment of extension at the level of the scapulohumeral joint

T-test for a sample average

Variables	Test value = 50					
	t	df (N-1)	Probability p Sig. (2-tailed)	Difference between average and test value	95 % confidence interval of the average difference	
					Inferior limit	Superior limit
Shoulder extension in the left sagittal plane	-4.682	2	0.043	-13.333	-25.59	-1.08
Shoulder extension in the right sagittal plane	-3.965	2	0.058	-8.667	-18.07	0.74

Regarding shoulder extension in the sagittal plane after performing the t-test for the mean of a single sample, it resulted that there are significant differences between the test value and the sample mean for the left side ($t = -4.682$, $p = 0.043 < \alpha = 0.05$). The t-test suggests that there are no statistically significant differences for shoulder extension in the right sagittal plane ($t = -3.965$, $p = 0.058 > \alpha = 0.05$). In both cases the test value is higher than the sample average by 36.36% for the left side and by 20.97% for the right side.

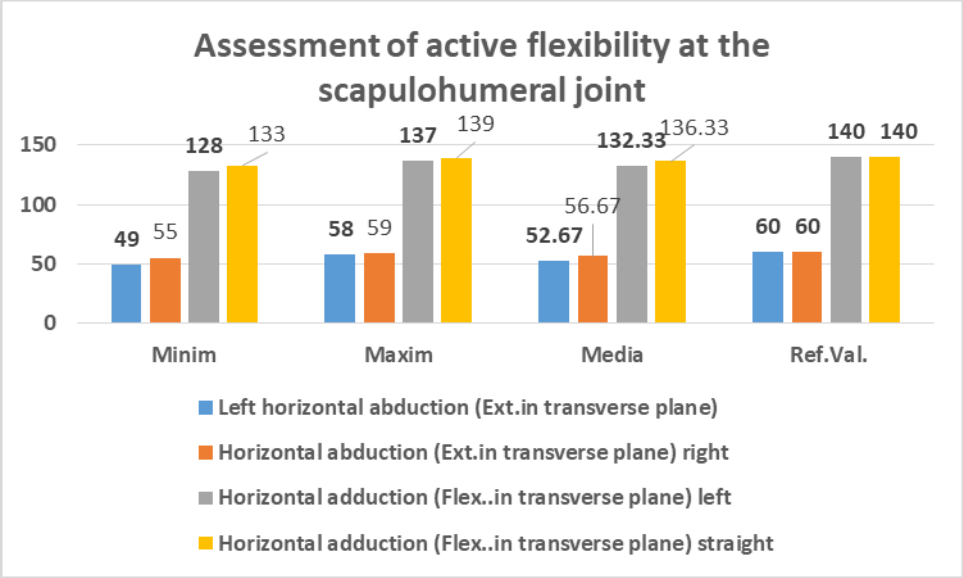


Figure 15.Horizontal abduction-adduction at the level of the scapulohumeral joint

When it comes to the design of the shoulder, adduction in the horizontal plane or adduction in the frontal plane, the pectoral muscle (pectoralis major and pectoralis minor) has a major involvement in making the movement.

From figure nr.15. we can see that the data obtained in the case of horizontal abduction and adduction are not very close to the reference values: horizontal abduction 52.67^0 left -56.67^0 right-60^0 being the reference value; horizontal adduction 132.33^0 left -136.33^0 right -140^0 reference value equipment Mobee Med. We identify a reduced flexibility in the posterior deltoid, subspinous, teres minor, teres major, rhomboid muscles in the case of horizontal abduction, and in terms of horizontal adduction a mobility deficit of 7.67^0 left is observed. and $3,67^0$ right generated by the pectoralis major.

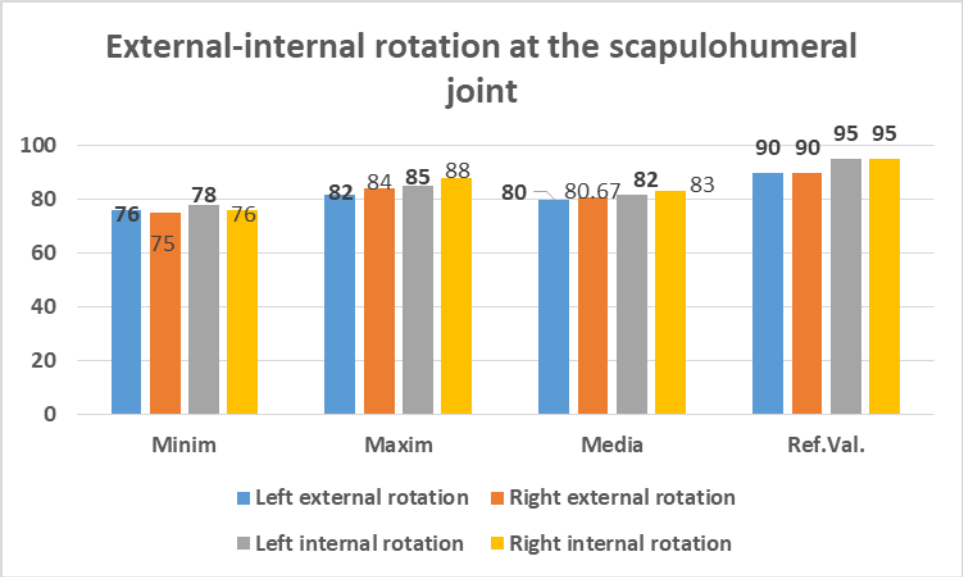


Figure 16.Internal-external rotation at the level of the scapulohumeral joint

From graph no. 60 we can see that the average values obtained by the examined athletes, both in the case of external rotation and in the case of internal rotation, present for both arms angular values below the reference values indicated by the Mobee Med equipment: external rotation 80^0 left -80.67^0 right versus 90^0 reference value and internal rotation 82^0 left -83^0 right versus 95^0 reference value. In the case of external rotation, the mobility deficit, generated by the subspinous, posterior deltoid and teres minor muscles, is 10^0 on the left side, and $9,33^0$ on the right side. In internal rotation, the pectoralis major, latissimus dorsi, and teres major muscles registered a deficit of 13^0 degrees on the left side and 12^0 degrees on the right side.
Note: for the other joints the collection, processing, graphical representation and interpretation of the data obtained from the measurement of static and dynamic flexibility with the related software (Mobee Med and Dartfish 360 S) can be followed in the doctoral thesis.

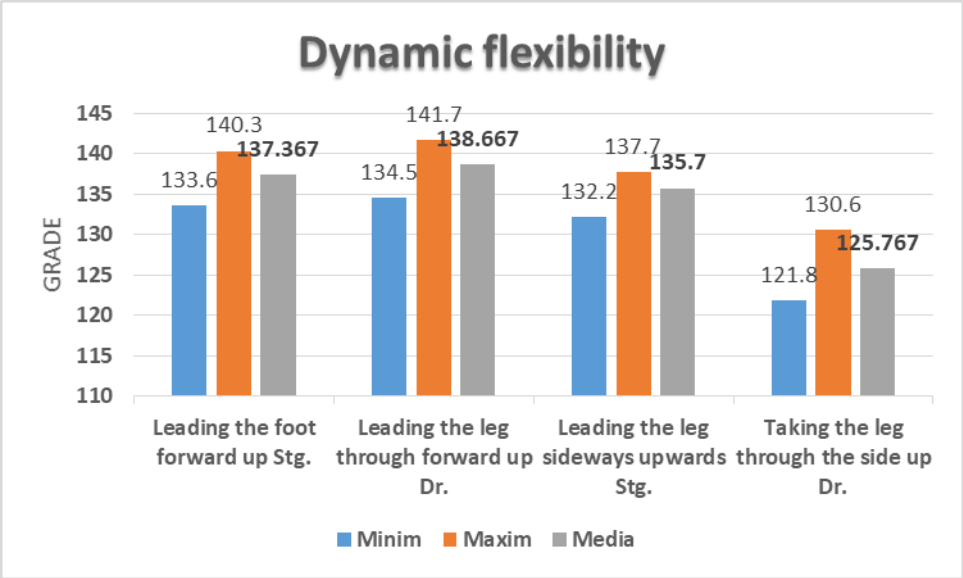


Figure 17.Assessment of dynamic flexibility

From figure no.17. in the case of abduction of the left lower limb, in the sagittal plane, a flexibility deficit between the minimum value recorded and the maximum value of 6.7^0 is observed, and in the case of the right lower limb a deficit of 7.2^0 is recorded. The lack of flexibility is generated by the entire compartment of the posterior compartment: the gluteus maximus muscle (stiff gluteus maximus means a stiff back), biceps femoris, semitendinosus and semimembranosus (muscles which, through their rigidity, can pull the pelvis back into retroversion and create a straightness at the lumbar level, i.e. a herniated intervertebral disc), the internal – external gastrocnemius muscle and the soleus muscle. There are no significant differences between the average values obtained by the group (137.36^0 left -138.66^0 right).

In abduction in the frontal plane (taking the leg outstretched laterally) the average values obtained were 135.7^0 left-125.76^0 right. On the right side there is a large deficit of flexibility of 10^0 registered mainly by the stiffness of the muscles of the inner thigh: adductor (large, short, long), gracilis and pectineus.

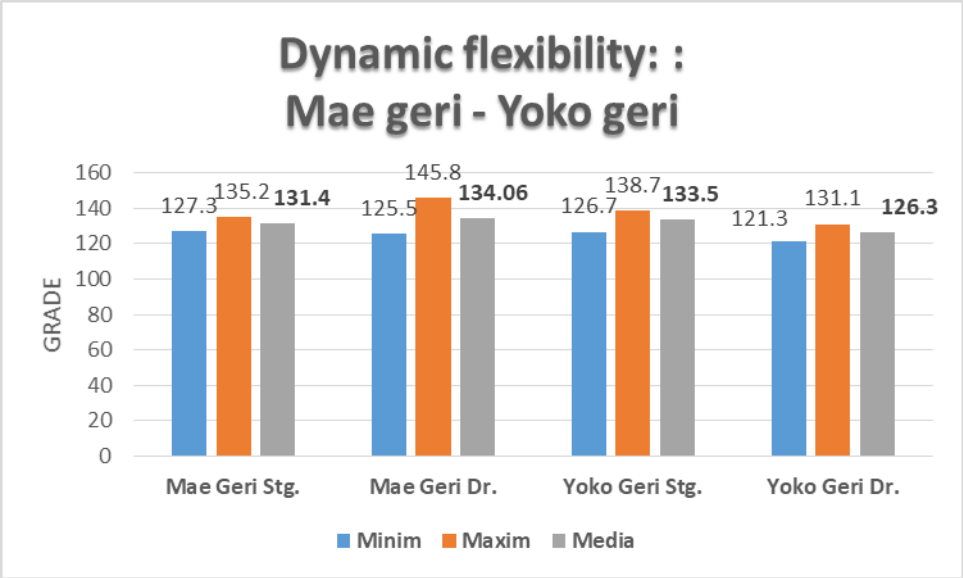


Figure 18.Technique specific flexibility assessment by Mae Geri and Yoko Geri

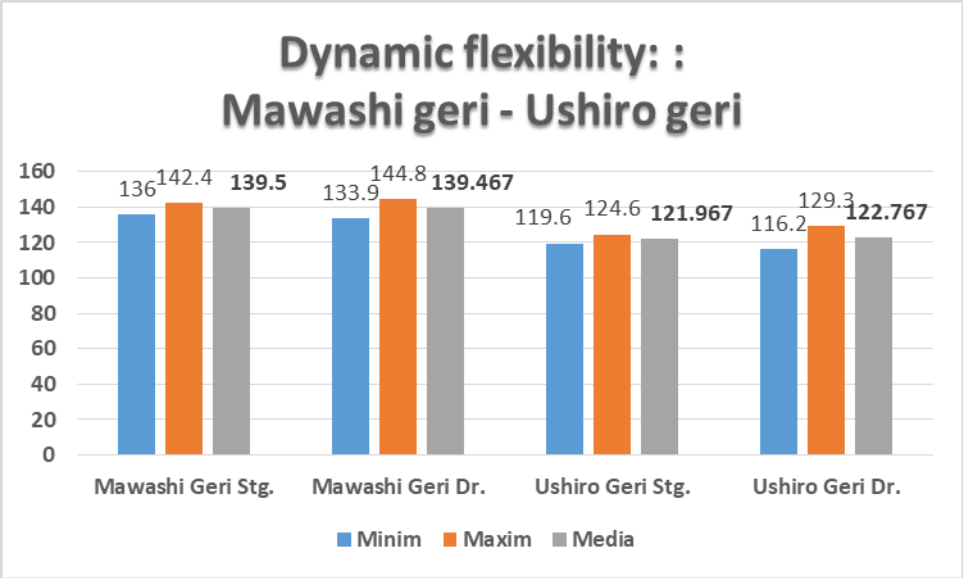


Figure 19.Evaluation of flexibility specific to Mawashi Geri and Ushiro Geri techniques

For the dynamic flexibility, specific to shotokan karate foot techniques, only executions that did not distort the technique were evaluated, observing for each kick the arming, the trajectory, the point of impact and the return to the initial position.
Since the initial position was Hachiji – Dachi (sitting, legs close together in semiflexion, center of gravity low) markers were attached on the pubic symphysis and knees. The flexibility in the case of the Mae Geri technique shows, according to figure no 18, a small difference of 3^0 between the two executions generated by the muscles on the back of the left leg, for the Yoko Geri technique the flexibility deficit is 7.2^0, at Mawashi Geri, according to figure no. 19, the differences between the means are not significant, and in Ushiro Geri the execution with the left leg registers a very small deficit of flexibility due to the reduced flexibility of the accessory muscles but also of the muscles on the back side of the supporting leg.

8.4. Postural analysis with the Posturotest equipment (Sensor Medica 2020) for the assessment of physical deficiencies

This methodology of postural analysis was used because in the process of selecting the subjects, who will participate in the actual (fundamental) research, it will facilitate the identification of athletes who do not present physical deficiencies and who are fit from a postural point of view to complete a program of flexibility development in order to improve sports performance and implicitly the quality of life.

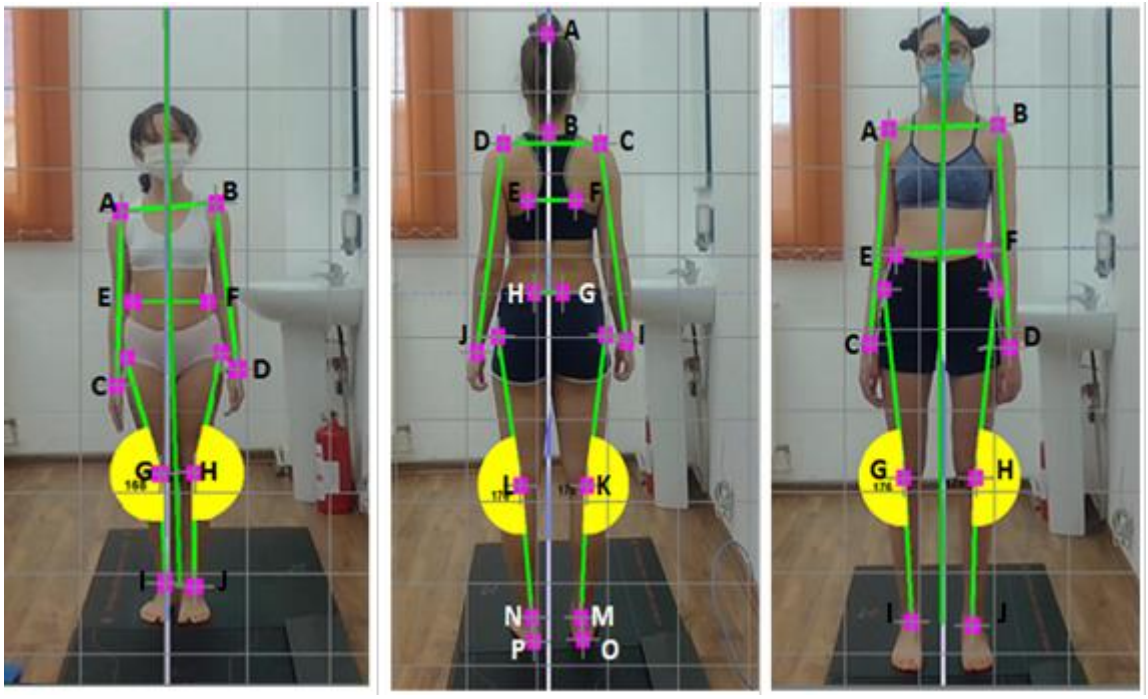


Figure 20.Postural analysis of the three subjects using images (Freestep)

A - view from the front; B – rear view; C - view from the front (A=C)

Table 6.The angular value of the postural attitude of the subjects in the frontal plane (anterior and posterior view) obtained with the Sensor Medica 2020 equipment

Nr.crt	Analysis of the anatomical benchmark	Angular values
A 1.B.C.M.	Shoulder inclination (v.a.)	5° left ^
	Pelvis inclination (v.a.)	0
	Scapular inclination (v.p.)	2° left ^
	S.I.P.S inclination (v.p)	0^0
B 2.P.D.C.	Shoulder inclination (v.a.)	0^0
	Pelvis inclination (v.a.)	0^0
	Scapular inclination (v.p.)	0^0
	S.I.P.S inclination (v.p)	0^0
C 3.G.M.	Shoulder inclination (v.a.)	2° left ^
	Pelvis inclination (v.a.)	2^0
	Scapular inclination (v.p.)	0^0
	S.I.P.S inclination (v.p)	0^0

From Figure no. 20 one can observe, in the case of the athlete B.C.M., a tilting in the trunk by 50 and in the scapula by 20 to the right, generating a scoliotic attitude. The joint of the right hand is asymmetric, lower, and at the level of the right anterior-superior iliac spine and the left anterior-superior iliac spine there are no changes. The manifested postural deficiency does not recommend her to complete the flexibility development program proposed for fundamental research.

The other two athletes, P.D.C. and GM, present normal values (the reference values indicated by Sensor Medica are between 00-20 for each characteristic or anatomical landmark analysed) and meet the conditions, from a postural point of view, to participate in the flexibility development program within the actual research or fundamentals

CHAPTER 9. THE CONCLUSIONS OF THE PRELIMINARY RESEARCH

From the perspective of martial arts, flexibility is an indispensable quality in the direction of practicing Shotokan Karate-do. This intermediate motor quality involves increasing the amplitude of movements at the level of body joints (scapulohumeral, at the level of the upper limbs, of the spine, acetabulofemoral and at the level of the joints of the lower limbs).
Both attack and defence techniques (blockages), performed statically or in evolution (dynamically), place intense stress on the joints of the body (anatomical joints). For this reason, in the framework of the preliminary research, the flexibility of the most important joints was methodically evaluated in order to have an overview of their capacity, and on the basis of the analysis of the obtained results to propose, in the context of the actual (fundamental) research, an original program for the development of the flexibility of Shotokan karate practitioners (cadets and juniors) consisting of methodically staggered action systems, carefully selected on the basis of a basic training in physical therapy and gymnastics, in order to improve sports performance, and implicitly the quality of life of the practitioners.
At the level of the scapulohumeral joint, the evaluated actions were those of flexion, extension, horizontal and frontal abduction-adduction, internal and external rotation of the shoulder. Among the techniques that place intense demands on this joint and on which the execution performance depends, we mention: age uke (flexion), soto uke in the arming phase and ushiro empi (extension), shuto uke in the arming phase (horizontal adduction), haiwan uke (external rotation).
The cervical area of the spine is very stressed in kata tests by the sudden movement of the head towards the directions (axes) of movement, but also in kumite tests (fighting with a real opponent) when it is required to constantly follow the partner's attacking actions of competition. The dorsolumbar region is activated both in block and in attack techniques (hanmi-gyaku trunk twist).
The joints of the upper limbs are involved in the arming stage of various blocks (flexion: age uke, soto uke, shuto uke, gedan barai, etc.), in the execution of attack techniques (extension: uraken technique) but also in the phase of interception of the attack and deflection of it to the inside or outside (supination - uchi uke, pronation - soto uke).
In the case of the coxofemoral joint, the demands are mostly determined by the execution of the leg techniques (abduction - yoko geri, hip flexion - arming phase of the mae geri technique, extension - ushiro geri, internal rotation - yoko geri kekomi). Transverse twists of the hips are acted upon when performing blocks, gyaku tsuki, kizami tsuki, etc.
The techniques that require the actions of flexion at the level of the lower limb are mae geri, and mawashi geri (arming phase); extension - yoko geri, ushiro geri, mae geri, mawashi geri (final moment of execution); dorsiflexion at ankle level - kakato geri technique; plantar flexion - haisoku kick; inversion - the kick with the foot in the yoko geri keage technique; adduction - taisoku mawashi soto keage technique.
Before increasing the range of motion in the joints, it is imperative that athletes have information about the bone structures, muscles and elements that give stability to a joint. Subjects must be aware of joint functionality. That's why we propose to insert into the flexibility development program, which we will implement in the actual research, theoretical presentations so that the athletes understand that the methods and procedures of flexibility education are based on a sequence of physical and biomechanical laws. Developing the flexibility of cadets and juniors does not happen by accident. The actions performed must be methodically staggered and they also must obey anatomically determined motor laws.
In the preliminary scientific approach, the hypotheses formulated as follows were verified and confirmed:
1. Following the application of the survey based on an opinion questionnaire, to the 48 specialists in the Shotokan Karate field, a series of conclusions were drawn that highlight the importance and necessity of developing a methodology for measuring, evaluating and improving static and dynamic flexibility at cadets and juniors as follows:

- the need to measure flexibility in order to know the degree of development at the level of the joints;

- the transition from the classic means of measuring flexibility to the use of emerging technologies thus emphasizing the need to digitize the assessment of the flexibility of athletes to increase the accuracy of the measurement;
- the need for a program to develop the flexibility of Shotokan karate athletes, an aspect that must be well planned as an integral and constant part of sports training;
- flexibility is a very important element for the quality of technical executions;
- dynamic flexibility is an important benchmark for reducing the execution time of strikes;
- there is a direct relation of conditionality between the flexibility of the athletes and the quality of the results obtained in the kata and kumite competitions;
- dynamic flexibility conditions both the number of points obtained with blows of the upper limbs and the number of points obtained with blows of the lower limbs;
- the development of flexibility determines an increase in the quality of life both in sports activity and in everyday life.

2. Measurement using the Mobee Med computerized system:

The use of emerging technologies (laboratory equipment) at this stage provided us with reliable data in relation to the possibility of tracking progress in all selected joints. We consider it necessary to transition from the classic means and methods of measuring and evaluating flexibility to the use of emerging technologies, since the classic tools in certain contexts present considerable limits. One such example would be the protractor. According to Balint&Diaconu, et al, (2007), despite the fact that they are very convenient, they can generate numerous errors in the estimation of angular values, especially if the calibration was not correctly performed. Avramescu (2006) claimed that a big disadvantage of the goniometer is that it appreciates the angular value of the movement amplitude only in one plane, while joint actions are performed simultaneously in several planes. At the level of the knee joint, flexion is accompanied by internal rotation and extension by external rotation of the calf, and this handicap can be overlooked when the evaluation is done with the help of the goniometer. For other bone segments, the resultant of combined actions in several planes cannot be overlooked. For example, eversion and inversion movements are impossible to measure with the goniometer because it is necessary to measure the range of motion from the ankle level in three directions.

These limits are virtually nullified with the Mobee Med equipment selected at this preliminary stage. Featuring a sensitive, 3-sensor technology, it allows incredible accuracy to measure the range of motion at the body's joints in the three planes. Accuracy in measurement, instant display of measured angular values and automatic comparison of these values with normative range values justify the use of Mobee Med as a macro-level flexibility measurement tool in actual research.

3. Using the 360 S software

To measure dynamic flexibility, the Dartfish 360s software was selected, which allows video recording of dynamic executions, and with the help of the tools within the software, markers can be attached to the joints that want to be evaluated. Video analysis that can be stopped, fragmented when playing dynamic runs, as well as measuring intersegmental angles and automatic trajectory tracking make Dartfish a reliable tool for measuring dynamic flexibility in the context of actual (fundamental) research.

Although karate coaches state that the development of flexibility leads to a qualitative execution of techniques, this is only found at a theoretical level in the specialized literature (Scopus, Web of Science, Google Scholar J-Gate and ReseachGate, doctoral theses as well as the Faculty of Physical Education and Sport’s library from Galati and UNEFF’s from Bucharest, etc.) For this reason, we propose to demonstrate from a practical point of view the influence of flexibility on technical executions in fundamental research. We propose that in the fundamental experiment the evaluation of the executions of the foot techniques be carried out with the help of the federal referees.

We also propose to analyse in the fundamental approach the impact of flexibility on sports results in kata and kumite competitions, but also to what extent the development of static and dynamic flexibility influences the execution time and the number of points obtained with the upper and lower limbs.

Thus, we consider as novelty and innovation in our research in the implementation of emerging technologies in the measurement of flexibility (the first use in Romania of the Mobee Med

computerized equipment for measuring static flexibility) and we bring added value to our fundamental approach through this new strategy to analyse and approach static flexibility and dynamics.

The selection of subjects in the next stage will be done with the Posturotest equipment (Sensor Medica 2020) which in the preliminary phase helped us to create an overview regarding the assessment of postural deficiencies. The necessary condition for the athletes to be part of the experimental group is to be healthy from an osteo-muscular point of view. There will be a triage of the athletes because the research within the doctoral thesis is not focused on the correction of postural deficiencies but on the development of flexibility and the reduction of the deficit of mobility from the muscular level, where it is registered, in order to improve the sports performance and the quality of life of cadets and juniors practicing Shotokan karate do.

PART II. CONTRIBUTIONS TO IMPROVING SHOTOKAN KARATE PERFORMANCE THROUGH DEVELOPMENT OF FLEXIBILITY IN CADETS AND JUNIORS

CHAPTER 10. THE OPERATIONAL FRAMEWORK OF FUNDAMENTAL RESEARCH

10.1. The premises of the research

Knowing that flexibility manifests itself in the learning of motor skills by reducing the time interval for their acquisition when it is adequately improved, but also the fact that a high degree of flexibility leads to an increase in the efficiency and economy of movement, we will be able to implement an original program for the development of flexibility in order to achieve sports performance, as well as new methodologies for measuring and evaluating flexibility using emerging technologies.

10.2. The purpose of the research

We want to demonstrate that by designing and implementing a flexibility improvement program we can increase the quality of technical executions and also achieve outstanding performance in both kata and kumite competitions.
It is known that in kumite matches most of the points are scored with the upper limbs. By properly developing the flexibility of the lower limbs, reducing the deficit of left-right mobility, we will be able to considerably increase the number of points obtained with the lower limbs, increasing the chances of victory for cadets and juniors practicing Shotokan karate.

10.3. Research objectives

- The selection of the club and the athletes who will make up the control group.
- The selection of the club and the athletes who will be part of the experiment group.
- Measuring and evaluating flexibility with the Mobee Med equipment at the level of the scapular joint, upper limbs, spine joint, acetabulofemoral joint and lower limbs.
- The measurement and assessment of dynamic flexibility and specific flexibility of foot techniques in Shotokan karate.
- The analysis of the execution of foot techniques using the DartFish 360 S sensor.
- The evaluation of executions of foot techniques with the help of federal referees.
- Improving static and dynamic flexibility.
- Improving dynamic flexibility by approaching isoinertial training using the emerging DESMOTEC equipment as a specific means.
- Monitoring the points obtained in competitions with the upper and lower limbs by the subjects of the two groups (witness and control).
- Monitoring the results obtained in competitions by the control group and the experimental group before and after completing the original training program focused on the development of flexibility.

10.4. Research hypotheses

- Using emerging technologies (Mobee Med equipment and the Dartfish 360 s sensor) we can obtain accurate and complex data regarding the level of development of the flexibility of the research subjects as well as the quality of the technical executions;
- Flexibility development program adapted to the structure of the sports training lesson and preparation stages can increase sports performance;
- Improving the flexibility of the lower body can increase the number of points obtained with the lower limbs in sports competitions;

10.5. Research tasks

- ✓ Selection of athletes for the experimental group using the Sensor Medica 2020 (Posturotest) equipment.
- ✓ Determination of the control group and the experimental group.
- ✓ Collaboration with the Satori Sports Club and the S.K.D.U.N (Shotokan Karate-Do of United Nations) karate department within the Romanian Martial Arts Federation (FRAM).
- ✓ Initial testing of research subjects using emerging technologies: the Mobee Med equipment and DartFish 360 s sensor.
- ✓ Evaluating the execution of foot techniques using federal referees.
- ✓ Application of the original training program focused on developing flexibility and efficiency of attacking techniques executed with the lower limbs.
- ✓ Intermediate testing of the experimental group.
- ✓ Monitoring the results obtained in competitions by the subjects of the two groups.
- ✓ Monitoring of the points obtained in competitions by the research subjects using upper and lower limbs.
- ✓ Final testing of subjects of the two groups (control and experimental).
- ✓ Drawing conclusions from the fundamental experimental approach.

10.6. Research methods and techniques

The methods used in basic research are those generally accepted but also those particularized according to the topic addressed in the doctoral thesis:

- The bibliographic study method and technique
- The method and technique of pedagogical observation
- The method of conversation
- The hermeneutic method and technique
- The logical method
- The statistical-mathematical method
- The audio-video recording method
- The computer graphics method

CHAPTER 11. THE ORGANIZATION OF THW FUNDAMENTAL RESEARCH

11.1. Place, time, research subjects and collaborators

The experimental research was carried out in: the dojos (training rooms) of the selected sports clubs C.S. Kazumi and C.S. Satori from Focșani, Vrancea County, in the biomechanics laboratory and the physiotherapy clinic within the Faculty of Physical Education and Sport, Dunărea de Jos Galați University and Superfit Medical Center Bucharest. The selection of the experimental group took place between February and March 2021 and was carried out at the Physiotherapy clinic of the Faculty of Physical Education and Sport, Dunărea de Jos Galați University with the support and the guidance of professor dr. Claudiu Mereuță, eng. dr. Daniel Ganea and university assistant Iordan Daniel-Andrei.
The initial testing and the final testing, during which emerging measurement and evaluation tools were used (Mobee Med equipment and the Dartfish 360 s sensor), were carried out at the Superfit Medical Center Bucharest with the support of the teaching staff prof.univ.dr. Claudiu Mereuță and the director of the medical center Dr. Damian Șerban.
The evaluation of the executions of the foot techniques took place in the Sala Polivalentă Hall in Focșani and was carried out with the help of federal referees from the Romanian Martial Arts Federation.
The fundamental experiment corresponding to the progress report number three was carried out during May 2021 when the initial tests took place, the final tests May-June 2022, ending with the drafting stage of the scientific approach.
The fundamental experimental approach was carried out on a group of 40 athletes (cadets and junior Shotokan karate practitioners) divided into two groups (experiment and control) of 20 athletes each.
The experimental group consisted of karatekas registered at the Kazumi Focșani Sports Club, and the control group consisted of athletes from the Satori Focșani Club. The original training program focused on improving the flexibility and efficiency of attack techniques executed with the lower limbs was implemented only for the subjects of the experimental group simultaneously with the physical, technical, tactical, theoretical, psychological training, and the subjects of the control group went through the training program designed by the sensei or their coach.

11.2. The logistics of the fundamental experimental research

In carrying out the actual experimental approach, both means specific to the Shotokan Karate Do discipline were used as well as means characteristic of other disciplines such as medicine, mathematical statistics, computer science with the aim of facilitating the smooth running of the experimental activity but also in the recording, processing and interpretation of data:

- Soft Mobee Med equipment for measuring and evaluating active static flexibility.
- Soft Dartfish 360 s for measuring and evaluating dynamic flexibility but also for analyzing the execution of foot techniques in Shotokan karate.
- Soft Sportdata&GmbH KG 2000-2022 for monitoring points obtained in upper and lower limb competitions; monitoring the results obtained in competitions by the research subjects.
- Sensor Medica 2020 software (Posturotest) for selecting the subjects of the experiment group.
- Emerging DESMOTEC equipment used in isoinertial training to develop dynamic flexibility.
- HP laptop, Windows 10 operating program.
- The Sports Hall from Focșani, Vrancea County.

- Physical Education and Sports Hall of the ‘‘Mareșal Alexandru Averescu’’ Adjud High School, Vrancea County.
- The University Physiotherapy and Medical Rehabilitation Centre within the ‘‘Dunărea de Jos’’ Galati University.
- The Physiotherapy Clinic within the Superfit Medical Clinic Bucharest.

11.3. Selection of the experimental group

In the selection process, the main interest was that the experimental group was composed of healthy athletes from an osteomuscular point of view. In order to be able to fulfil this objective, in the selection stage, we made the decision to evaluate the subjects of the experimental group with the help of the Sensor Medica 2022 equipment that identifies possible postural deficiencies.
The posture analysis was carried out at the Physiotherapy Office within the Faculty of Physical Education and Sport - Dunărea de Jos Galati University. The individuals subjected to the analysis were the cadets and juniors of the Kazumi Sports Club from Focșani. From these, 20 karateka who obtained values between 0-3 degrees for the inclination of the shoulders, scapula, pelvis and iliac spine were selected. These values show us that the subjects are in the green, healthy zone of tolerance of the Posturotest equipment. The exceeding of this zone (00 – 30) would certify that the subjects have postural deficiencies.

CHAPTER 12. THE CONDUCT OF THE FUNDAMENTAL RESEARCH

12.1. Experimental research design

The actual experimental research aimed to use emerging technologies to measure and evaluate flexibility as well as to identify a strategy to improve the flexibility of cadets and juniors by implementing a stretching program in parallel with physical, technical-tactical, theoretical and psychological training.
The scientific approach was carried out for the entire duration of a competitive year. We mention the fact that series of competitions and tournaments have been taken out from the competitive calendar because of the COVID 19 pandemic. In order to have the experimental group in full formation throughout the competitive season, we took the decision to participate only in competitions where there were no mandatory vaccination and testing criteria, given the reluctance of the athletes' parents towards these medical criteria. The selected competitions were those in which the athletes' participation was conditional on completing a COVID 19 questionnaire: Satori Cup, Kazumi Cup and Takeshi Cup – Bucharest.
To improve flexibility, elements specific to the Shotokan Karate Do discipline were used with an emphasis on influencing the degree of flexibility at the level of the scapulohumeral joints, spine, but also on the development of flexibility specific to the foot techniques mae geri, mawashi geri, yoko geri, ushiro geri.
The tests for measuring and evaluating the static, dynamic and specific flexibility of the Shotokan karate foot techniques had the mission of highlighting relational aspects and values that can be capitalized in our own research focused on improving performance by improving flexibility using emerging technologies.

12.2. Initial testing of research subjects

This stage consisted of a series of evaluations aimed at establishing the initial research data both within the experimental group and within the control group. The collected data offered the possibility to compare the initial level but also to adopt the most suitable strategies for developing flexibility in order to improve sports performance.

12.2.1. Measuring static flexibility with the Mobee Med equipment

Within these evaluations, flexibility was measured in the two groups as follows:

- At the level of the scapulohumeral joint
    - Shoulder flexion
    - Shoulder extension
    - Horizontal shoulder adduction
    - Horizontal shoulder abduction
    - Abduction of the shoulder in the frontal plane
    - Shoulder adduction in the frontal plane
    - External rotation of the shoulder
    - Internal rotation of the shoulder
- The assessment of the active flexibility of the upper limbs
    - Flexion of the upper limb
    - Extension of the upper limb
    - Supination
    - Pronation
- Hand articulation
    - Flexion

  - Extension
  - Radial inclination
  - Ulnar inclination
- The assessment of active flexibility in the spine (Cervical area)
  - Flexion
  - Extension
  - Side bending of the head
  - Head turning

- The evaluation of active flexibility at the spine level (Dors-lumbar area)
  - Flexion
  - Extension
  - Lateral bending of the trunk
  - Twisting the trunk
- The assessment of active flexibility at the acetabulofemoral joint level
  - Hip flexion
  - Hip extension
  - Hip abduction
  - Hip adduction
  - External rotation of the hip
  - Internal rotation of the hip
- The assessment of active flexibility at the joint level of the lower limbs
  - Flexion
  - Extension

- The evaluation of active flexibility in the ankle joint
  - Dorsal flexion
  - Plantar flexion
  - Eversion
  - Inversion

12.2.2. Measuring dynamic flexibility using the DartFish 360 s sensor

In the case of dynamic flexibility, the following control samples were used:
- bringing the leg forward-up
- taking the leg up from the side

We mention the fact that in both control samples the markers were fixed on the pubic symphysis and calcaneus.

12.2.3. Measuring dynamic flexibility specific to foot techniques with the DartFish 360 s sensor

Regarding the dynamic flexibility specific to the Shotokan karate do foot techniques, the control samples consisted of the execution:
- Mae Geri (kick with the forward leg) – the markers were fixed on the pubic symphysis and the knee;
- Mawashi Geri (semi-circular kick) - the markers were centred on the calcaneus and pubic symphysis;
- Yoko Geri (side kick) - markers were attached on the pubic symphysis and calcaneus;
- Ushiro Geri (back kick) markers attaching to symphysis pubis and knee.

12.2.4. Analysis of footwork execution using the DartFish 360 s sensor

- Analysis made with Dartfish 360 s of the execution of the Mae Geri leg technique – Starting position and arming
    - Initial position Zenkutsu Dachi (straight forward)
    - Arm - The angle between the torso and the thigh
    - Arm - Thigh-calf angle
    - Reinforcement - The angle between the foot and the calf

- Dartfish 360 S Analysis of Mae Geri's Leg Execution - Trajectory and Completion
    - End of execution - The angle between the trunk and the thigh
    - The end of the execution - The angle between the thigh and calf
    - End of execution - The angle between the foot and the calf
    - Total technical execution time

- Dartfish 360 S analysis of the execution of the Mawashi Geri leg technique - Starting position and arming
    - Starting position Zenkutsu Dachi (left forward)
    - Starting position Zenkutsu Dachi (straight forward)
    - Arm - The angle between the torso and the thigh
    - Arm - Thigh-calf angle

- Dartfish 360 S analysis of the execution of the Mawashi Geri leg technique - The final moment
    - End of execution - The angle between the trunk and the thigh
    - The end of the execution - The angle between the thigh and calf
    - Total technical execution time

- Analysis made with Dartfish 360 S of the execution of the Yoko Geri leg technique: Arming Trajectory and completion
    - Reinforcement - The inversion angle
    - End of execution - The angle between the trunk and the thigh
    - End of execution - Inversion angle
    - End of execution – Amplitude
    - Total technical execution time

- Dartfish 360 S analysis of the execution of the Ushiro Geri leg technique: Set-up – Trajectory and completion
    - Reinforcement - Thigh-calf angle
    - Reinforcement - Foot-calf angle
    - End of execution - The angle between the trunk and the thigh
    - End of execution - Foot-calf angle
    - End of execution – Amplitude
    - Total technical execution time

12.2.5. Evaluation of executions of foot techniques with the help of federal referees

In order to evaluate the efficiency and quality of execution of the four foot techniques of the athletes, we called on 5 independent karate experts who gave marks from 1 (unsatisfactory) to 10 (very good) to each subject separately for each of the 4 techniques leg kicks performed (mae geri, mawashi geri, yoko geri and ushiro geri), taking into account the following aspects: arming technique, trajectory, point of impact (accuracy) and return (to the initial position), i.e. by "performing it correctly under standard conditions, with low energy consumption, fluent, with increased indices of strength, speed and accuracy of shots”[13].

The quality of the technique used was thus expressed in the form of 4 variables obtained by calculating the average of the scores given by the 5 independent experts in karate for each executed foot technique.

12.2.6. Points scored in upper limb and lower limb competitions - 2021

The quantification of the points obtained in the competitions was made possible by introducing, at our request, an annex in which to record the segment with which the athlete obtained the point on the referee sheet.

12.2.7. Monitoring of results obtained in competitions – 2021

In order to be able to monitor the competition results of the two groups (experiment and control) we created a scoring scale for quantification:

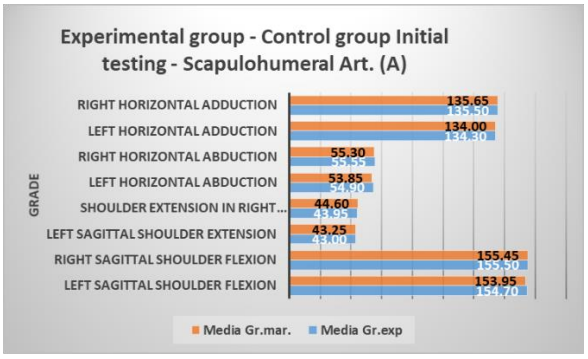
- ✓ First place – 10 points.
- ✓ Second place – 8 points.
- ✓ Third place – 6 points.
- ✓ Fourth place – 4 points.
- ✓ Fifth place – 2 points.

The scores obtained for each subject are presented in the appendices.

CHAPTER 13. STATISTICAL ANALYSIS OF DATA COLLECTED AFTER INITIAL TESTING

13.1. Measuring static flexibility with the Mobee Med equipment

13.1.1. Measurement of flexibility at the level of the scapulohumeral joint



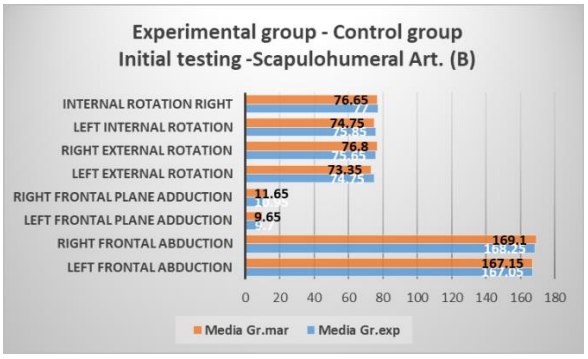
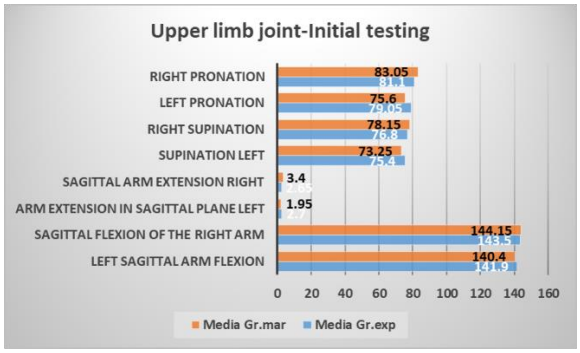


Figure 21.Scapulohumeral joint A *Figure 22.Scapulohumeral joint B*

The results obtained after performing the t-test for two independent samples show that there are no significant differences between the means of the experimental group and the control-control group at the initial testing ($p > \alpha = 0.05$). This is proof that, initially, the two groups of athletes had similar performances at the level of the scapulohumeral joint.

13.1.2. Measurement of flexibility in the joints of the upper limbs



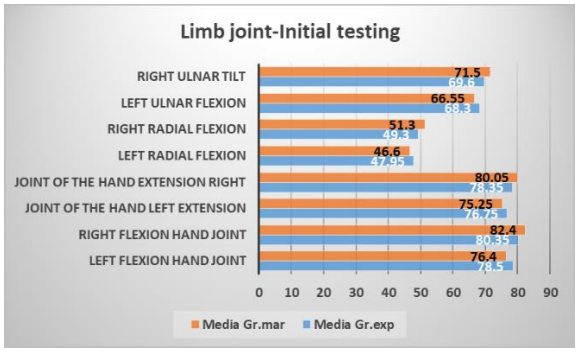
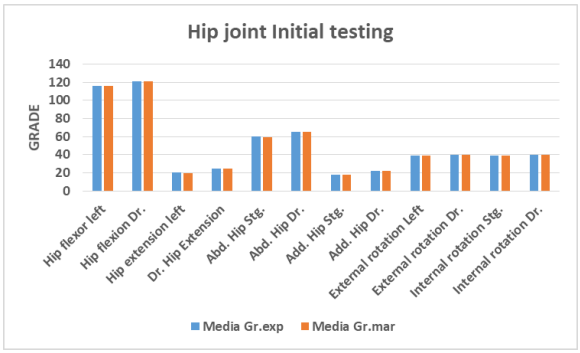


Figure 23.Upper limbs joints *Figure 24.Hand joint*

From Figures 23-24 we can see that the two groups of athletes had similar performances, except for:
- left pronation ($t = 2.183$, $p = 0.009$, difference between means = 3.450) for which the test shows that there are differences between the control and the experimental group, the mean value being higher in the experimental group;
- right radial tilt. ($t = -2.213$, $p = 0.035$, difference between means = -2.000) for which the test shows that there are differences between the control and the experimental group, the mean value being higher in the experimental group.

13.1.3. Measurement of flexibility at the level of the joints of the upper limbs, acetabulofemoral



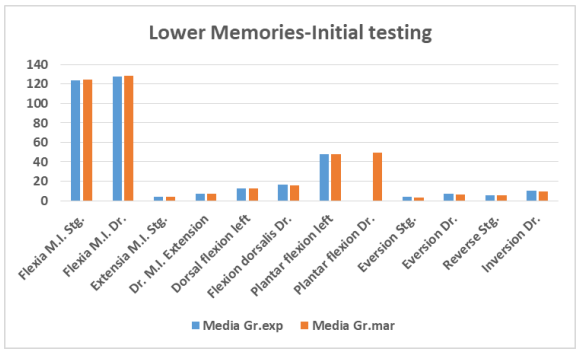


Figure 25.Acetabulofemoral joint *Figure 26.Lower limbs joints*

According to the t-test for two independent samples it results that there are no significant differences between the means of the experimental and control groups at baseline ($p > \alpha = 0.05$) for most of the variables analyzed (Figures 25-26). Differences at initial testing exist only for the right reversal movement ($t = 2.2421$, $p = 0.020$). This means that initially the two groups of athletes had similar performances.

13.2. Measuring dynamic flexibility with 360 S software

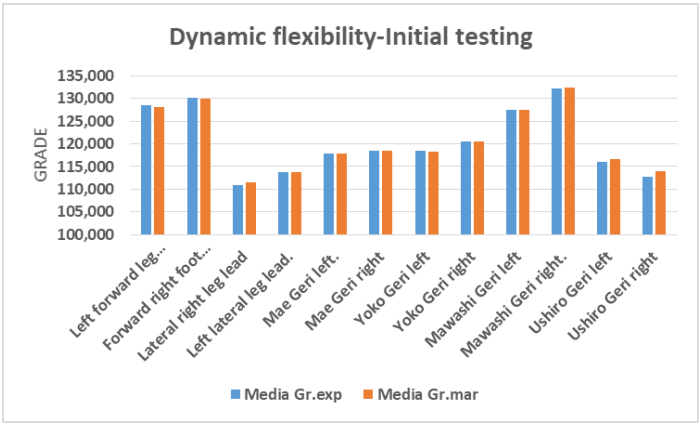


Figure 27Dynamic flexibility

13.2.1. Ushiro Geri Technique Analysis - Arming – Trajectory and Completion

Figure 28.Ushiro Geri - Arming *Figure 29.Ushiro Geri – Completion*

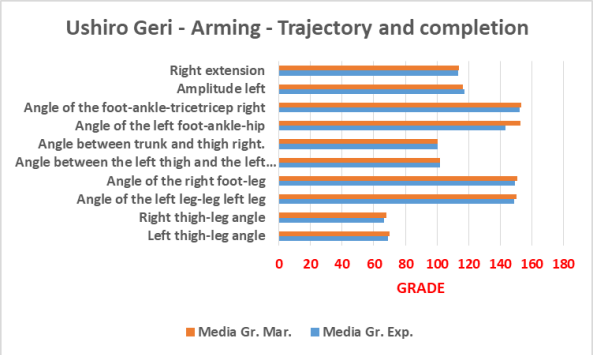


Figure 30.Ushiro Geri

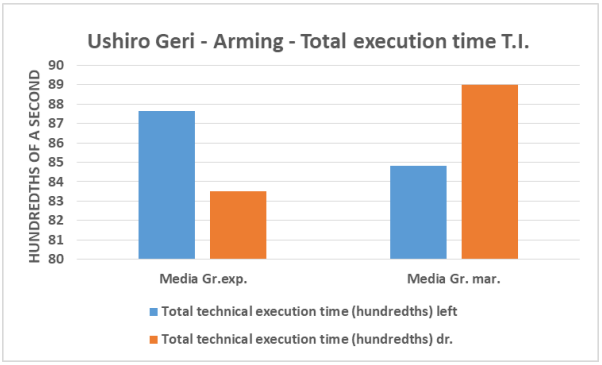


Figure 31.Ushiro Geri – Timing

The t-test for the means of two independent samples shows that there are no significant differences between the means of the experimental group and the control-control group at the initial testing, $p > \alpha = 0.05$ (figure no. 27.28,29,30), except for the total technical execution time Right (figure no.31, $p = 0.006$). These results show that initially the two groups of athletes had similar performances.

Note: the analysis of Mae Geri, Mawashi Geri, Yoko Geri techniques can be followed in the PhD thesis with the mention that also for these techniques there are no significant differences between the means of the experimental and control groups at the initial testing, $p > \alpha = 0.05$.

13.3. Evaluation of the executions of foot techniques with the help of federal referees

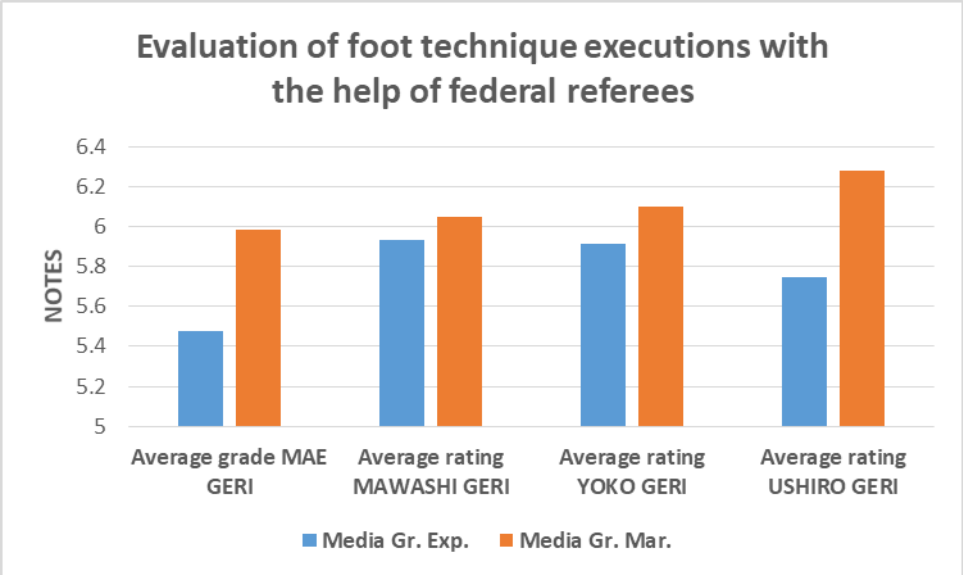


Figure 32.Evaluation of the executions of foot techniques with the help of federal referees

The results obtained after performing the t-test for two independent samples show that there are no significant differences between the mean scores of the experimental group and the control group at the initial test ($p > \alpha = 0.05$), except for MAE GERI (the mean is higher for the control group). This indicates that initially the two groups of athletes had similar performances (except MAE GERI).

13.4. Points obtained in competitions with regards to upper and lower limbs in the year of 2001

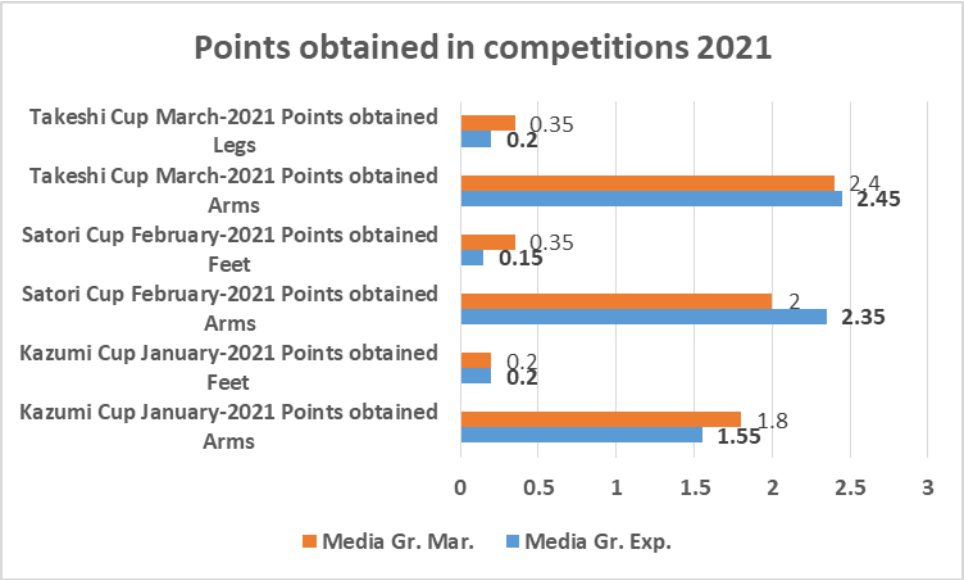


Figure 33.Obtained points

13.5. Results obtained in competitions in 2021

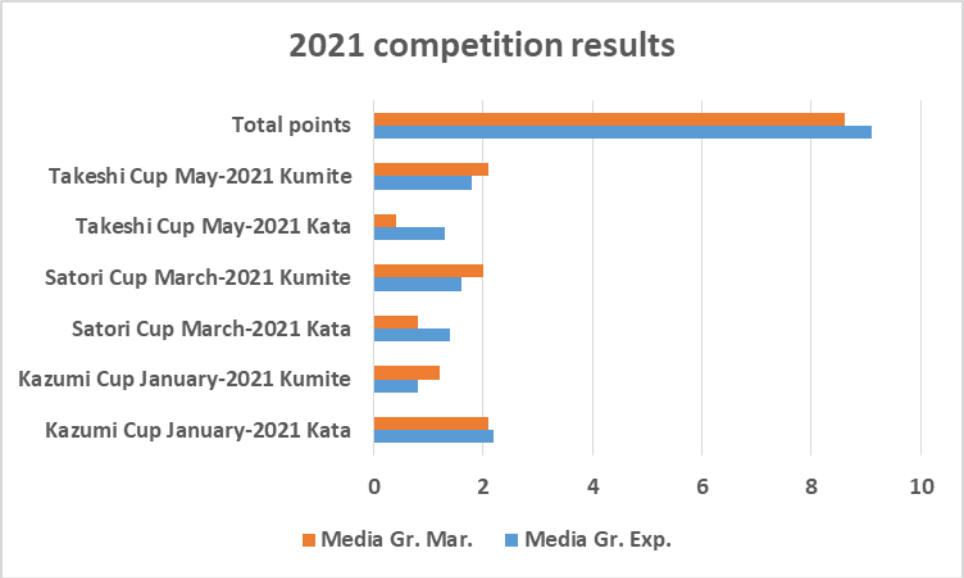


Figure 34.Points obtained in 2021 competitions

After performing the t-test for two independent samples, it was found that there were no significant differences between the means of the results of the experimental and control-control groups at baseline testing ($p > \square = 0.05$) in terms of the results obtained in all competitions (Figure 34) but also in the points obtained in the upper and lower limb competitions in the year 2021 (Figure 33).

So, the two groups of athletes had similar performances initially.

CHAPTER 14. CONCLUSIONS ELABORATE AFTER INITIAL TESTING

The t-test for independent samples is used to test the difference between the means of the same variable measured on two groups, made up of different subjects. Equality of variance is checked with Levene's test, and depending on its result, the t-test is calculated in two ways. We used the t-test to determine whether there were statistically significant differences between the experimental and control groups at baseline. We considered a significance threshold of $\alpha = 0.05$.

Following the statistical analysis, we could observe the equality of variances ($p > \alpha = 0.05$) for most of the calculated variables with some exceptions that do not significantly influence anything from a statistical point of view:

- Upper limbs - the variances are not equal for arm extension in the right sagittal plane ($p = 0.03$), left supination ($p = 0.017$), right supination ($p = 0.049$), right pronation ($p < 0.001$), right pronation ($p = 0.011$);
- The acetabulofemoral joint - variances are equal ($p > \alpha = 0.05$), except for left hip extension ($p = 0.001$), right hip extension ($p = 0.003$), left hip abduction ($p = 0.032$), right hip abduction ($p = 0.006$);
- Mae Geri - the equality of variances is confirmed ($p > \alpha = 0.05$) for most cases, with the exception of the end of the execution - the angle between the torso and the right thigh ($p = 0.009$) and the end of the execution - the angle between the foot and the right calf ($p = 0.007$).

At this stage, the t-test showed us that the athletes of the two groups (experiment and control) have similar performances. There were some differences between the averages of the same variable measured on two groups, made up of different subjects, but without significantly influencing the statistical analysis:

- *Upper limbs - the only exception is right pronation ($t = 2.183$, $p = 0.009$, difference between means = 3.450) for which the test shows that there are differences between the control group and the experimental group, the mean value being higher in the case of the experimental group;*
- *Hand joint - the exception is the right radial tilt ($t = -2.213$, $p = 0.035$, difference between means = -2.000) for which the test shows that there are differences between the control group and the experimental group, the mean value being higher in the case of the experimental group;*
- *Lower limbs - differences in case of initial testing exist only for the right inversion movement ($t = 2.2421$, $p = 0.020$);*
- *Ushiro Geri - the exception being the total time of technical execution with the right leg ($p = 0.006$), the average value being higher in the case of the experimental group;*
- *Mawashi Geri – an exception in the angle between the trunk and thigh (end of execution) on the right where the average is higher for the control group (132.395 experimental group – 188.650 control group);*
- *The evaluation of the execution of foot techniques with the help of referees - with the exception of the MAE GERI technique, the average marks are higher for the control group.*

CHAPTER 15. THE PROPOSED PROGRAM FOR THE DEVELOPMENT OF FLEXIBILITY TO IMPROVE SPORTS PERFORMANCE

15.1. Flexibility development program

Moon	June					July				August					September				October				November					December				January				February				March					April				May				
The Week	1-6	7-13	14-20	21-27	28-04	5-11	12-18	19-25	26-1	2-8	9-15	16-22	23-29	30-05	6-12	13-19	20-26	27-3	4-10	11-17	18-24	25-31	1-7	8-14	15-21	22-28	29-5	6-12	13-19	20-26	27-2	3-9	10-16	17-23	24-30	31-6	7-13	14-20	21-27	28-6	7-13	14-20	21-27	28-3	4-10	11-17	18-24	25-1	2-8	9-15	16-22	23-29
Competition calendar															Cup canceled			Restore													Per. Comp. Kazumi Cup	Restore									Per. Comp. Satori Cup	Restore									Per. Comp. Takeshi București Cup
Periodization	Mez. I. Pep. prep.									Mez. II. Per. prep.									Mez. III. Per. prep.									Mez. IV. Per. Pre-comp.								Mez. V. Per. prep.				Mez. VI. Per. Pre-comp.					Mez. VII. Per. Prep.				Mez. VIII. Per. Pre-comp.				
Steps	STAGE I					STAGE II				STAGE III									STAGE II				STAGE III					STAGE IV								STAGE III				STAGE IV					STAGE III				STAGE IV				
Grad exam																																																					
Intensity %	70%					80%				90%									80%				90%					95-100%								90%				95-100%					90%				95-100%				

Figure 35.Annual plan

THE YEAR	2021							2022				
MOON	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY
MACROCYCLE												
MEZOCYCLE	I		II		III		IV	V	VI	VII	VIII	
PERIOD	01.06 - 01.08. 2021		02.08 - 03.10.2021		04.10 - 05.12.2021		06.12.2021 - 16.01. 2022	17.01 - 27.02	28.02 - 03.04	04.04 - 01.05	02.05 - 29.05	

Figure 36.The macrocycle correlated with the cadet and junior competition calendar

15.1.2. The mesocycles

They are integrated parts of the training macrocycle, and in our research, there were eight of them, the duration of a mesocycle was between four and nine weeks, consisting of the preparatory, pre-competitive and competitive periods.
In the mesostructure training plan, the training objectives were focused on physical training (subjects being beginners, the sphere of interest was represented by the development of motor capacities), technical training (acquiring and strengthening technical procedures from kihon, kata, kumite with an emphasis on improving flexibility of the body), tactical training (studying the distance and combat angles, the length of the attack), basic psychological training (emphasis on the development of modesty, courage and the spirit of fair play), special (the ability to anticipate the opponent's actions, the complexity of thinking, etc.) and for the contest (adaptation to the state of the contest, resistance to stress when the opponent has an advantage, etc.)
The number one mesocycle took place between June 1 and August 1, 2021, with the objectives of adapting the body to effort, educating static and dynamic flexibility, acquiring the specific techniques of the Shotokan karate do discipline, using methods and means from basic gymnastics to achieve them, athletics and fitness for the development of motor skills, and in terms of the technical-tactical system we focused on training basic shots and optimizing kinaesthetic sensitivity.
The second mesocycle started on August 2 and ended on October 3, 2021. This mesocycle was supposed to coincide with the first competition (week 6 - September 12, 2021) which unfortunately was cancelled due to the pandemic of COVID 19. The physical training during this period was directed towards the development of dynamic flexibility (with the help of the emerging tool Desmotec), the relaxation of the lower train, the consolidation of basic techniques and the attack with mae geri, mawashi geri, yokogeri and ushirogeri, using themes with a high degree of complexity. In the week of September 27 - October 3, the main objective was to make the body recover after the training effort.
The third mesocycle took place between October 4 and December 5, 2021, and aimed to maintain the level of preparation previously achieved. Regarding the technical-tactical register, we focused on improving the execution of foot techniques at the jodan (face) level, launching attacks from a distance by increasing the degree of flexibility and speed of execution.
Mesocycle number four, held between December 6, 2021 and January 16, 2022, had as configuration the pre-competitive, competitive and recovery period. In this structure of the training process, the education of the static and dynamic flexibility of the kata positions and kumite, superior technical-tactical expression, high physical condition in order to successfully participate in the Kazumi Cup (January 8-9, 2022).
Drive systems for improving static and dynamic flexibility were addressed with the help of the emerging Desmotec device, topics with high complexity from the perspective of the attack techniques involved in the execution and movement on the combat surface. The suite of heian katas performed, kumite matches with opponents having a superior technical level were used to increase effort capacity, stimulate creativity in combat, and acclimatize to situations similar to sports competition.
In recovery, breathing exercises, aerobic efforts, stretching were addressed. Mesocycle number five (January 17 – February 27, 2022) was to compensate and preserve the previous level of training, due to its correlation with element number six in the training structure (mesocycle six) which involves attending the penultimate competition in the calendar, the Satori Cup. Particular

importance was given to the dynamic executions in the regime of flexibility and increased speed of the techniques of kihon, kata and kumite.
The sixth mesocycle completed between February 28 and April 3 overlapped with the penultimate contest in the competitive calendar, the Satori Cup (March 26-27, 2022). A best possible ranking of the cadets and juniors was pursued and in order to achieve this objective, the physical training was directed towards the development of the dynamic flexibility of the upper and lower limbs, the consolidation of specific kata and kumite techniques with a special emphasis on practicing the techniques of mae geri, mawashi geri, yoko geri and ushiro geri in the idea of increasing the amplitude of execution, speed and improving their biomechanics to achieve sports performance and fulfil the purposes of our research.
The mesocycle with number seven renders the penultimate element of the structure of the preparation process and regiments the period April 4 - May 1, 2022, being intended for training on all levels to support sports performances, but also mesocycle number eight in which we find the last official competition.
The mesocycle number eight (May 2 - May 29, 2022) has got the pre-competition period (May 2 - 22, 2022), in its structure and the competition period (May 23-29, 2022) represents the last organizational structure of the annual training plan, at the same time it also marks the participation in Takeshi Cup – Bucharest, one of the most important competitions in the competitive calendar. All the actions performed, the training methods and means implemented in this last stage were aimed at obtaining the highest possible sports form of the cadets and juniors practicing Shotokan Karate.
In this last stage, the physical training was focused on improving the specific effort possibilities, and the technical-tactical training was directed towards the content of the two Kata and Kumite contests.
The actions were started in order to develop all specific motor qualities, especially flexibility in all forms of manifestation. Desmotec emerging tool was used to improve the flexibility in force mode. Topics were also addressed to improve technical executions in Kata and Kumite, and in the training matches, opponents of the same age, older opponents and advanced belts, opponents of different genders were introduced.
The recovery actions consisted of relaxation stretching, aerobic exercises, massage sessions, swimming pool laps (Bazinul de înot și polo, Focșani, Vrancea county).
To illustrate the strategy of improving flexibility and making techniques more efficient in kata and kumite, the fourth mesocycle that corresponds to an important competition has been chosen as an example. The other mesocycles can be consulted in the appendices.

PREPARATION PLAN ON MESOSTRUCTURE

- Sports discipline: Shotokan Karate
- Period: Pe-competitive/Competitive
- Training level: cadets and juniors

TEACHING OBJECTIVES

- ✓ Physical preparation - maintaining both aerobic-anaerobic effort capacity at a high competition-specific level and combined and complex motor capacities.
- ✓ Technical training – strengthening the technical elements and procedures of kata and kumite with an emphasis on those in the attack (mae geri, yoko geri, mawashi geri, ushiro geri).
- ✓ Tactical training – practicing direct attack, feint and attack, original combinations (combining techniques, doubling or tripling the same arm or leg technique), counterattack (go no sen, sen no sen, ato no sen).
- ✓ Psychological preparation – self-control, self-control when the opponent is in advantage through handicap matches (the opponent is offered one or two wazars at the start of each match to stimulate competitiveness).
- ✓ Improving flexibility with the help of emerging Desmotec D.Full and V.Full stations.

Table 7.Training mesocycle nr. IV (06 december 2021 – 16 january 2022)

Days of the week	**I Date**	**II Physical prep./Tactical/technical prep. /Flexibility development**	**I**	**II**	**I**	**II**	**I**		**I**		**I**	**II**
Monday	6 Dec	**20'/ 40'/ 30'**	13	**20'/ 40'/ 30'**	20	**15' / 45' / 30'**	27	**- 60' / 30'**	3	**- 60'/ 30'**	10	**20'/ * 20'/ 20**
Tuesday	7	**-**	14	**-**	21	-	28	-	4	-	11	-
Wednesday	8	**20'/ 40'/ 30'**	15	**15'/ 45'/ 30'**	22	**10' / 50' / 30'**	29	**- 60' / 30'**	5	**- 60'/ 30'**	12	**20'/ * 20'/ 20**
Thursday	9	**20'/ 40'/ 30'**	16	**15'/ 45'/ 30'**	23	**10' / 50' / 30'**	30	**15' / 45' / 30'**	6	**- 60'/ 30'**	13	**20'/ * 20'/ 20**
Friday	10	**20'/ 40'/ 30'**	17	**15'/ 45'/ 30'**	24	**10' / 50' / 30'**	31	**15' / 45' / 30'**	7	-	14	**20'/ 40'/ 30**
Saturday	11	-	18	-	25	-	1 Ian	-	8	Kazumi Cup	15	-
Sunday	12	-	19	-	26	-	2	-	9	Kazumi Cup	16	-

PF=300min=5hours/PTH-TC=1020min=17hours/DEZ.FLEX=660min=11hours/Total=33hours
PF=16%/DEZ.FLEX=34%/PTH-TC=50%
* Shorter training sessions between 60 – 90 minutes.
Note: The values in table no. 88 resulted after subtracting 30 minutes from the total time allocated to the sports training lesson (20 minutes for preparing the body for effort, selective influencing, recovery of the body after effort, and the difference of 10 minutes being allocated to breaks).

15.1.3. The microcycle

The training microcycle consisted of four lessons per week, the structure of the training lesson being the classic one with a preparatory part, the fundamental part and the concluding part, usually lasting 120 minutes.

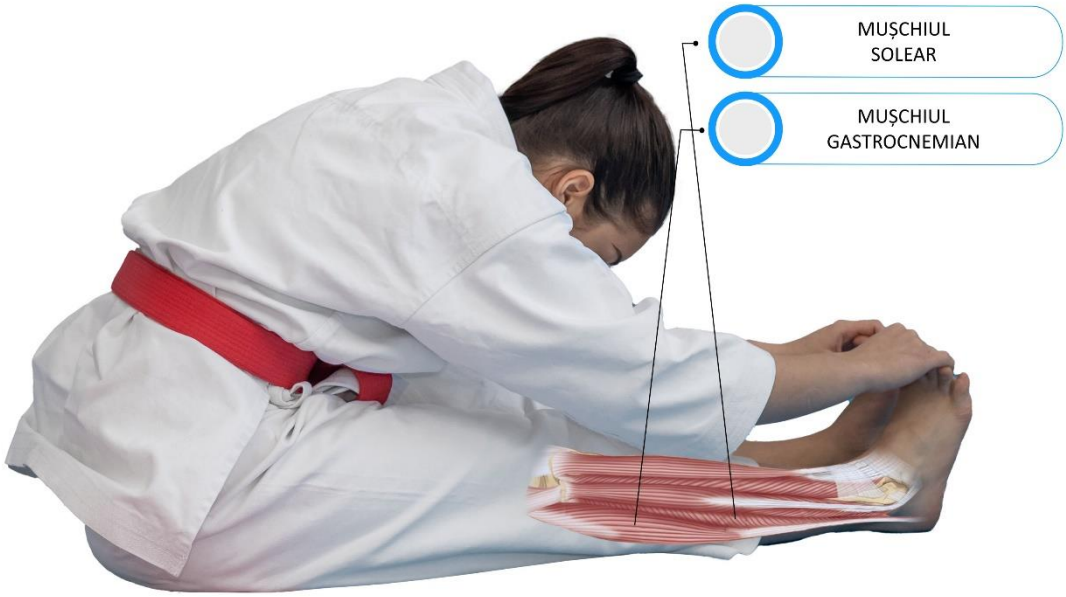
Modern trends in the duration of the core part of a training session support the idea of reducing it to about an hour. Exceeding this duration can have a negative impact on hormone levels that support muscle development (Poliquin, 1997). In this sense, I allocated 60 minutes to the fundamental part. At the end of the 60 minutes when the muscles are very well warmed up,

methodically staggered sessions from the original flexibility improvement program were introduced. This structural formation of the training process was aimed at improving the flexibility of female and junior karate do practitioners, achieving performance goals and making the foot techniques used in the Kata and Kumite contests more efficient. The means and methods used in sports training lessons were aimed at adapting the subjects to effort, developing motor qualities, especially flexibility without neglecting strength and speed because when we refer to static flexibility, we must not neglect strength development, and when we talk about dynamic flexibility it is imperative to develop strength and speed at the same time as flexibility training.

The preparatory period was divided into three stages, the weight of the training factors being different at each stage. During this period, special importance was given to the development of motor skills with an emphasis on the development of static and dynamic flexibility as well as the flexibility specific to Shotokan karate techniques. With the aim of preparing for the contest and improving competitive performance by developing flexibility, in the other two periods (pre-competition and competition) the share of physical training was reduced, increasing the share of technical-tactical training considerably (decrease by 25% physical training, increase by 15% technique, and the share of tactical training has doubled compared to the preparatory period).

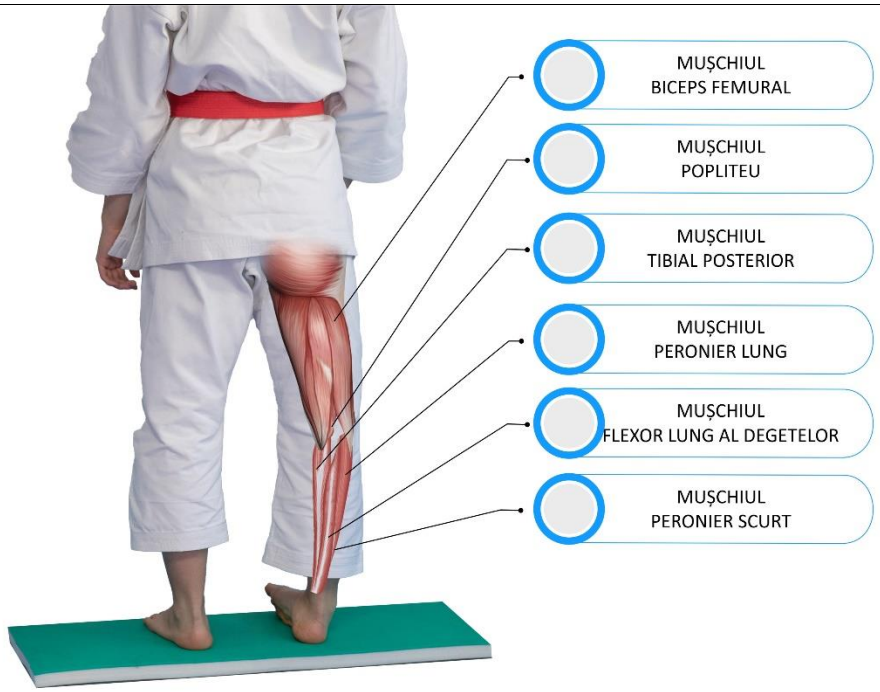
In order to ensure that the training path of the athletes is heading in the right direction, the degree of flexibility development was determined at the initial testing stage and taken into account in the relationship with the research subjects and in the development and dosing of the actuation systems.

15.1.4. Actuation systems applied in the experiment for the musculature of the lower limbs



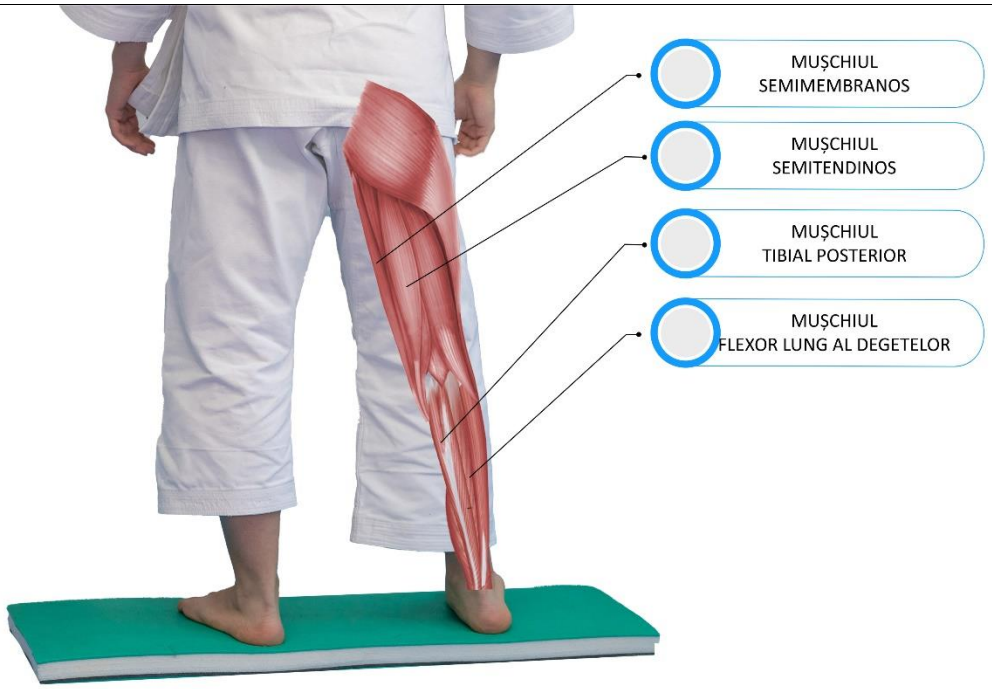
Exercise for static flexibility development
Initial Position: I.P. – Sitting down, legs stretched, straightened torso, hands on the floor;
Motor action: The torso is flexed over the thighs at the same time as the backwards pulling of the toes;
Dosage: Hold for 15-20 seconds; 3 x 15-20 seconds;
Movement type & Break type and duration: Active & Passive break for 5-10 sec;
Comments and explanations: This exercise helps with the correct positioning of the leg within the final step of the Mae Geri technique

Figure 37. Exercise for static flexibility development (A)



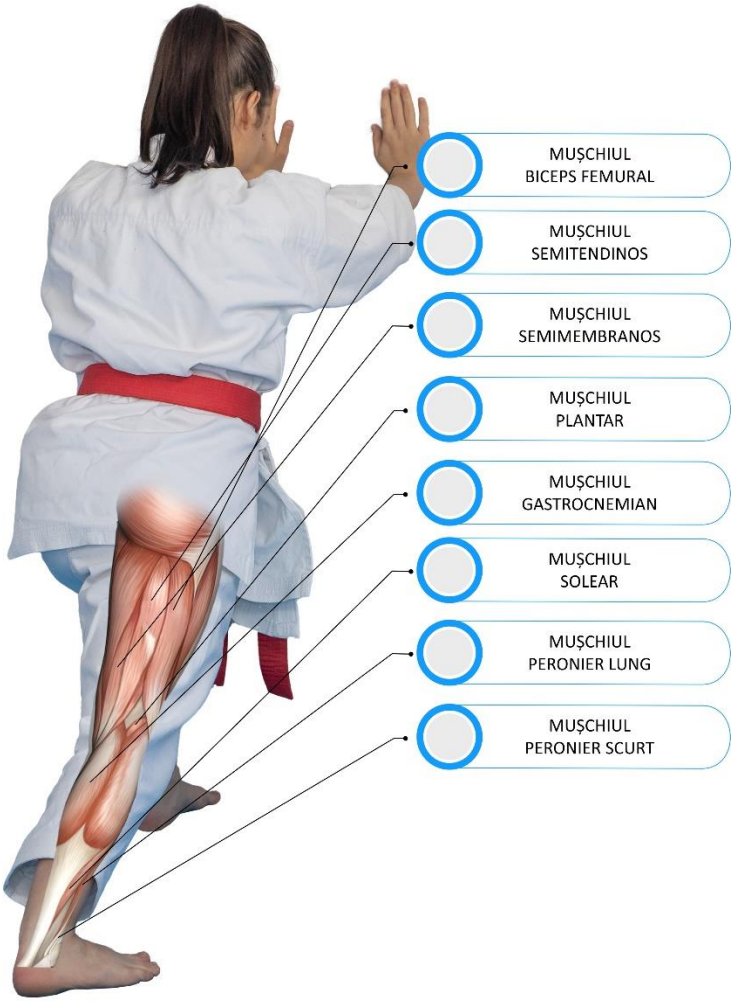
Exercise for static flexibility development
Initial Position: I.P. – Standing up, arms relaxed
Motor action: The inversion movement is executed with the right leg
Dosage: Hold for 15-20 sec; 3 x 15-20 sec; repeat with the other leg
Movement type & Break type and duration: Active & Passive break for 5-10 sec;
Comments and explanations: The inversion movement is made out of three more actions: supination, plantar flexion, adduction of the foot. Beginner karate athletes typically manifest a reduced level of flexibility of this joint.

Figure 38. Exercise for static flexibility development (B)



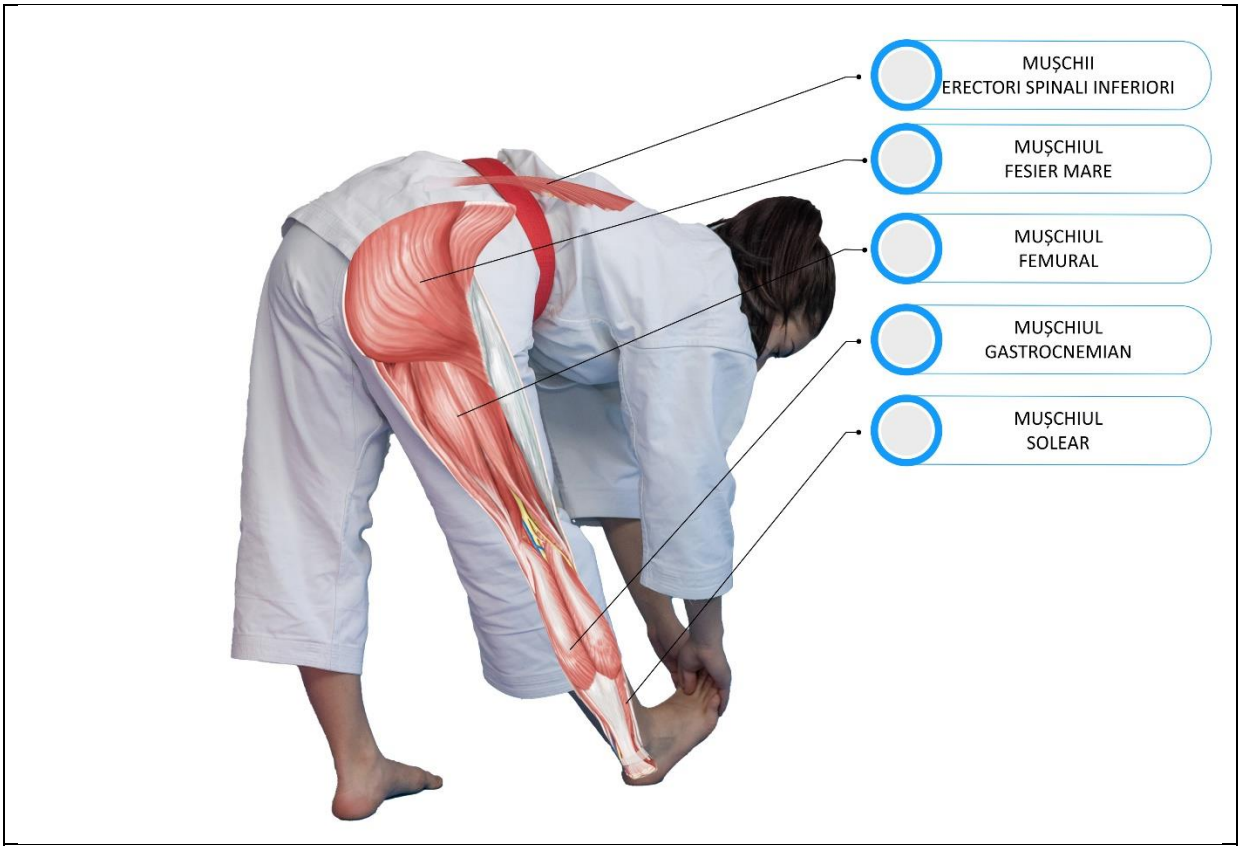
Exercise for static flexibility development
Initial position: I.P. – Standing up, arms relaxed near the body;
Motor action: The eversion movement is executed with the right leg;
Dosage: Hold for 15-20 sec; 3 x 15-20 sec; repeat with the left leg;
Movement type & Break type and duration: Active and passive break for 5-10 sec;
Comments and explanations: The eversion movement is the outwards twisting of the foot. The correct execution of the Ura Mawashi Geri technique is what determines the level of flexibility, a technique where the foot is in eversion during the last step.

Figure 39. Exercise for static flexibility development (C)



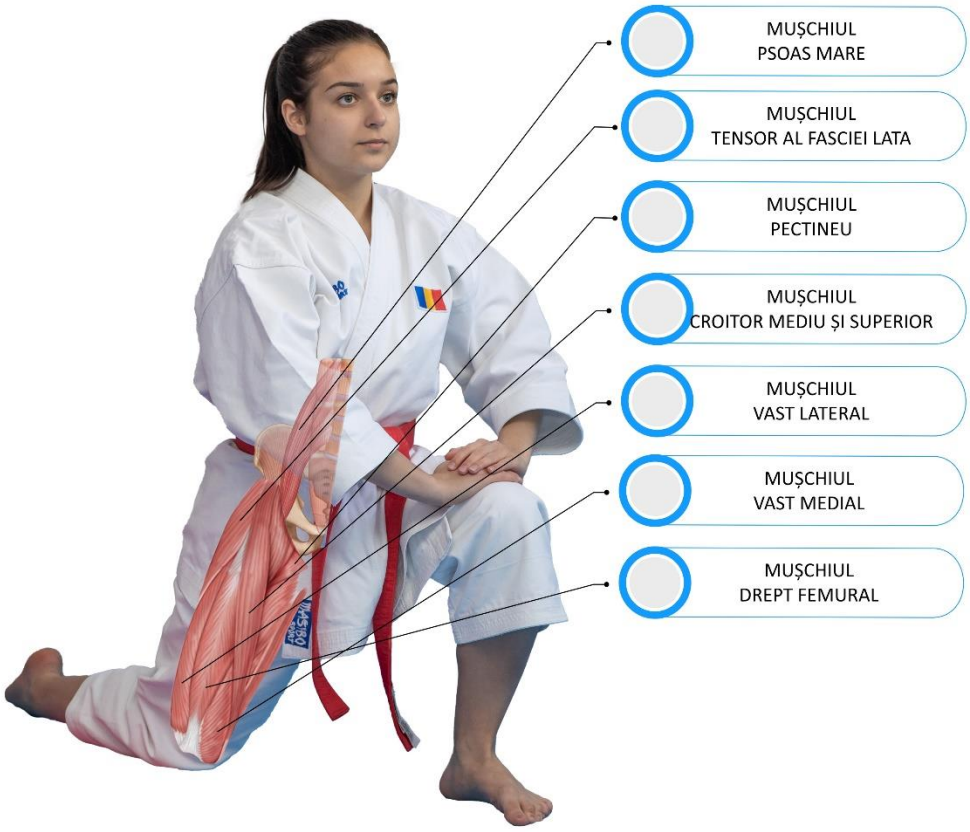
Exercise for static flexibility development
Initial position: I.P. – Facing the wall, the left leg is bent forward, the right leg is stretched backwards, the hands rest on the wall.
Motor action: The forward inclination of the torso is executed at the same time as the left leg's flexion and the right leg's stretching.
Dosage: Hold for 15-20 sec; 3 x 15-20 sec; repeat for the other leg;
Type of movement & Break type and duration: Active & Passive break 5-10 sec;
Comments and explanations: This exercise is specific for the Shotokan Karate athletes, aiding them with the correct execution of the Ushiro Geri technique (backwards leg blow). It is very important that during this action, the stretched leg be straight and the heel be in constant contact with the floor.

Figure 40 Exercise for the static flexibility development (D)



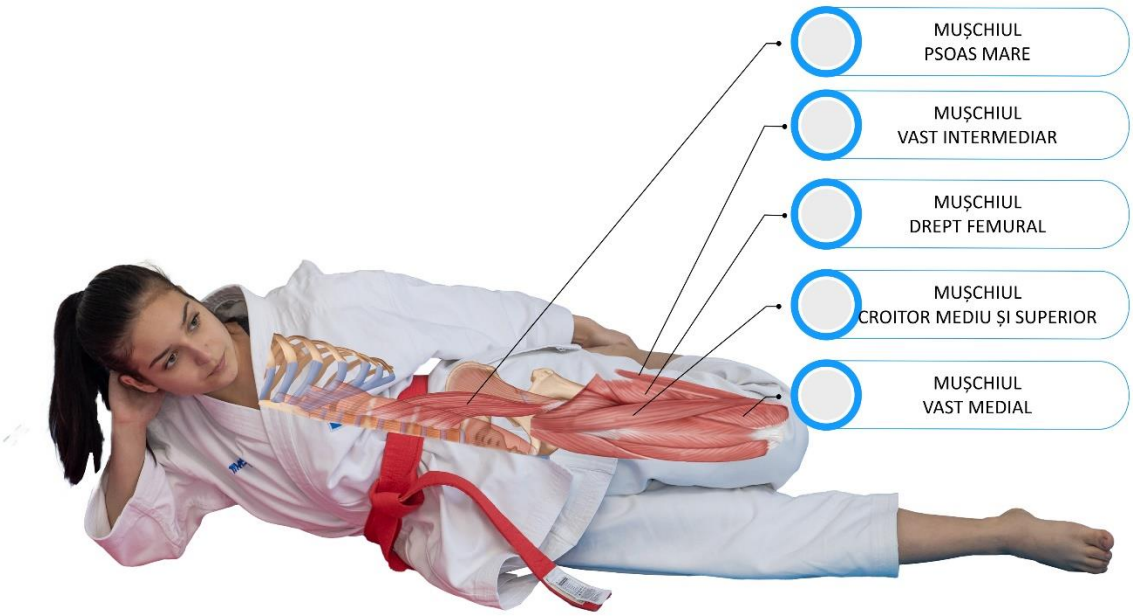
Exercise for the static flexibility development
Initial position: I.P. – Standing up, arms parallel to the body, right leg outstretched in front of the left leg;
Motor action: The forward bending over of the torso (over 90^0) is executed, the hands grab the front of the foot;
Dosage: Hold for 15-20 sec; 3 x 15-20 sec; repeat for the other leg;
Type of movement & Break type and duration: Active & Passive break 5-10 sec;
Comments and explanations: This action aids Shotokan Karate athletes to execute the Mae Geri technique (forward leg blow) in a superior level (jodan – front)

Figure 41. Exercise for the static flexibility development (E)



Exercise for the static flexibility development
Initial position: I.P. – Standing with the left leg bent forward at 90^0 and the right leg is bent backwards, on the floor, hands on the knees;
Motor action: The forward movement of the hips is executed at the same time as the bending of the torso;
Dosage: Hold for 15-20 sec; 3 x 15-20 sec; repeat for the other leg;
Type of movement & Break type and duration: Active & Passive break 5-10 sec;
Comments and explanations: The tension level of the muscular stretching can be influenced by the flexion of the left leg. This exercise helps with the correct execution of the Ushiro Geri and Ushiro Ura Mawashi Geri techniques.

Figure 42. Exercise for the static flexibility development (F)



Exercise for the static flexibility development
Initial position: I.P. – Lying down sideways, resting of the right arm, legs outstretched;
Motor action: The left leg is pulled backwards with the left hand grabbing the ankle;
Dosage: Hold for 15-20 sec; 3 x 15-20 sec; repeat for the other leg;
Type of movement & Break type and duration: Active & Passive break 5-10 sec;
Comments and explanations: The level of muscle stretching can be increased through the backward pulling of the leg. The only muscle which ties the lower and the upper parts is the iliopsoas muscle (starts from the L1-L4 vertebras, skips L5 and is held on the lesser trochanter. In the case of the Ushiro Geri technique, it holds two very important roles: • When arming, it fixes the hip into place; • At the final moment of the strike, it suffers a considerable load because it is very stretched and because at the same time, the muscles from the back part of the thighs are also stretched – and in the majority of times, if one has a lack of proper flexibility, the strike can result in pains (groin strains) at the moment of impact.

Figure 43. Exercise for the static flexibility development (G)

Note: the global stretching program can be traced in the PhD thesis.

15.1.5. Means used

Taking into account the optimization of the indices of the training factors but also the achievement of the performance objectives, exercises, means and methods specific to the physical, technical-tactical, recovery and theoretical register were implemented in correlation both with the component period of the mesocycle and with the age category and sports form of cadets and juniors.

Regarding the technical-tactical register specific to kumite, themes were designed that contain in their structure the following procedures:

- Gyaku Tsuki - on the spot (from zenkutsu dachi), with only the movement of the front leg (tshuri-ashi), the movement of both legs (yori-ashi), from the guard (kamae), with a partner.
- Kizami Tsuki - with the movement of only the front leg (tshuri-ashi), the movement of both legs (yori-ashi), from the guard (kamae), with a partner.
- Uraken - from guard (kamae), with partner.
- Mae Geri – from the spot, from the distance, from the guard (with the front foot and with the back foot) chudan and jodan level.
- Yoko Geri – on the place, from the trip and from the return (ushiro yoko).
- Mawashi Geri - from the place, from displacement and return (ushiro mawashi), from kamae (tshuri-ashi and yori-ashi).
- Ushiro Geri - on the spot, from displacement and from kamae (tshuri-ashi and yori-ashi).
- Variants of default kumite were addressed: gohon kumite (one attack and block repeated five times), sanbon kumite (one attack and block repeated three times), ippon kumite (one time). In free fighting (jiyu kumite) the analysis of maai (distance) and hyoshi (sense of rhythm) was integrated.

To make kata executions more efficient, themes focused on:

- Taikyoku Shodan
- Heian Shodan
- Heian Nidan
- Heian Sandan
- Heian Yondan
- Heian Godan

The logical progression in the execution of a kata was established and implemented: following the techniques related to each kata, correctly mastering each technique together with the related positions, framing the techniques (learned, consolidated, perfected) in a sequence of kata (blocking-counterattack) and the execution of the ensemble in this order, on a line of kata two, three or more sequences are executed, the kata is executed up to the first kiai (battle cry) then to the second, and at the end of the logical progression the entire kata is executed.
In the case of improving static flexibility, we refer to some actuation systems implemented, the rest can be analysed in the appendices:

- Cervical area – traction (stretching) of the extensor muscles of the neck.
- Scapulohumeral joint, back, chest – traction of the shoulder flexor muscles, shoulder retractors, adductors and extensors.
- Upper limbs – drive systems for the flexibility of the wrist flexor and extensor muscles.
- Trunk – from a sitting position, exercises for the flexibility of the flexor muscles and lateral flexors of the lower trunk.
- The acetabulofemoral joint - from a sitting position, actuation systems for the flexibility of the external rotator muscles of the hip, from lying on the back, exercises for the flexibility of the

extensor and external rotator muscles of the hip, from a sitting position, exercises for stretching the extensor and adductor muscles of the hip.

- Lower limbs – from a sitting position, exercises for the flexibility of the knee flexor muscles, from sitting actuation systems for the flexibility of the plantar flexor muscles.

Desmotec D. Full and V. Full emerging stations were used to develop dynamic flexibility.

Figure 44.Desmotec V.Full

The technology that Desmotec makes available (D.Full and V.Full) is a technology that was initially approached for the training of astronauts and has the following benefits: improving the amplitude of movements due to the maximum force at which the muscles work throughout the exercise, improves flexibility in ligaments and tendons, prevents injuries due to isoinertial training. Isoinertial training is performed with the help of a device that maintains an inertia, i.e. a constant resistance during the entire movement both in the effective contraction phase of the muscle and in the relaxation phase, thus the muscles work at maximum force at any angle. Resistance is created by the inertia of a wheel that is accelerated or decelerated with muscle force by the movement of the athlete (similar to a yo-yo mechanism) not by an external weight.
Desmotec comes with a series of accessories (ropes, harnesses, handles, discs) for the purpose of increased training efficiency, in order to perform the desired movement or complex movements at different angles according to the needs and reasoning of the preparation of the training process. Desmotec accessories can be adjusted according to the height of the athlete or the joint at which we want to improve flexibility. Discs can be changed according to sizes (S, M, L, PRO) to increase the efficiency of muscle work.

CHAPTER 16. INTERMEDIATE TESTING

Five months after the training method we proposed, the experimental group underwent a mid-term test to ensure that our research is moving in the right direction and the progress made by the subjects of the experimental group is significant.
Both static and dynamic flexibility were tested, and for these types of flexibility the same specimens were used as in the initial testing.

16.1. Intermediate testing conclusions

Following the intermediate testing, the following conclusions can be drawn:

- ✓ At the level of the joints, the experimental group recorded a significant progress compared to the initially identified level of flexibility development:

- ➢ Scapulohumeral joint

Flexion exceeds the benchmark (160^0) by 8^0 on the left and 12.35^0 on the right, the extension exceeds the benchmark (50^0) by 1.45^0 left, 3.8^0 right, the horizontal abduction scores above standard (60^0) 3.45^0 left and 5.25^0 right, horizontal adduction scores above the reference value (140^0) 3.550 left, 5.05^0 right. Frontal abduction and adduction, internal rotation and external rotation show a higher degree of flexibility development in relation to the initial one but without exceeding the reference values proposed by the emerging equipment Mobee Med.
At the level of the scapulohumeral joint, the smallest progress recorded compared to the initial level of flexibility development is 5.48% (abduction in the frontal plane), and the highest percentage value is 73.71% (adduction in the frontal plane of the limb upper right).

- ➢ Articulation of the upper limbs

Flexion shows a 6.66% increase compared to the initial level for the left upper limb and 7.11% for the right upper limb, extension 75.93% left upper limb, 86.79% right upper limb, supination 10.74% left upper limb, 11.72% right upper limb, pronation 9.93% left upper limb, 9.74 right upper limb.

- ➢ The vertebral column

At the level of the cervical area, the percentage values increase compared to the initial level in flexion 12.68%, extension 21.84%, lateral bending to the left 17.53%, 14.89 to the right, turning the head to the left 7.30% and 6 .65% to the right. We note that only the lateral bending movement to the right exceeds the reference value (70^0) by 4.85^0.
At the level of the dorsolumbar area, the values increase in relation to the initially identified degree of flexibility with 10.36% in flexion, 56.91% in extension, 10.73% lateral bending to the left, 9.82% to the right, trunk twisting to left 7.74%, 7.08% to the right. The standard value proposed by the Mobee Med equipment is exceeded by the flexion movement by 1.35^0 and the right lateral bending movement by 2.10^0.

- ➢ The acetabulofemoral joint

The following progress is recorded: left hip flexion 4.57%, 4.70% right hip flexion, left hip extension 25.55%, 19.71% on the right, right hip abduction 15.79%, right 15.25%, left hip adduction 32.05%, right 30.07%, left hip external rotation 15.94%, right 16.48% left hip internal rotation 18.11%, right 17.92% Reference value exceeded of right hip flexion by 2^0, right hip abduction by 4.80^0, left external rotation by 0.45^0, right external rotation by 1.65^0, right internal rotation by 1.30^0, right internal rotation by 2.05^0.

- ➢ The joints of the lower limbs

Standard flights in the case of joints of the lower limbs are exceeded by: flexion of the right lower limb by 0.65^0, extension of the right lower limb. with 1.50, dorsiflexion right lower limb. $2,60^0$, plantar flexion right lower limb, 0.20^0, eversion movement right lower limb. $1,50^0$, inversion movement of the right lower limb. 0.70^0. The other movements evaluated at the level of the joints of the lower limbs show progress but are below the reference value proposed by Mobee Med.

- ➢ Dynamic flexibility

In terms of dynamic flexibility assessed with the Dartfish 360 S software we record the following progress compared to the initial one: leading the leg through the front up 12.93% left, 11.02% right, leading the leg through the side up 20.13% left, 20 ,64% right, Mae Geri 14.08% left, 14.58 right, Yoko Geri 12.77% left, 12.50% right, Mawashi Geri 8.52% right, 8.29% right, Ushiro Geri 13, 86% left, 16.87% right

- ✓ Although a higher degree of flexibility is recorded in relation to the one initially identified, we still identify a flexibility deficit: at the level of the cervical area in the case of lateral bending, the flexibility deficit is 7^0 for the left side and is generated by the levator scapula muscle, sternocleidomastoid and scalene muscle; the dorsolumbar area presents a flexibility deficit of 6 degrees in the case of lateral bending to the left generated by the reduced flexibility of the main and accessory muscles; hip flexion has a deficit of 6^0 for the left hip generated by the iliopsoas muscles and part of the rectus femoris; the execution of the mawashi geri technique presents a flexibility deficit for the left lower limb of 5 degrees.
- ✓ Intervention will be made in the flexibility development program in the dosing process. In cases where the degree of flexibility exceeds the reference value proposed by the emerging Mobee Med equipment, the level of flexibility development will be maintained and the flexibility deficit on the less dominant side will be reduced to 0^0.

CHAPTER 16. EXPERIMENTAL RESEARCH RESULTS

Following our flexibility development program correlated with the competitive calendar, the following results were obtained:

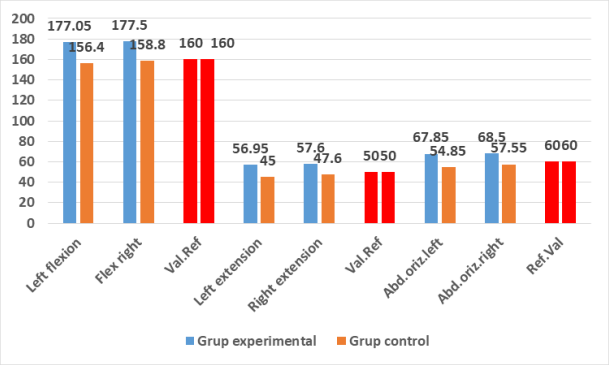


Figure 45.Scapulohumeral joint

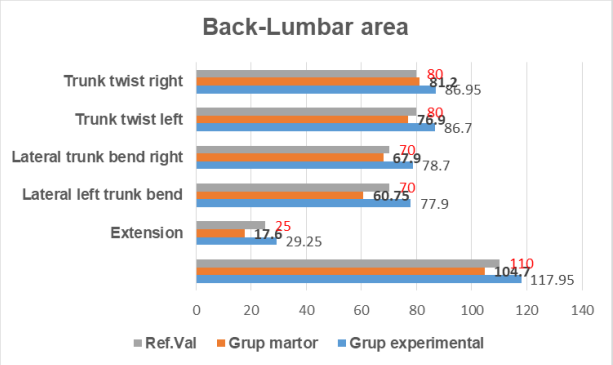


Figure 46.Art. C.V. Dorsolumbar area

1. At the level of the scapulohumeral joint, the subjects of the experimental group exceed the reference values proposed by the emerging Mobee Med equipment.

In the case of the control group, the averages of the samples are lower than the test value in the case of flexion (160 degrees, reference value), extension (50), horizontal abduction (60), horizontal adduction (140).

2. In the case of the spine joint, the experimental group exceeds the test values generated by the Mobee Med digital instrument for all motor actions evaluated. The values obtained by the control group do not reach the test value except for turning the trunk to the right.

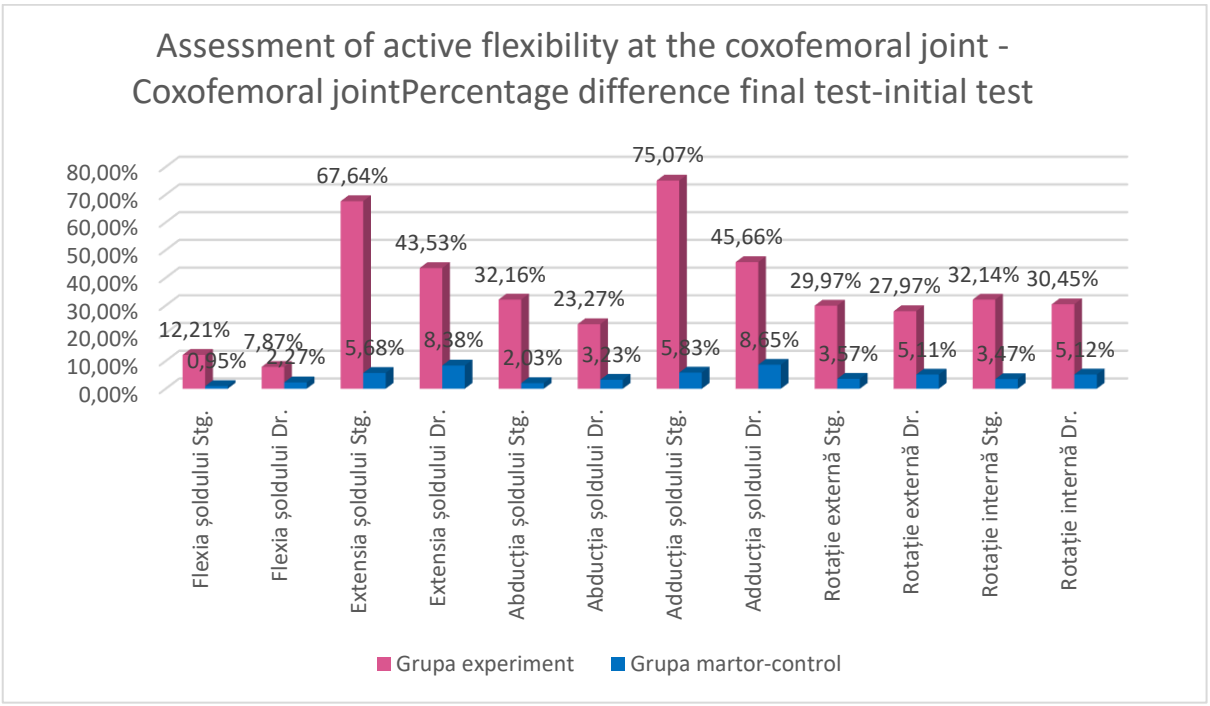


Figure 47.Acetabulofemoral joint

3. At the level of the acetabulofemoral joint, the experimental group registers a statistically significant progress compared to the control group:

- Left hip extension records an improvement from the initial level of 67.64% in the experimental group compared to 5.68% in the control group.
- The right hip extension recorded an improvement from the initial level of 43.53%% in the experimental group compared to 8.38% in the control group.
- Left hip adduction 75.07% experimental group compared to 5.83% control group.
- Left internal rotation 32.14% experimental group versus 3.47% control group.
- Right internal rotation 30.45% experimental group versus 5.12% control group.
- Left external rotation 29.97% experimental group versus 3.57% control group.
- Right external rotation 27.97% experimental group versus 5.11% control group.

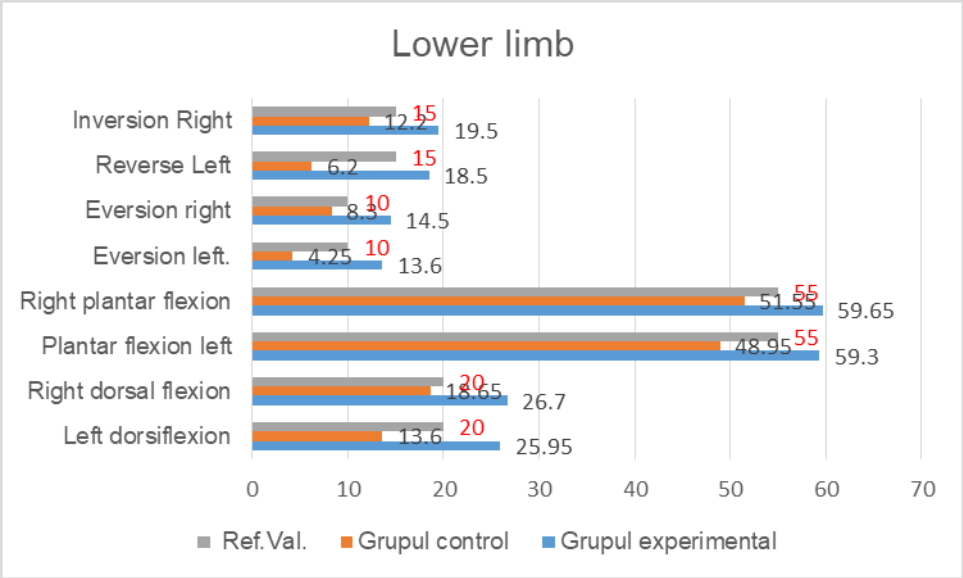


Figure 48.Lower limb joint

4. The degree of flexibility identified at the level of the ankle joint exceeds the reference values indicated by the emerging tool Mobee Med in the case of the experimental group as follows: by 4.5 degrees for the right inversion movement, 3.5 degrees for the right inversion movement. , 3.6 degrees for right eversion and 4.5 degrees for right eversion, with 4.65 degrees for right plantar flexion, and 4.30 degrees for right plantar flexion, with 6.7 degrees for dorsiflexion right, and 5.95 degrees for dorsiflexion right. The degree of flexibility identified at the level of the ankle joint in the case of the control group is below the test values generated by the Mobee Med equipment.

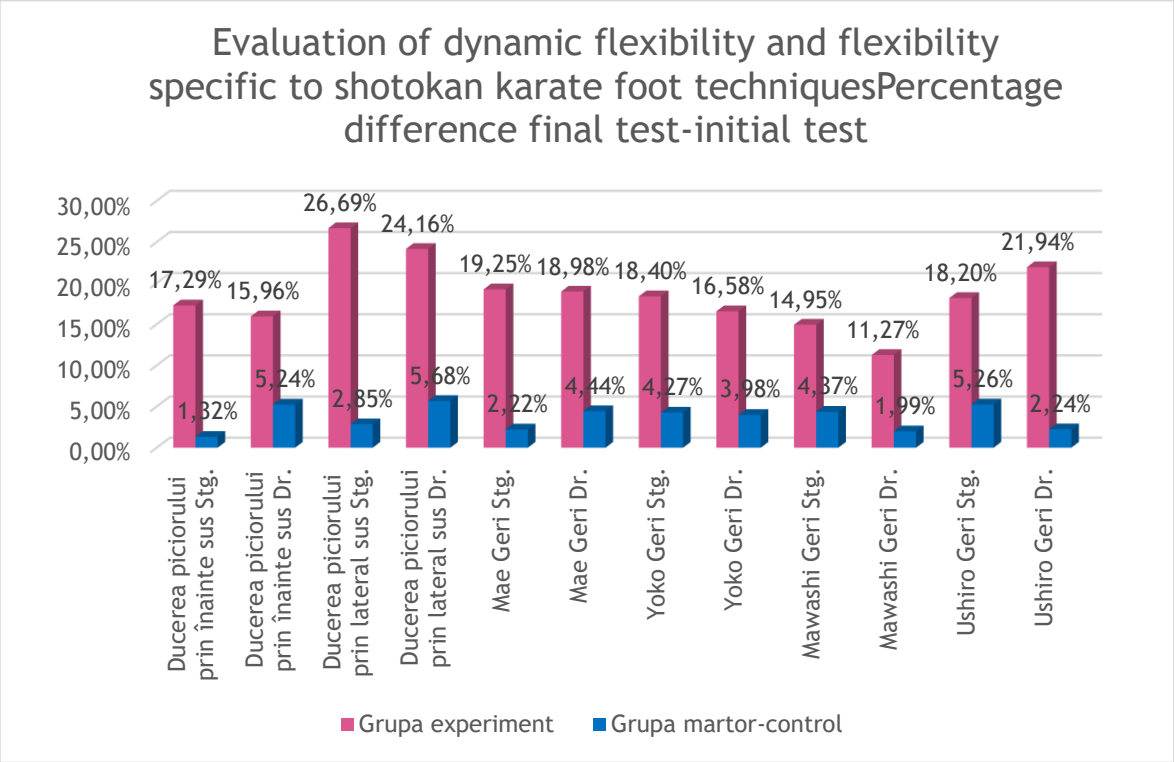
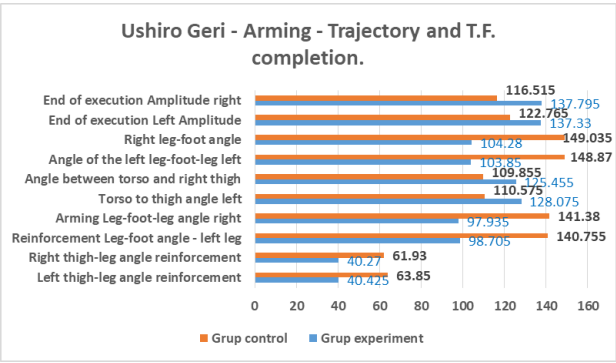


Figure 49.Dynamic flexibility assessment

5. We can highlight with the help of the graph that in terms of dynamic flexibility and specific foot techniques, the percentage values in the case of the experimental group are higher and statistically significant than those of the control group for all variables.



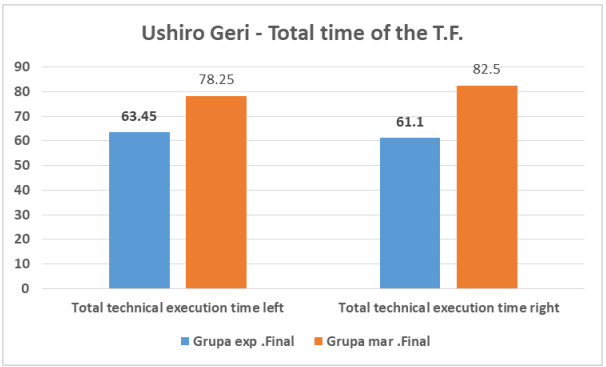


Figure 50Tf. Ushiro Geri *. Figure 51.Tf. Ushiro Geri - Timing*

6. Figure no 50 shows us that the experimental group presents, at the end of the implementation of the program focused on the development of flexibility and the efficiency of leg techniques, an improvement in the technical execution of ushiro geri by: reducing the angle between the thigh-calf, the foot-calf in the arming phase , increasing the amplitude of the execution by improving the angular value between the thigh and the calf at the final moment, increasing the angle between the trunk and the thigh at the final moment of the execution, improving the execution time (figure no.51).

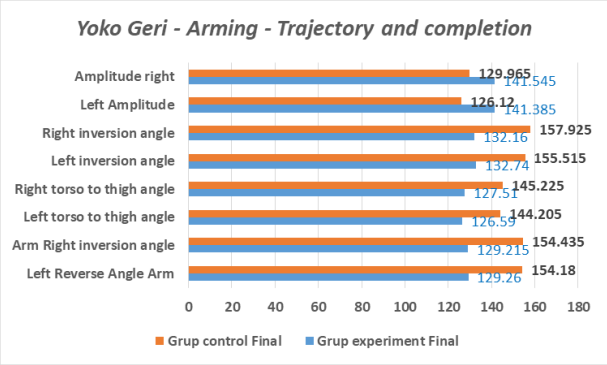


Figure 52.Tf. Yoko Geri

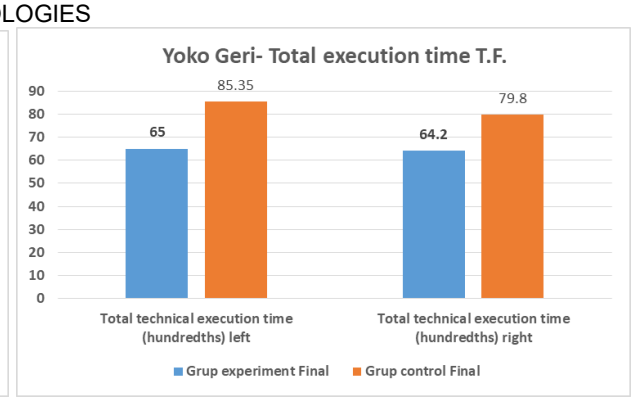


Figure 53.Tf. Yoko Geri - Timing

7. Regarding the technique of yoko geri (kicking with the foot to the side after a direct trajectory) we can detail from figure no. 52 that at the level of the experimental group an improvement in the technical execution can be observed, following the training program proposed by us, through: a reduction of the inversion angle both in arming and at the end of the execution, increasing the amplitude by improving the angular value between the thigh and the calf, reducing the angle between the trunk and the thigh, improving the execution time (figure no. 53).

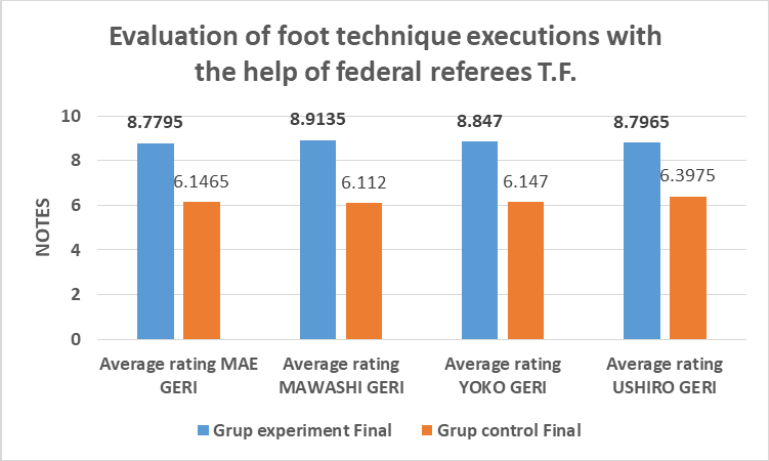


*Figure 54.*Average values of the obtained marks

Table 8.The average values of the obtained marks (T.I.-TF)

Experiment group

	Initial	Final	Difference between final-initial
Average mark MAE GERI	5.4795	8.7795	60.22%
Average mark MAWASHI GERI	5.9295	8.9135	50.32%
Average mark YOKO GERI	5.9120	8.8470	49.64%
Average mark USHIRO GERI	5.7455	8.7965	53.10%

8. From table no. 7 we can see a significant increase in the grades of the experimental group compared to the initial level: mae geri 60.22%, mawashi geri 50.32%, yoko geri 49.64% and ushiro geri 53.10%.
   In the case of the control group, compared to the initial level, the grades recorded the following increases: mae geri 2.78%, mawashi geri 1.08%, yoko geri 0.83% and ushiro geri 1.86%.

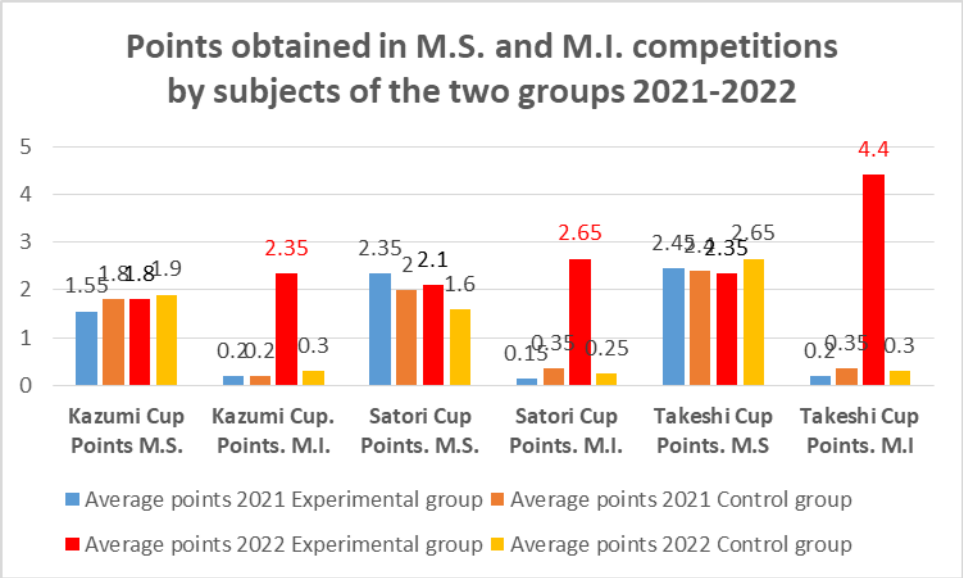


*Figure 55.*Point obtained in lower and upper limb competitions 2021-2022

9. From figure no 55 we can see in the experimental group, following the implementation of the original program for developing flexibility and improving the efficiency of foot techniques used in competitions, a significant improvement in the points obtained with the lower limbs compared to the 2021 competition year.We used the t-test to determine if there were statistically significant differences between the average score obtained in the 2021-2002 competitions by the experimental group and the average score obtained in the 2021-2002 competitions by the control-control group. We considered the significance threshold $\alpha = 0.05$. The equality of variances was done with Levene's test, to determine the t-test which is calculated in two ways.The results obtained after performing the t-test for two independent samples show that there are significant differences between the means of the points of the experimental group and the control-control group at the final test ($p > \alpha = 0.05$).

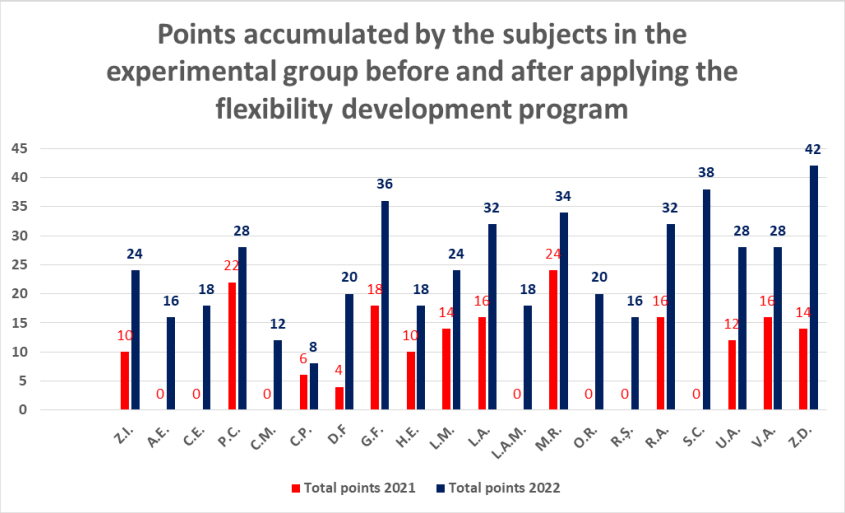


Figure 56. Results obtained in experimental group competitions

For the most accurate evaluation of the competitive results, a score was given to the performances obtained as follows: 10 points for first place, 8 points for second place, six points for third place, four points for fourth place and two points for fifth place, thus realizing the score for each athlete in the competitive years 2021 - 2022. Note that both the experimental and control groups participated in the three competitions, and the initial testing was performed in 2021

immediately after the subjects' participation in the three competitions.From figure no 56 we can see that 7 athletes in the experimental group failed to accumulate any points in the 2021 competition year, the highest number of points collected in the 2021 competition year before the application of the flexibility development program belongs to subject P.C. - 22 points. We can also emphasize that in the competitive year 2022 we record a statistically significant progress of points accumulated in all athletes of the experimental group, the highest number of 42 points belongs to subject Z.D. The number of points represented graphically for each subject is the sum of the points obtained in Kata and Kumite in 2021 and 2022.

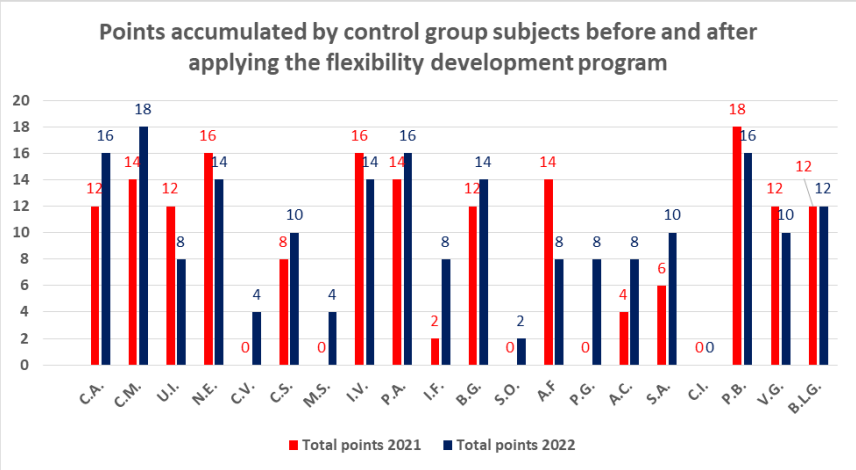


Figure 57. Results obtained in control group competitions

10. According to Figure no. 57 we highlight in the case of the control group that 5 athletes failed to accumulate points in the 2021 competition year, subject C.I. did not register any performance in the 2022 competition year. As a comparative analysis, from the two competitive years, of the performances of the subjects of the control or control group, a progress but statistically insignificant is observed for 12 athletes (C.A., C.M., C.V., C.S., M.S., P.A., I.F., B.G., S.O., P.G., A.C., S.A.), a stagnation in the performance of B.L.G. and a regression in the performance of 6 athletes (U.I., N.E., I.V., A.F., P.B. and V.G.).

Table 9. .Points obtained in competitions Gr.exp - Gr.mar. 2021-2022

Total points gr. Exp.	**182 – Year 2021**	**492 – Year 2022**
Total points gr. Cntr.	**172 – Year 2021**	**200 – Year 2022**

11. We can observe an increase in the score obtained by the experimental group from 182 points in 2021 to 492 in 2022. In the control group we observe an increase from 172 points in 2021 to 200 points in 2022 (in annexes one can follow the points obtained broken down by the two groups both for kata and kumite as well as by competitions and years). We used the t-test to determine if there were statistically significant differences between the competition results of the experimental group and the control-control group in the case of initial testing and final testing. The significance threshold is $\alpha = 0.05$. Equality of variances was verified with Levene's test. Levene's test will help us interpret the results of the t-test. The results of the t-test for two independent samples show that there are significant differences between the competition results of the experimental group and the witness-control group at the final test ($p < \alpha = 0.05$), except Kazumi cup January-2022 Points obtained Kata ($p = 0.148$).

CHAPTER 17. OVERALL RESEARCH CONCLUSIONS AND RECOMMENDATIONS

This scientific research that was carried out aimed to highlight both the concept of flexibility and its influence on the quality of technical executions and the methodical strategies designed to make the Mae Geri, Mawashi Geri, Yoko Geri and Ushiro Geri attack techniques more efficient, using these technical procedures in the direction of capitalizing on the performance capacity of female cadets and juniors practicing Shotokan Karate Do. We started from the premise that flexibility can be improved at this age in order to achieve sports performance, and strategies implemented in training for kata and kumite competitions together with emerging measurement and evaluation technologies can create the directions to achieve this.

The theoretical foundation of the first chapter of the doctoral thesis was carried out by studying the specialized literature on Shotokan Karate Do as a sports discipline, the importance of using emerging technologies in the study of flexibility, the importance and specificity of the technical procedures mae geri, mawashi geri, yoko geri and ushiro geri, the bio-psycho-socio-motor peculiarities of cadets and juniors, the ways to improve the flexibility and efficiency of foot techniques by implementing certain methodological strategies. Therefore, books and articles edited by specialists in the field were selected, articles from journals indexed in international databases considered useful in our research endeavour with the aim of creating methodological directions that improve the flexibility and optimize the biomechanics of mae geri, mawashi techniques geri, yoko geri and ushiro geri.

Following the actions of theoretical documentation, we found that the subject of our scientific research was no longer approached from the perspective of the implementation of emerging technologies in the development of flexibility and the efficiency of attack techniques performed with the lower limbs in order to improve the sports performance of the cadets and juniors practicing Shotokan Karate Do.

In terms of theoretical originality, we can say that the PhD thesis highlights a new approach to measuring flexibility by implementing emerging digital tools (Mobee Med, Dartfish 360S), developing dynamic flexibility through isoinertial training using emerging Desmotec equipment as a means. We also want to demonstrate how flexibility influences the quality of technical executions and the performances of Shotokan karate cadets and juniors, because in the specialized literature there are definitions and premises regarding the positive effects of a high degree of flexibility on sports performance, but without proving as much through a concrete study.

The preliminary scientific exploitation research was pursued through the implementation, among the specialists in the field, of an opinion questionnaire through which to identify the most useful methodological strategies for analysis and education of flexibility in order to improve the sports performance of cadets and juniors practicing Shotokan karate. The results of the social survey based on a questionnaire highlighted the need to measure flexibility with the help of emerging technologies (equipment, digital tools), the implementation of a flexibility development program adapted to the structure of the sports training lesson and the preparation stages, the need to select athletes participating in the protocol of improvement of flexibility, identification of joints in order to evaluate and develop the degree of flexibility at their level, the influence of flexibility on increasing the quality of technical execution, competitive results and points obtained with the upper and lower limbs.

Also within the preliminary approach, the direction of research was decided through theoretical substantiation and the possibility of using emerging tools (Mobee Med, Dartfish, Sensor Medica Posturotest) was verified in order to achieve the basic research in good conditions, realized through an approach to improve flexibility and efficiency of mae geri, mawashi geri, yoko geri, ushiro geri attack techniques to improve sports performance in cadets and juniors by implementing an original training program.

In the case of the basic research, the degree of flexibility at the level of the scapulo-humeral joints, spine, acetabulofemoral, upper limbs, lower limbs, the dynamic flexibility specific to the foot techniques mae geri, mawashi geri, yoko geri, ushiro geri and the qualitative level of their executions, both the points obtained in the competitions with the upper and lower limbs and the performances of the cadets and juniors in the kata and kumite competitions were monitored. The

progress achieved compared to the initial testing was also analysed, as well as the yield of the training strategy applied within each training microcycle (30 minutes allocated to improving flexibility).
Following the implementation of our training strategy focused on the improvement of sports performances by educating the flexibility and efficiency of foot techniques, according to the statistical-mathematical analysis, the experimental group compared to the initial level shows a progress as follows:

- Flexibility at the level of the scapulohumeral joint
  - Flexion of the shoulder in the right sagittal plane. 14.45%; right 14.15%.
  - Extension of the shoulder in the right sagittal plane. 32.44%; right 31.06%.
  - Horizontal right abduction. 23.59%; right 23.31%.
  - Horizontal right adduction. 10.28%; right 9.63%.
  - left internal rotation. 26.37%; 24.94%.
  - External rotation left 21.20%; 20.03%.
- Flexibility in the upper limbs
  - Left flexion 10.11%; right 9.23%.
  - Extension left 155.56%; right 162.26%.
  - Supination left 16.91%; right 15.17%.
  - Left pronation. 15.05%; right 12.33%.
- Flexibility at the level of the hand joint
  - Left flexion 4.62%; right 4%.
  - Extension left 4.17%; right 3.16%.
  - Radial inclination left 7.76%; right 5.41%.
  - left ulnar inclination. 5.36%; right 4.76%.
- Flexibility in the spine Cervical area
  - Flexion 20.66%.
  - Extension 36.04%.
  - Lateral bending left 28.47%; right15.27%.
  - Turning the head left. 13.35%; right 9.57%.
- Flexibility at the spine level - dorsolumbar area
  - Flexion 16.90%.
  - Extension 88.10%.
  - Lateral bending left 29.62%; right 19.88%.
  - Twisting of the trunk left. 13.33%; right 9.99%.
- Flexibility at the acetabulofemoral joint level
  - Right hip flexion. 12.21%; right 7.87%.
  - left hip extension. 67.64%; right 43.53%.
  - left abduction 32.16%; right 23.27%.
  - left adduction 75.07%; right 45.66%.
  - External rotation left. 29.97%; right 27.97%.
  - left internal rotation. 32.14%; right 30.45%.
- Flexibility in the joints of the lower limbs
  - Left flexion 11.84%; right 9.26%.
  - Dorsal flexion of the right foot. 100.39%; right 65.33%.
  - Extension or plantar flexion of the right foot. 23.80%; right 20.63%.
  - Left inversion 242%; right 88,41.

The validity of our training program within the competitive macrocycle to improve flexibility is confirmed by the increase in the degree of flexibility at the level of the selected joints, the periodization of the training, the means and methods implemented facilitating the improvement of the performance of the female cadets and juniors involved in the experiment.
Regarding the analysis of the quality of the execution of foot techniques with the Dartfish 360 S computerized equipment, the angular values recorded the following progress:

Dynamic flexibility specific to foot techniques

- Bringing the leg forward up left. 17.29%; right 15.96%.
- Taking the leg through the upper left side. 26.69%; right 24.16%.
- Amplitude of technique executions: Mae Geri left 19.25%, right 18.98%; Yoko Geri left 18.40%, PhD 16.58%; Mawashi Geri left 14.95%, PhD 11.27%; Ushiro Geri left 18.20%, right 21.94%.

- Mae Geri
  - Reinforcement: ∢ trunk-thigh between 32-35%, ∢ thigh-calf between 45-46%, ∢ foot-calf between 16-17%.
- End of execution and speed of execution: ∢ trunk-thigh between 26-27%, ∢ thigh-calf between 16-20%, ∢ foot-calf between 17-19%.
- Mawashi Geri
  - Arming: ∢ torso-thigh between 19-22%, ∢ thigh-calf between 17-21%.
  - End of execution and speed of execution: ∢ trunk-thigh between 22-23%, ∢ thigh-calf between 19-22%.
- Yoko Geri
  - Arming: ∢ of inversion 20%.
  - End of execution and speed of execution: ∢ trunk-thigh between 15%, ∢ of inversion between 18-19%.
- Ushiro Geri
  - Arming: ∢ thigh-calf between 39-41%, ∢ foot-calf 33-34%.
  - End of execution and execution speed: ∢ trunk-thigh 24-25%, ∢ foot-calf between 27-31%.

As a result of the higher angular values resulting from the final testing, of the experimental group in relation to the control group, we validated the application of an isoinertial training plan with the help of Desmotec emerging stations (V.Full and D.Full), carried out during the competition calendar, for the development of dynamic flexibility and the efficiency of mae geri, mawashi geri, yoko geri and ushiro geri attack techniques, which through the implementation of means, methods and design led to the confirmation of the hypotheses of our scientific research.
The performance recorded at the level of the quality of the executions of the attack techniques performed with the lower limbs also validates our training strategy that can be followed by athletes, instructors and martial arts trainers in which the weight of physical, technical-tactical training is harmoniously completed with the 30 minutes improving flexibility and making the mae geri, mawashi geri, yoko geri, ushiro geri techniques more efficient within each training microcycle.
The clearly superior quality in terms of the execution of the foot techniques of the female athletes of the experimental group favourably influences the execution time as follows:

- 60.22% better execution of the Mae Geri technique led to an improved execution speed between 38-44%.
- 50.32% better execution of the Mawashi Geri technique increases execution speed by 32-44%.
- Technical execution streamlining by Yoko Geri results in 27-28% execution speed.
- Technical Execution Streamlining by Ushiro Geri improves execution speed between 26-27%.

The results obtained after measuring the Pearson correlation coefficient highlight some essential aspects:

- The directly proportional correlation between flexibility and the quality of executions.
- The influence of flexibility on points scored with the lower limbs in Shotokan karate competitions.
- The influence of flexibility on sports performance.

With the help of the implemented control samples and the statistical analysis programs, a series of correlations between the flexibility variables in relation to the qualitative level of the executions of the selected leg techniques were highlighted, but also correlations between the stages that make up the correct and efficient execution of the mae ger techniques, yoko geri, mawashi geri

and ushiro geri that lead us to propose an execution model, for researchers in the field, which emerges from the ameliorative research approach carried out. The landmarks of a biomechanical nature we propose are:

- ✓ For the execution of the Mae Geri technique (forward kick)
  - The reinforcement will be made at an angular value achieved by the trunk and thigh between 50^0 - 60^0 and between the foot and calf < 130^0.
  - Hit completion > 140^0.
  - Execution speed 0.50 second
- ✓ For the execution of the Mawashi Geri technique (the kick following a semicircular trajectory)
  - Reinforcement will be carried out at an angular value made by the torso and thigh
  - < 100^0.
  - Completion of shot >145^0.
  - Execution speed 0.60 seconds.
- ✓ For the execution of the Yoko Geri technique (kick to the side after a direct trajectory)
  - Reinforcement will be carried out at an angular value made by the torso and thigh < 125^0.
  - Completing the shot >140^0 with an inversion angle <130^0.
  - Execution speed 0.65 seconds.
- ✓ For the execution of the Ushiro Geri technique (back kick)
  - Reinforcement will be carried out at an angular value made by the thigh-calf <40^0 and foot <90^0.
  - Hit completion > 135^0.
  - Execution speed 0.60 seconds.

Another aspect pursued in our research approach was the monitoring of points scored with the lower limbs in kumite competitions. In order to achieve this, at our request, a box was inserted on the referee sheet in which the table referees, when recording the point obtained by the athlete, also specified the segment with which he scored.
Following the implementation of the original training program focused on the development of flexibility and the efficiency of the execution of foot techniques, the athletes of the experiment group recorded a special progress in terms of the points obtained with the lower limbs at the three competitions Kazumi Cup, Satori Cup and Takeshi Cup Bucharest as follows:

- ➢ Kazumi cup
  - 2021 points obtained with arm tech. 31; points obtained with tech. of foot 4
  - 2022 points obtained with arm tech. 36; points obtained with tech. of foot 47
- ➢ Satori cup
  - 2021 points obtained with arm tech. 47; points obtained with tech. of leg 3
  - 2022 points obtained with arm tech. 42; points obtained with tech. of foot 53
- ➢ Takeshi cup
  - 2021 points obtained with arm tech. 49; points obtained with tech. of foot 4
  - 2022 points obtained with arm tech. 47; points obtained with tech. of foot 88

The most points obtained with the lower limbs in the three competitions in 2022 were obtained by the athlete Puflea Cerasela from the experimental group: 5 points Kazumi Cup, 4 points Satori Cup and 9 points Takeshi Bucharest Cup representing a total of 18 points. The scores obtained broken down by groups, athletes, years and competitions can be analysed in the appendices.
A final element of analysis from the basic research was the monitoring of the performance of the experimental group in the kata and kumite competitions obtained following the implementation of the proposed training program, focused on improving the flexibility and efficiency of the attack techniques executed with the lower limbs (mae geri, mawashi geri, yoko geri and ushiro geri).
In order to achieve this, we proposed the following quantification scale: First place - 10 points, second place - 8 points, third place - 6 points, fourth place - 4 points, fifth place - 2 points.
Following the application of the ameliorative protocol, the experimental group recorded an increase in points from 182 in 2021 to 492 in 2022, and the control group from 172 points in 2021 to 200 points in 2022 (appendices).

Physical, technical, tactical, theoretical training in the direction of improving the flexibility and efficiency of the most used foot techniques in competitions (mae geri, mawashi geri, yoko geri and ushiro geri), constituted the road to success in achieving the goal of fundamental research.
By synthesizing the elements of progress highlighted previously we can conclude that the general hypothesis according to which, using emerging technologies (Mobee Med equipment and Dartfish 360 s sensor) we can obtain accurate and complex data regarding the level of development of flexibility and the quality of technical executions of the subjects subjected to research, and by implementing a flexibility development program adapted to the structure of the sports training lesson and preparation stages can increase sports performance, it was confirmed.
Since in the specialized literature there are premises and definitions regarding the influence of flexibility on sports performances but without a concrete study, our scientific research experimentally argues that by identifying the degree of flexibility with the help of emerging technologies (Mobee Med, Dartfish 360 S), by implementing a program focused on improving static flexibility (with the help of correctly selected actuation systems), dynamic flexibility and efficiency of foot techniques (through isoinertial training with the help of the emerging Desmotec equipment) in each training microcycle, sports performance can be improved.

Recommendations

In the practice of Shotokan karate style, flexibility is an absolutely necessary quality that involves increasing the range of motion in the upper and lower limbs in order to better exploit strength and speed.
A first step in the flexibility analysis process is to identify the degree of flexibility at the selected joints. For this purpose, we recommend the use of the Mobee Med digital tool, emerging equipment that is recognized by the Australian Department of Health. With its help we can quickly and accurately measure the level of static-active flexibility developed at the level of the joints having over 100 different measurement options, apart from the joints of the fingers and toes it offers a wide selection for most joints.
Mobee Med records the angular values obtained from the assessment of the range of motion, and as a digital companion, the system displays the measurements recorded throughout the research period and also makes the progress visible. The study of static flexibility is carried out by a compact device based on sensors with the help of which the evaluated athlete can follow his movement in real time, the examiner can enter additional information, active-passive and left-right comparisons are used in the evaluation. It can be used very easily because it is a portable equipment with no restrictions regarding the space of use, we can apply it both in the training room and outside, the only conditionality is related to the quality of the wireless reception.
Regarding the assessment of dynamic flexibility and the study of the execution quality of the mae geri, mawashi geri, yoko geri and ushiro geri techniques we recommend the emergent computerized equipment Dartfish 360 S which helps us through the work tools on the platform to analyse the biomechanics of the execution, the audio-video images, and permits to fix the markers at the level of the segments that interest us.
To develop flexibility in terms of strength and speed, we recommend inserting isoinertial training into the training process with the help of Desmotec emerging stations. This technology favours the improvement of the range of movements due to the maximum force at which the muscles work throughout the exercises, improves the flexibility of ligaments and tendons, and also prevents injuries.
We propose that in each microcycle of training after the technical-tactical weight, 30 minutes should be allocated to homework to improve flexibility because this approach leads to a special exploitation of strength and speed. We also recommend that in Shotokan Karate Do dojos through the aspect of systematic and scientific training we ensure the improvement of all the elements that lead to a special sporting form of a karate-ka, including flexibility.

CHAPTER 18. ELEMENTS OF NOVELTY AND ORIGINALITY, LIMITS AND DIRECTIONS OF RESEARCH, VALUATION OF RESEARCH RESULTS

In the process of theoretical documentation, we found that studies on the implementation of emerging technologies in flexibility analysis are few in number in our country but also in the specialized literature from other countries. In doctoral schools in the country, scientific papers were supported in the field of karate but without addressing flexibility from this perspective, thus demonstrating that our research aligns with the rigor of a doctoral thesis in terms of elements of novelty and originality.

The identified correlations between flexibility and the quality of technical executions, the influence of flexibility on the points obtained with the lower limbs and implicitly on the competitive performances of female cadets and juniors provide new information to Shotokan Karate Do specialists.

The original way of working out the mesocycles and microcycles within the annual training macrocycle, the implementation of 30 minutes aimed at improving flexibility at the end of each fundamental structure of sports training lessons, the emerging means and applied methods for the efficiency of mae geri, mawashi geri, yoko geri techniques and ushiro geri can be novel elements illustrating the originality of our idea of training and improving sports performance by educating static and dynamic flexibility

Another new element of our research is the implementation of the emerging tool Mobee Med in the analysis of active static flexibility in the context where digitalization invades the sports environment imposing itself in the teaching-learning-evaluation process. The use of Mobee Med in our research approach represents a pioneering action in the sense that it is the first time in Romania that this equipment is used in this scientific research, and in this sense, there is a collaboration and exclusivity contract concluded between our doctoral school and the holder of this software, the Superfit Clinic from Bucharest, valid until the end of the doctoral cycle.

The Dartfish 360 S computer software used in the study of the execution stages of the mae geri, mawashi geri, yoko geri and ushiro geri techniques represents a novelty for the Shotokan karate Do discipline, following the analysis of the specialized literature in our country or in the international sphere, it has never been identified a similar scientific paper.

The approach to isoinertial training in order to improve flexibility in strength and speed regime with the help of emerging Desmotec stations (D.Full, V.Full) also constitutes an element of originality and pioneering in the context of our discipline. We also see as novelty and elements of originality: the description of the technical execution model with the benchmarks and values specified in the conclusions of the basic research, the elaboration and presentation of the annual training plan for cadets and juniors, including the realization of the content of the opinion questionnaire implemented in the preliminary scientific approach with the aim of highlighting the importance of flexibility and methodologies to improve it.

We consider a contribution aimed at improving the existing theoretical information baggage in our field of activity the following: the emerging assessment equipment implemented in research, the design of control samples intended to score the degree of flexibility of the cadets and juniors practicing Shotokan Karate Do.

Following the exhaustive investigation of the elements related to our scientific approach, we still recognize that there are a number of aspects that have slowed down, limited our research and implicitly the transmission to the spheres of interest of a larger and more accurate amount of information for the Shotokan Karate discipline Do.

Among the limiting factors we mention: the state of emergency and alertness in the context of the prevention and spread of Covid 19 which generated the cancellation of some competitions as well as the closing of sports halls, the small number of clubs, athletes, coaches willing to participate in our research, high costs for the purchase emerging technologies (software, computerized assessment tools and improving flexibility), costs to be able to read articles from international publications, limited number of articles to correlate with our research direction and also limited number of libraries to hold scientific materials with a sports theme for Shotokan Karate focused on cadets and juniors.

Regarding the limiting aspect of the emerging technologies used in our investigative approach, we mention the fact that the Mobee Med digital tool cannot assess dynamic flexibility nor the flexibility of the phalanx joints. The Dartfish 360 S computerized software does not three-dimensionally assess biomechanical landmarks. The kinematic analyses carried out with the emerging equipment are very precise, but unfortunately in our country they are very few in number, making it rather difficult to carry out evaluations as often as possible and on a considerable number of subjects. Therefore, the monitoring of the degree of performance, especially for beginners and semi-advanced, will have to be carried out by means and methods that are as accessible as possible.

As research directions we propose:

- ✓ The identification of unexplored research niches, emerging equipment to influence the technical-tactical sphere specific to the Shotokan KarateDo discipline.
- ✓ The evaluation of national cadet and junior teams with digital tools to identify the degree of flexibility at the level of body joints.
- ✓ Improving flexibility by implementing isoinertial training at the level of national cadet and junior teams.
- ✓ Monitoring the results of national cadet, junior teams in the context of the influence of flexibility on international competitive results.
- ✓ The analysis of the quality of the techniques performed with the upper limbs (our research focusing only on the lower limbs) with the help of emergent technologies used in our research but also with other kinematic analysis technologies such as MOVEN.
- ✓ The use of Mobee Med and Desmotec in the recovery of some joints.
- ✓ The use of Desmotec in the strength development of Shotokan karate practitioners (Desmotec being used in our research to improve flexibility).
- ✓ Using the emerging technologies used in our research to improve the laterality of Shotokan karate practitioners.
- ✓ The implementation of our program to improve sports performance by developing flexibility with the help of emerging technologies and in national cadet and junior teams.
- ✓ The influence of our proposed program for improving static and dynamic flexibility on the quality of life of Shotokan karate practitioners.

The results obtained from the investigative actions carried out at the experimental and control group level, as well as the methodological strategies aimed at improving sports performance by developing flexibility, will be disseminated through the creation of specialized scientific articles supported in conferences, symposia, profile workshops and published in BDI indexed journals. We also want to make the results of the research known within the scientific sessions; the training courses organized by the Romanian Federation of Martial Arts (F.R.A.M).

In the future, we intend that the emerging technologies used in our scientific approach, the data obtained as a result of objective analyses, the strategies for identifying and improving the degree of flexibility can be found in a methodical guide that supports performance sports in the field of interest of the Shotokan Karate discipline Do.

The findings of current scientific research have been disseminated in national and international conferences, BDI indexed journals, as follows:

1. The study on the dynamics of physical and motor development in high school students, Dunărea de Jos University Scientific Conference of the Doctoral Schools 7th Edition, Cojocaru Marius, Mereuță Claudiu- 2019.
2. Development of specific flexibility of leg techniques in karate (mae geri,yoko geri, mawashi geri,ushiro geri), Dunărea de Jos University Scientific Conference of the Doctoral Schools 7th Edition,Cojocaru Marius, Mereuță Claudiu - 2019.
3. Development of body mobility in karate practices (cadets and juniors), Dunărea de Jos University Scientific Conference of the Doctoral Schools 7th Edition; Cojocaru Marius, Mereuță Claudiu, Enoiu Răzvan Sandu, Talaghir Laurențiu Gabriel, Ganea Daniel- 2019.
4. Development of Specific Mobility of Karate Technologies; ,,Sport, education, culture - interdisciplinary approaches in scientific research"; Marius Cojocaru, Claudiu Mereuță- 2019.
5. “Theoretical study on the identification and neutralization of the causes that lead to the wrong execution of karate foot techniques”, Dunărea de Jos University Scientific

Conference of the Doctoral Schools 8 th Edition,Cojocaru Marius, Mereuță Claudiu Ganea Daniel – 2020.

6. "Study on identifying and neutralizing the causes that lead to the wrong execution of shotokan karate foot techniques in cadets and juniors using classical methods", Dunărea de Jos University Scientific Conference of the Doctoral Schools 8 th Edition,Cojocaru Marius, Mereuță Claudiu Ganea Daniel- 2020.
7. "Analytical study on the dynamics of physical, functional and motor development in beginners of shotokan karate practices, cadets and juniors", Dunărea de Jos University Scientific Conference of the Doctoral Schools 8 th Edition,Cojocaru Marius, Mereuță Claudiu Ganea Daniel- 2020.
8. Development of body mobility in karate practices (cadets and juniors), Ovidius University of Constanța- International Scientific Conference Perspectives in Physical Education and Sport 21 th edition Cojocaru Marius, Mereuță Claudiu, Iordan Daniel-Andrei – 2021.
9. Analytical study on the dinamic of physical, functional and motrical development to beginner practitioners of karate shotokan, cadets, Transilvania University International Scientific Conference Youth in the Perspective of the Olympic Movement Cojocaru Marius 2021.
10. Analytical study on the dynamics of physical, functional and motor development in beginners of shotokan karate practices, Dunărea de Jos University Scientific Conference of the Doctoral Schools 9 th Edition, Cojocaru Marius - 2021.
11. Study on improving the mobility of the body of shotokan karate practitioners with the help of emerging technologies cojocaru marius, mereuță claudiu. The 5th Edition of the International ConferenceSEC – IASR 2021"Sports, Education, Culture - Interdisciplinary Approaches in Scientific Research" 28th – 29th MAY, Cojocaru Marius – 2021.
12. Study on measuring and educating flexibility in karate practitioners using emerging technologies, , Dunărea de Jos University Scientific Conference of the Doctoral Schools 9 th Edition, Cojocaru Marius, Mereuță Claudiu - 2022.
13. Study on measuring and evaluating coxofemural joint flexibility in karate practitioners using emerging technologies, , Dunărea de Jos University Scientific Conference of the Doctoral Schools 9 th Edition, Cojocaru Marius, Mereuță Claudiu - 2022.
14. Cojocaru, M., Mereuță, C. and Iordan, D. (2020) "Development of static-active flexibility specific to Shotokan karate foot techniques", Annals of "Dunarea de Jos" University of Galati. Fascicle XV ISSN – 1454 – 9832 – 2020; ISSN – L 1454 - 9832, Physical Education and Sport Management, doi: https://doi.org/10.35219/efms.2020.2.04.
15. Mocanu G. D, Iordan, D. A, Mocanu M. D, Cojocaru M, Nechifor A. (2021). Investigation of plantar pressure and plantar imbalances in the static phase of karate do athletes. Balneo and PRM Research Journal, 12(2), 133-144, doi:10.12680/balneo.2021.433.
16. Cojocaru, M., Mereuță, C. and Iordan, D. (2021). Development of body mobility in karate practices (cadets and juniors), Ovidius University Annals, Series Physical Education and Sport/Science, Movement and Health, Vol.XXI, ISSUE 2 Supplement 2021.
17. Cojocaru, M., Mereuță, C. and Iordan, D. (2021). Analytical study on the dynamic of physical, functional and motrical development to beginner practitioners of karate shotokan, cadets and juniors, Bulletin of theTransilvania University of Braşov Series IX: Sciences of Human Kinetics • Vol. 14(63) No. 2 – 2021 https://doi.org/10.31926/but.shk.2021.14.63.2.5.
18. Cojocaru, M., Mereuță, C. and Iordan, D. (2022). Study on Measuring and Evaluating Shoulder Joint Flexibility in Karate Practitioners using Emerging Technologies, Bulletin of theTransilvania University of Braşov Series IX: Sciences of Human Kinetics • Vol. 15(64) No. 1 – 2022. https://doi.org/10.31926/but.shk.2022.15.64.1.11.

BIBLIOGRAFIE

1. *** 2006, Dictionary of Sport and Exercise Science, Published by A&C Black, London
2. Abdel-Rahman, M.E., Hefzy, M.S., 1998, *Three-dimensional dynamic behavior of the human joint under impact loading*, Medical Engineering& Physic
3. Abernethy, B. et al., 2013, *Biophysical Foundation of Human Movement,* Human Kinetics
4. Abu Ilius Faisal , Sumit Majumde, Tapas Mondal , David Cowan ,Sasan Naseh and M. Jamal Deen, *Monitoring Methods of Human Body Joints: State-of-the-Art and Research Challenges,* 2019, MDPI, Disponibil la: https://www.mdpi.com/1424-8220/19/11/2629/htm
5. ACADEMIA ROMÂNA,1998, *Dicţionarul explicativ al limbii române, Institutul de Lingvistică "Iorgu Iordan"*, Editura Univers Enciclopedic, Bucureşti
6. Achim, A. ,2002, *Karate-do spirit şi filozofie*. Editura Orient, București
7. Ackland, T., Elliot, B. C., Bloomfield J., 2009, *Applied anatomy and biomechanics in sport*, Human Kinetics, Champaign, IL
8. Adrian, N., Ionescu, A., Mazilu V., 1968 , *Creșterea normală și dezvoltarea armonioasă a corpului*. Editura CN. Pentru EFS
9. Alexei, M., 2006, *Abordarea interdisciplinară în sport*, Napoca Start, Cluj-Napoca
10. Allard-Latour, E., Rannou J. , Kermarrec , G.,Université de Bretagne Occidentale, France, 2022, *Adolescent girls' and boys' situational interest for a learning task in physical education*, Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 6), Art 170, pp. 1356 - 1362, June 2022 online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES.Disponibil la: https://efsupit.ro/images/stories/iunie2022/Art%20170.pdf
11. Allen, M. C., și Capute, A. J., 1990, *Ton și dezvoltare reflexă înainte de termen*, Pediatrie, 85(3), 393-399
12. Alter, M. 1998, *Sciense of Stretching*, Leissure Press
13. Amălinei, N., 2006, *Curs Practic de Karate Do*, Editura Polirom
14. Amălinei, N., Ichim, V., 2010, *Shotokan Karate do – kumite*, Editura Shogun Center, Iaşi
15. Anderson, R.A., Guttman, H.N., 1992, *Exercise, Nutrition and Energy Metabolism*, Editura Macmillan, Pub
16. Apostu, M.,2003, *Modificările biochimice induse de efortul fizic*, Editura Arvin, București
17. Appleton,B.,1998, *Streching and Flexibility*, Version: 1.42, Last Modified 98/06/10
18. Ardelean V., De Hillerin P.J., Bidiugan R., 2014, *Study on the possibility of high light in ginvariants of motion in martial arts kata exercises*, Arena – Journal of Physical Activities, no.3: pp.87-94
19. Ardelean, G., Filipaș, I., 2003, *Biomecanica exerciţiilor fizice şi sportului*, Editura Daia, Satu Mare
20. Ardelean, V.P., de Hillerin, P. J., Bidiugan, R., 2014, *Study on the possibility of highlighting invariants of motion in martial arts kata exercises*, Arena - Journal of Physical Activities no. 3/2014, (87-97), Editura Universitatii Aurel Vlaicu, Arad
21. Arnold, G.N., Juoko K., Jason, M.,2011, *Stretching Anatomy*, Editura Human Kinetics
22. Atanasiu, C., L., 1988, *Particularitățile de creștere la copii și juniori și valorificarea lor în antrenament*, Rev. E.F.S.
23. Atanasiu, C., L., 1988, *Unele aspecte privind dezvoltarea calităților motrice la copii și juniori,* Rev. E.F.S.
24. Avramescu T., E., 2006, Kinetoterapia în activități sportive, Editura didactică și pedagogică.
25. Baenninger,R., Binkley S., Baenninger , M., *Field observations of yawning and activity in humans*, Psychonomic bulletin & review, [1997, 4(2):198-207]
26. Balint&Diaconu, et al, *Evaluarea aparatului locomotor*, 2007.
27. Balsalobre-Fernández, C., Martinez-Majolero, V., Villacieros-Rodriguez, J., & TejeroGonzález, C. M. (2013). *Diferencias en el salto vertical y la velocidad de patada mae-geri entre karatekas internacionales y nacionales*. Revista de Artes Marciales Asiáticas, 8(1), 13–20

28. Baroga, L., 1984, *Educarea calității fizice combinate*, Editura Sport-turism, București.
29. Barris, S., & Button, C. (2008). *A review of vision-based motion analysis in sport. Sports* Medicine (Auckland, N.Z.), 38(12), 1025–1043
30. Barth, B.,1995, *Pregătirea pentru competiție printr-un antrenament strategic-tactic complex*, Leistungssport nr.1, trad.CCPS, SDP nr.362-3-4
31. Basile A., 1994*, Karate – sau cum să te aperi cu succes când ești atacat*, Editura Universul & Calistrat Hogas, București
32. Beaulieu, J.E., 1980, *Stretching pentru toate sporturile*, Pasadena: Athletic Press.
33. Behm. B.G., 2018, *Science and Physiology of Flexibility and Stretching,* Editura Tylor&Francis Ltd.
34. Bernstei, N.,A., 2007, *Coordonarea mişcărilor în ontogeneză*, ANPS, INCS, Bucureşti
35. Bertolucci ,L.F., 2011, *Pandiculation: nature's way of maintaining the functional integrity of the myofascial system*, National Library of Medicine
36. Bertolucci LF. *Pandiculation: nature's way of maintaining the functional integrity of the myofascial system?* Bodyw Mov Ther. 2011 Jul;15(3):268-80.: 10.1016/j.jbmt.2010.12.006. Epub 2011 Jan 14. PMID: 21665102. pubmed.ncbi.nlm.nih.gov/21665102
37. BIOMOTRIC. Sistemul informatic integrat pentru cercetarea paramentrilor de biomotricitate în populația tânără din România, Ministerul Educației Naționale și Cercetării Științifice. Disponibil la : http://www.biomotric.ro/
38. Blakemore S-J.,: *Misterioasele căi ale creierului adolescent.* TED Global, 2019. Disponibil la: https://www.ted.com/talks/sarah_jayne_blakemore_the_mysterious_workings_of_the_adolescent_brain/transcript?language=ro.
39. Brown, D., Jennings, G., and Molle, A. (2009). *Exploring Relationships between Asian Martial Arts and Religion.* Stadion-Internationale Zeitschrift.
40. Bomba T. O., 2010, *Teoria şi metodica antrenamentului. Periodizarea*, Ediția a 4-a, Editura Tana, Curtea de Argeș
41. Bompa, T., 2001, *Dezvoltarea calităţilor biomotrice – periodizarea*, MTS, ŞNA, Bucureşti
42. Bompa,T.O., Buzzichelli, C., 2021, *Periodizarea. Teoria si metodologia antrenamentului,* Editura Librys, București
43. Bordes, B., Salmeron P., 1995, *Evaluarea calităților motrice*, Revue education physique et sport, nr. 251.
44. Bosco, G., 1993, *O nouă metodă de evaluare și programare a antrenamentului*. Sportul de performanță nr. 337, București.
45. Bosco, G.,1996, *Aspecte fiziologice ale antrenamentului forței explozive în special în sportul de elită* Atletica studii, nr. 1.
46. Bota, A., 2007, *Kinesiologie*, Ed. Didactică şi Pedagogică, Bucureşti
47. Bota, C., 2000*, Ergofiziologie*, Editura Globus, București
48. Boțoacă (Pătru) N. Maria-Luminița, Îmbunătățirea performanței în karate-do prin educarea bilateralității la începători, Teză de doctorat, Bucureşti, 2018
49. Bucher, H.G.,1998, *Karate-do Artă marțială și sport*, Editura Mirador, Arad
50. Budescu E., 2013, Biomecanica generală, Universitatea Gheorghe Asachi, Iaşi
51. Budescu,E.,2013, *Biomecanică generală*, Curs
52. Bull J. Stephen, 2011, *Psihologia sportului. Ghid pentru optimizarea performanțelor*, Ed.Trei, București
53. Buzescu, A., Scurtu, L. 1999, *Anatomia omului: Aparatul locomotor*, Editura Alexandru 27, București
54. Cavanagh, P. R., & Landa, J. 1976, A *biomechanical analysis of the karate chop*, The Research Quarterly, 47, 610–618.
55. Cârstea, G. ,2000, *Didactica educaţiei fizice*, ANEFS, Bucureşti
56. Cârstea, Gh. ,1999, Educaţia fizică - fundamente teoretice şi metodice. Casa de editură Petru Maior, Bucureşti.
57. Chan, S. (2000). *The construction and export of culture as artefact: the case of Japanese martial arts.* Body Soc. 6, 69–74. doi: 10.1177/1357034X00006001005.
58. Chananie, J., 1999, *The physics of karate strikes, Journal of how things work, vol 1*

59. Chatzopoulos, Galazoulas, Patikas, Kotzamanidis*, Acute effects of static and dynamic stretching on balance, agility, reaction time and movement time, Journal of Sport,2014. Science and Medicine, 13 (2): 2014m 403–409;*
60. Chiriță, A., 2008, *Curs de Neuropsihologie*, Universitatea din București, Facultatea de Psihologie și Științele Educației.
61. Chou, L., Link, N., G., 2011*, The Anathomy of Martial Arts, Editura Ulysses Press*
62. Cochran, S., 2001, *Complete conditioning for Martial Arts*, Human Kinetics, USA
63. Cohen, L. A. (1954). *Organizarea reflexului de întindere în două tipuri de arcuri spinale directe*. Revista de neurofiziologie, 17(5), 443-453.
64. Cohen, L. A.,1953, *Localizarea reflexului de întindere*. Jurnalul de Neurofiziologie, 16(3), 272-285.
65. Concetto, G., 2010, *Physics of Karate. Kinematics analysis of karate techniques by a digital movie camera*, Lat. Am. Phys. Educ. Vol.4, No.1, Jan. 2010
Copyright © 1993-1998 by Bradford D. Appleton.
66. Corbin, C.B., Noble, L. ,1980, *Flexibility: a major component of physical fitness*, The Journal of Physical Education and Recreation, 51, 23-24, 57-60.
67. Contiero, D., Kosiewicz, J., and Baker, J. S. (2018). *Karate: emotions and movement anticipation.* Phys. Cult. Sport Stud. Res. 79, 62–71. doi: 10.2478/pcssr-2018-0021
68. Cordun, M. ,2009, *Kinantropometrie,* Ed. CD PRESS, București,
69. Cordun, M., 2011 – *Bioenergetică şi ergometrie în sport*, Editura CD Press, Bucureşti
70. Cordun, M.,1999, *Postura corporală normală şi patologică*, Editura ANEFS, Bucuresti, Davis, M., Eshelman, E.R., McKay, M. (2019). *The Relaxation an Stress Reduction Workbook,* New Harbinger Publications, Inc.
71. Cushing, L. (2013). *Spirituality and Wellness.* (Ph.D. Thesis), Creighton University (USA).
72. Deliu, D., 2008*, Antrenamentul sportiv în disciplinele de combat,* Editura Bren, București
73. Deliu, D*.,* 2008*, Metodica disciplinelor de combat,* Editura Bren, București
74. Demeter, A. ,1981, *Bazele fiziologice şi biochimice ale calităţilor motrice,* IEFS
75. Demeter, A. ,1979, *Fiziologia și biochimia educației fizice și sportului*, IEFS.
76. Deshimaru, T., *Zen et Arts martiaux*, Edition Albin Michel, Paris, 1982
77. Dragnea, A. (coord.),2002, *Teoria educaţiei fizice si sportului*, Editura Fest, Bucureşti
78. Dragnea, A., 1996, *Antrenamentut sportiv*, Editura Didactică și Pedagogică, Bucureşti
79. Dragnea, A., Bota, A., 1999, *Teoria activităţilor motrice*, Editura Didactică şi Pedagogică, Bucureşti.
80. Dragnea, A., Teodorescu, S. ,2002, *Teoria Sportului*, Editura Fest, Bucureşti.
81. Draxler, T., Ostermann, H., and Honekamp, W. (2010). *Relationship between Asian martial arts and health-related quality of life in Germany.* J. Public Health 19, 57–64. doi: 10.1007/s10389-010-0343-9.
82. Dumitru, I.F., 1989, *Hormonii corpului omenesc, organismelor animale și vegetale*. Universitatea din București
83. Dworak, L., B., Dziewiecki, K., & Maczynski, J. 2005, *Characteristichs of kinematics and kinetics of strokes in karate –Biomechanical approach*, 23 International Symposium on Biomechanics in Sports, p 109-112, Disponibil la: https://ojs.ub.unikonstanz. de/cpa/article/download/848/775
84. Egami, S., 1992, *The way of Karate Beyond Technique,* Kodansha Int.Ltd.,Tokyo
85. *Enciclopedia educației fizice și sportului din România*, 2002,vol. 1-4, Editura Aramis, București
86. *Enciclopedia pentru tineri – Sporturile*,2001, Editura Rao, București
87. *Encyclopedia of Body Image and Human Appearance*, Volume 2. Disponibil pe https://www.sciencedirect.com/book/9780123849250/encyclopedia-of-body-image-and-human-appearance#book-info
88. Enoka, R. M., 1988, *Control of Muscle Force*, in H. K. Books (Ed.),
89. Epuran, M., 1968, *Psihologia sportului*, Editura. Sport-turism, Bucureşti
90. Epuran, M., 2013, *Motricitate şi psihism în activităţile corporale*, Vol.II, Editura FEST, Bucureşti
91. Epuran, M., Stănescu, M., 2010, *Învățarea motrică – aplicații în activități corporale*, Editura Discobolul, București

92. Epuran,M., Holdevici, I., Toniță, F., 2008, *Psihologia sportului de performanță*, Editura Trei, București
93. Epuran,M., Holdevici,I. , 1993, *Psihologie- compediu pentru antrenori*, Ed. Sport-turism,Bucureşti
94. Etnyre, B.R., Abraham, L. D., 1988, *Antagonistic muscle activity during stretching: a reevaluated paradox,* Medicine and Science in Sport and Exercise, 20, 285-289
95. Federația Română de Chanbara . Disponibil la: https://spochan.ro/index.php/istoric
96. Federația Română de Taekondo WT. Disponibil la: https://taekwondowt.ro/
97. Feldenkrais, M., 1949, *Body and mature behaviour: a study of anxiety, sex, gravitation and learning.* New York : International Universities Press
98. *Flexibility, control and power,* 2008, Sports Performance Bulletin
99. Frederic L., 1993, *Dicţionar de arte marţiale*, Editura Enciclopedică,
100. Free University of Bozen-Bolzano,2017, *Martial arts and adolescents: Using theories to explain the positive effects of Asian martial arts on the well-being of adolescents*. Disponibil la: https://www.researchgate.net/publication/315836097_Martial_arts_and_adolescents_Using_theories_to_explain_the_positive_effects_of_Asian_martial_arts_on_the_well-being_of_adolescents
101. French, D. N., Kraemer, W. J., & Cooke, C. B., 2003, *Changes in dynamic exercise performance following a sequence of preconditioning isometric muscle actions, Journal of Strength and Conditioning Research*, 17(4), 678-685.
102. Funakoshi, G., 1974, *Karate-Do Kyohan*, Published by Kodansha Internațional Ltd. Printed in Japan.
103. Funakoshi, G., 1981, *Karate-do My Way of Life*, Kodansha International, Tokyo, Japan
104. F*unakoshi*, G., 1988, *Karate-Do Nyumon*, Published by Kodansha Internațional Ltd. Tokyo & New York. Printed in Japan
105. Golla, F. L., Antonovitch, S., 1929, *Relația tonusului muscular și reflexul rotulian cu munca mentală*, Journal of Mental Science, 75(309), 234-241.
106. Goodman, F., 2010, *The ultimate book of martial arts*, Hermes House, London
107. Gorgy, O., Vercher, J., Coyle, T., 2008, *How does practice of internal Chinese martial arts influence postural reaction control?* Journal of Sports Sciences, 2008, vol 26, n. 6, p. 629 – 642, Disponibil la: http://www.ncbi.nlm.nih.gov/pubmed/18344134
108. Green, T. A., 2001, *Martial arts of the world: an enciclopedia*, Published by ABC_CLIO, Inc., Santa Barbara, California
109. Gummerson,T., 1990, *Mobility Trening for the Martial Arts*, A & C Black Publishers Ltd
110. Guy Sauvin, 1986, *Karate de la tehnique de base au combat*, Edition Primatice, Paris
111. Hagele,W., 1992, *Lumea sportului - Problema definirii conceptului de sport. în: Sportul de performantă* nr. 330-331,C.C.P.S. Bucureşti
112. Hanna, Th. L., 1980, *The Body of Life: Creating New Pathways for Sensory Awareness and Fluid Movement*, Knopf
113. Hanna, Th. L., 1988, *Somatics: Reawakening the Mind's Control of Movement, Flexibility, and Health*, Da Capo Press
114. Hanna, Th. L., 1995, *What is Somatics?* In Don Hanlon Johnson, ed., *Bone, Breath and Gesture*. 341–53. Berkeley: North Atlantic.
115. Hans J. Markowitsch, Angelica Staniloiu,2011, *Amigdala în acțiune: transmiterea semnificației biologice și sociale memoriei autobiografice*, Neurophologie, Volumul 49, numărul 4
116. Hassel, Randell G., 2007, *Shotokan Karate: Its History and Evolution*, Empire Books
117. Hawkins, J., L., 2012, *The martial arts: An introduction to the arts*
118. Healy, K., 2008, *Martial Art Basic:Karate*, Grange Books, UK
119. Holdevici,I., Vasilescu, P.,1988, *Autodepăşirea în sport*, Ed. Sport-turism, Bucureşti

120. Holdevici,I., 1992, *Psihologia succesului*, Ed. Ceres, Bucureşti
121. Holland,L., Henk W. de Regt, Drukarch,B., *Thinking About the Nerve Impulse: The Prospects for the Development of a Comprehensive Account of Nerve Impulse Propagation*. Frontiers in Cellular Neuroscience. Disponibil la : https://www.frontiersin.org/articles/10.3389/fncel.2019.00208/full
122. Holland, G.J., 1968, *The physiology of flexibility: a review of the literature*, Kinesiology Review, 49-62.
123. Hollander, J. A. (2004). "I Can Take Care of Myself ": the impact of selfdefence training on Women's lives. Violence Against Women 10, 205–235. doi: 10.1177/1077801203256202.
124. Holt, L.E., Travis, T.M., Okita, T. ,1970, *Comparative study of three stretching techniques. Perceptual and Motor Skills*, 31, 611-616.
125. Horghidan, V. ,2000, Problematica psihomotricităţii. Editura Globus, Bucureşti
126. Hung-Ta, C. & Tzyy-Yuang S., 1999, *A new approach to evaluate karate punch techniques, Disponibil la: https://ojs.ub.unikonstanz.de/cpa/article/viewFile/4052/3751*
127. Iacobini, M., 2008, *The Mirror Neuron Revolution: Explaining What Makes Humans Social*,-interviu în Scientific AmericanTM. Disponibil la: http://www.scientificamerican.com/article.cfm?id=the-mirror-neuronrevolut
128. *Illustrated Guide to the Muscle Used for each Strike, Kick and Throw*, Ulysses Press, Berkeley, CA, p 18 – 21
129. Impact of Static Stretching on Performance. Phisiopedya. Disponibil la: https://www.physio-pedia.com/Impact_of_Static_Stretching_on_Performance
130. Institul Hanna Somatics. Hystory an Founder. Disponibil la: https://hannasomatics.com
131. Isopescu, F., Momani, R., 2011, *Determinismul pubertății*, Revista medicală română, Volumul LVIII, nr.. 3
132. Iuliana-Alina Sprânceană, Florina -Claudia Ghițulescu, *Biologie*, 2019, Editura Ars Libri
133. Izquierdo, M. ,2004, *Maximal strength and power, muscle mass, endurance and serum hormones in weightlifters and road cyclists.* Sports Sci. May;22(5):465-78.
134. Jakobson,E., 1978, *You Must Relax: Practical Methods for Reducing the Tensions of Modern Living,* McGraw-Hill
135. Jinga, G. ,2010,*Interdisciplinaritatea în educație fizică și sport*, Ed.ASE
136. Kahneman, D.,2015, *Gândire rapidă, Gândire Lentă*, Editura Publică
137. Kanazawa, H., 1981, *Shotokan Karate Internațional Kata* (vol.1),SKI Suzuden building1-10,Tokyo 160, Japan
138. Kanazawa, H., 1987, *SKI Kumite Kyohan*. Printed în Japan.
139. Kandel, Eric R. (2007), In Search of Memory: The Emergence of a New Science of Mind, New York: W. W. Norton & Company,
140. Karlson, P., 2006, *Manual de biochimie*, Ed. Medicală, București
141. Kay AD, Blazevich AJ., 2012, *Efectul întinderii statice acute asupra performanței musculare maxime: o revizuire sistematică.* Medicine & Science in Sports & Exercise.Ian 2012 : 44(1) :154-164.
142. Karpovich, P.V. , 2009, *Physiologie de l'activite musculaire*, Ed. Vigot, Paris
143. Kempo, Federația Română. Istoric. Disponibil la: http://www.frkempo.ro/ro/page/istoric-3
144. Kono, T., 1982, *Karate*, Editura Niro, Hamburg
145. Kravitz, LR, 1980, *A comparative analysis of variable proprioceptive neuromuscular facilitation, controlled over time, slow-hold-hold-relaxation stretching to active assistance stretching.* Master's thesis, San Jose State University.
146. Kumpf, C. I. R. (2018). *Wellness and Karate*. Ph.D. Dissertation, Duquesne University, Pittsburgh, PA.
147. Lambu , E. , 2013, *Strategii de dirijare a pregătirii tehnico-tactice în karate do în vederea optimizării performanțelor sportive*, Teză de doctorat, UNEFS București

148. Layton, C., 1993, *Reaction + Movement time and sidedness in shotokan karate students. Perceptual and Motor Skills*, vol 76, n.3, p. 765– 766. Disponibil la: http://dx.doi.org/10.2466/pms.1993.76.3.765
149. Lechoslaw, B., Dworak, C., Dziewiecki, K., Maczynski,J. 2005, *Characteristics of cinematics and kinetics of strokes în karate -Biomechanical approach*, 23 International Symposium on Biomechanics in sports, p. 109 – 112. Disponibil la: https://ojs.ub.unikonstanz.de/cpa/article/view/848/775
150. Lee D.T., Swinnen S.P., Serrien D., 1994, *Cognitive effort ant motor learning*, Rev. Quest, nr.46
151. Lewis, P., 1996, *Introducere in arte martiale – origini, filosofie,Practica*, Editura Teora, Bucuresti
152. Lian N.,Yamashita T. Niz, Takahashi M., Murakami T.,Yahagi s., et al., 2008, *Temporal modulation of agonist and antagonist muscle activities accompanying improved performance of ballistic movements*, Hum Mov Sci 2008, 27(1), p12–28
153. Liebermann, D. G., Katz, L., Hughes, M. D., Bartlett, R. M., McClements, J., & Franks, I. M. ,2002, *Advances in the application of information technology to sport performance,* Journal of Sports Sciences, 20(10), 755–769
154. Link, N., Chou, I., 2011, *The Anatomy of martial arts – An illustrated guide to the muscle used in key kicks, strikes & throws*, Ulyses Press, Berkeley
155. Litvan, I., Mangone, C. A., Werden, W., Bueri, J. A., Estol, C. J., Garcea, D. O., ... & Bartko, J. J.,1996, *Fiabilitatea scării reflexului miotatic,* NINDS.Neurologie, 47(4), 969-972.
156. Macoveanu D., 1998, *Karate kata aspect metodice ale antrenamentului pentru competiția de kata*, Editura Garell, București
157. Macovei, S., 2011, *Kinantropologie – particularități și capacități motrice în ontogeneză*, cursul nr.9 București
158. Magill R., 1994, *The influence of augumented feedback on skill learning depends on characteristics of the skill and the learner*, Rev. Quest, nr. 46, 314-327.
159. Mainland, M. (2010). *Martial Mind: Examining the Relationship Among Martial Arts Participation, Identity, and Well-Being. (Ph.D. Thesis), University of Waterloo (Canada).*
160. Matthews, C. R., and Channon, A. (2016). *Understanding sports violence: revisiting foundational explorations. Sport Soc. 20, 751–767. doi: 10.1080/17430437.2016.1179735.*
161. McCaughey, M. *(1997). Real Knockouts: The Physical Feminism of Women's SelfDefence. New York, NY: NYU Press.*
162. McCaughey, M. *(1998). The fighting spirit: Women's selfdefence training and the discourse of sexed embodiment. Gender Soc. 12, 277–300. doi: 10.1177/089124329801200 3003.*
163. McCorkle Jr., William W.,2010, *Ritualizing the Disposal of the Deceased: From Corpse to Concept*, Peter Lang
164. McLeod,S., 2018, *Erik Erikson's Stages of Psychosocial Development*. SimplyPsychology. Disponibil la : https://www.simplypsychology.org/Erik-Erikson.html
165. Medical dictionary. Disponibil la: https://medical-dictionary.thefreedictionary.com/ballistic+stretching
166. Miyamoto Musachi, 2000, *Cartea celor cinci cercuri*, Gorin-no-Sho, Editura Polirom, Iași
167. Nakayama M., 1977, *Best karate*, Editura Kodansha Int. Ltd., Tokyo
168. Nakayama M., 1986, *Dynamic karate, Kodansha America*, Inc. 1986
169. Neagu, N., 2012, *Motricitatea Umană Fundamente Psihopedagogice*, Editura University Pres,Târgu Mureș.
170. Negulescu, C.I. 2007, *Sistemul de comunicare interumană* (sinteze documentar-bibliografice). ANEFS, București.
171. *Neuromechanical Basis of Kinesiology*, p. 155-178, Champaign
172. Nicu, A., 1993 *Antrenamentul sportiv modern*, Editura Editis, București
173. Niculescu, M., 2003, *Metodologia cercetării ştiinţifice în educaţie fizică şi sport*, vol. I.Editura Bren, București.

174. Nishiyama,H., Brown, R., 1992, *Karate the art of ,,empty hand"fighting*, Rutland, Vermont. Charles e: Tuttle Company: Tokyo, Japan
175. Nörenberg, R., 1981,*Scrisoare către Charlotte Selver*. Buletinul Fundației Charlotte Selver: Elsa Gindler, 1885-1961, Vol. 10 (II)