TMG: Today and Future

ISOT 2014

INTERNATIONAL SOCIETY OF TENSIOMYOGRAPHY

Descrierea CIP a Bibliotecii Naţionale a României

TMG : TODAY AND FUTURE. Conferinţă internaţională (2014 ; Roma)
TMG : today and future : ISOT 2014 : International Society of tensiomyography : Rome, 24th October 2014 / ed.: Srdjan Djordjevic. - Craiova : Universitaria, 2014
ISBN 978-606-14-0860-3

I. Djordjevic, Srdjan (ed.)

61(063)

TMG: Today and Future
ISOT 2014
INTERNATIONAL SOCIETY OF TENSIOMYOGRAPHY
Rome, 24th October 2014

Srdjan Djordjevic (editor)

TMG: Today and Future

ISOT 2014
INTERNATIONAL SOCIETY OF TENSIOMYOGRAPHY

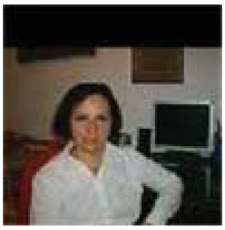
Rome, 24th October 2014

Organizators:
TMG-BMC, Slovenia
Sports Medicine and Kinesiology Department - University of Craiova, Romania

Editura Universitaria Craiova

Editura UNIVERSITARIA
Craiova, 2014

CO-CHAIRS



Ligia Rusu
University of Craiova
Romania

Brief Bio

Ligia Rusu – Professor, M.D.PhD., Department of Sports Medicine and Kinesiology, University of Craiova Fields of scientific interest: medicine, rehabilitation and physical therapy, sports medicine, biomechanics, physiology. Publishing activity: 30 papers in ISI or other journals indexed in International Databases, 6 invited lectures in International conferences, author and co-author of 8 books. Participation in research contracts (national and international): 8 as director, 3 as member of the research team. Director of Research Centre-Study of Human Body Motricity. Patent: „Portable system for assessment and rehabilitation of ankle foot", nr. OSIM: 104628/ 19.08.2009 Membership of professional bodies/ international recognition: member of European Association of Sports Medicine, research member of ECOSEP committee, Romanian Sports Medicine Society, reviewer for Diabetes Research and Clinical Practice, Service Science and Management Research. Expert for evaluation FP7-ESF-Exploratory Workshop calls 2011,2012. Researcher profile: http://cis01.central.ucv.ro/educatie_fizica-kineto/departamente.html

David Rodriguez-Ruiz
University of Las Palmas de Gran Canaria
Spain

Brief Bio

David Rodríguez-Ruiz – Assistance Professor, Ph.D., Department of Physical Education (Faculty of Sciences of Physical Activity and Sport), University of Las Palmas de Gran Canaria (Canary Island – Spain) Fields of scientific interest: Sport Training, Performance Training, Healthy and Physical Activity, Physical Activity for Elderly, Biomechanics. Publishing activity: More than 35 papers in ISI or other journals indexed in International Databases, 3 invited lectures in International conferences, author and co-author of 4 books. Participation in research contracts (national and international): 1 as director, 5 as member of the research team. Coordinator of Laboratory of Analysis and Planification of Sport Training (LAPED). Membership of professional bodies/ international recognition: member of European Group for Research into Elderly and Physical Activity (EGREPA), member of Spanish Society of Geriatric and Gerontology (SEGG), member of "Physical Activity and Health" expert committee of National Council of College Graduates in Sciences of Physical Activity and Sport, research member of Canaries Alzheimer Association, reviewer for 10 international journals and member of scientific committee of two international journals, External researcher of EUM group and UCAM group. Researcher profile: https://www.researchgate.net/profile/David_Rodriguez-Ruiz/contributions/?ev=prf_act Related Experiences: Organize and direct ULPGC International Conference on ULPGC

Scope:

Tensiomyography(TMG) is a method of muscle assessment that has gained popularity in recent years because of its simplicity, non invasive, reliability and high performance. Its progressive introduction into the area of health and training has caused an increased interest of researchers has allowed a deeper knowledges of the tool and its utilities. As a result, the number of scientific publications that have appeared over the three last years has increased exponentially and the areas of focus have been diversified. The dynamics of adaptations to load in muscles and tendons are different. Understanding their mechanical loading behavior during different sport activities is a necessary step toward more efficient adaptation processes in training and sports pathology management.

Do we have enough information to reduce musculoskeletal disorders?

Jemec Jure ; Đorđevič Srđan
Slovenia

Abstract. Musculoskeletal disorders are one of the biggest burdens of modern humanity. Total cost of musculoskeletal disorders can reach 3,4% of gross domestic product. There are four major musculoskeletal disorders and low back pain is the biggest of them. Low back pain is nonspecific pathology and can be caused by a large number of reasons. Effective methods to diminish conditions for low back pain have not been well developed at this point and also clear indication criteria for low back pain have not yet been determined. The key question concerning low back pain is, do we have relevant information about skeletal muscles, to be able to diminish conditions for low back pain? Whatever methodology would be used it must be selective, functional, valid, repeatable, non-invasive and simple to use. The aim of this review is to evaluate Tensiomyography as potential methodology that could be used in order to find critical points of each individual to avoid injury with preventive treatment. Tensiomyography is non-invasive, selective functional muscle diagnostic method that has very high repeatability. The review showed that Tensiomyography can be used to detect critical points to diminish conditions for low back pain. Furthermore Tensiomyography can contribute to optimize the process of rehabilitation and physical recovery of patients. In the future Tensiomyography will need more clinical studies in order to further develop basic characteristic models and crucial indication parameters.
Key words- *Musculoskeletal disorders, osteoarthritis, rheumatoid arthritis, osteoporosis, lower back pain, Tensiomyography, Fiber type, repeatability, validity, simplicity, critical points*

1. Introduction

Musculoskeletal disorders are one of the biggest burdens of modern humanity. There are four major musculoskeletal conditions: osteoarthritis, rheumatoid arthritis, osteoporosis and lower back pain. Osteoarthritis (lost joint cartilage that leads to pain and loss of function in the knees and hips) affects 9.6% of men and 18% of woman aged > 60 years [1]. Rheumatoid arthritis is an inflammatory condition that usually affects multiple joints. It affects 0.3–1.0% of the general population and is more prevalent among women and in developed countries [1]. Osteoporosis, which is characterized by low bone mass and micro architectural deterioration, is a major risk factor for fractures of the hip, vertebrae, and distal forearm. Hip fracture is the most detrimental fracture, being associated with 20% mortality and 50% permanent loss in function [1]. Lost ability to move is considered as one of the biggest reasons for osteoporosis. Low back pain is the most prevalent of musculoskeletal conditions; it affects nearly everyone at some point in time and about 33% of the population at any given point [1]. Disease-related costs, from a societal perspective, were measured in Canada, year 1994, using prevalence based analysis. The results showed the total cost of musculoskeletal disorders in Canada was 3.4% of the gross domestic product [2]. Gross domestic product in European Union in 2012 was €12.899 trillion and 3,4% of gross domestic product in European Union represents €438,566 billion.

2. Low back pain and diagnosis

2.1 *Low back pain*

Low back pain is a considerable health problem in all developed countries and is most commonly treated in primary healthcare settings. It is usually defined as pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain (sciatica). The most important symptoms of non-specific low back pain are pain and disability.

2.2 *Cause of low back pain*

Low back pain is not specific symptom and can be caused by a large number of reasons like ageing, losing bone strength, change of muscle tone and elasticity, muscle sprain or similar. Most of low back pain follows injury to the back, but pain may also be caused by degenerative conditions such as arthritis, disc disease or others. Latest studies indicate that individual back muscle asymmetry could be one of the main reasons for low back pain. Back muscle asymmetry might also be caused by non back muscle functional asymmetry such as Gluteus muscles, Hamstring muscles, Quadriceps muscles or facial muscles.

2.3 Prevention of low back pain

Effective methods to diminish conditions for low back pain have not been well developed [3]. Exercise is probably effective in preventing recurrences in those with pain that has lasted more than six weeks. [4] [5] There is little to no evidence that back belts are any more helpful in preventing low back pain than education about proper lifting techniques[6] [7]. Clear indication criteria for low back pain have not yet been determined.

2.4 How is low back pain diagnosed

A variety of diagnostic methods are available. *X-ray imaging* includes conventional and enhanced methods that can help diagnose the cause and site of back pain. *Computerized tomography (CT)* is a quick and painless process used when disc rupture, spinal stenosis, or damage to vertebrae is suspected as a cause of low back pain. *Magnetic resonance imaging (MRI)* is used to evaluate the lumbar region for bone degeneration or injury or pathology in tissues and nerves, muscles, ligaments, and blood vessels. *Electrodiagnostic procedures* include electromyography (EMG), nerve conduction studies, and evoked potential (EP) studies. EMG assesses the electrical activity in a nerve and can detect if muscle weakness results from injury or a problem with the nerves that control the muscles. *Bone scans* are used to diagnose and monitor infection, fracture, or disorders in the bone. Thermography involves the use of infrared sensing devices to measure small temperature changes between the two sides of the body or the temperature of a specific organ. Ultrasound imaging, also called ultrasound scanning or sonography, uses high-frequency sound waves to obtain images inside the body. Electromyography is the only selective method that was used but EMG devices don'r measure muscle function and still has too high variability.

3. Tensiomyography

The key question we can have concerning low back pain is do we have relevant information about skeletal muscles to be able to diminish conditions for low back pain? What kind of information about skeletal muscles would be of high importance? Whatever methodology would be used it must be selective, functional, valid, repeatable, non-invasive and simple to use. Several attempts were made, but there is no indication that selective functional muscle diagnostic would be used in order to diagnose or manage low back pain.

The aim of this review is to evaluate Tensiomyography as potential methodology that could be used in order to find critical points of each individual and to avoid injury, or if they have already occurred, to identify them with certainty and to prescribe a personalized recovery until the injury is completely recovered.

Tensiomyography (TMG) is measuring used for monitoring radial muscle belly displacement under isometric conditions. Latest studies showed that radial muscle belly displacement is of big importance since changes in the radial distance between the actin and myosin filaments, the filament lattice spacing, are responsible for between 20% and 50% of the change in force. Thus, lattice spacing is a significant force regulator, increasing the slope of muscle's force–length dependence [8].

Tensiomyography was developed in the Laboratory for bioelectromagnetics (LBM) at the Faculty of Electrical engineering, University of Ljubljana, Slovenia. The displacement sensor is positioned perpendicularly to the tangential plane on the largest area above the muscle belly. The muscle belly displacement (enlargement) during contraction is observed and monitored [9] [10].

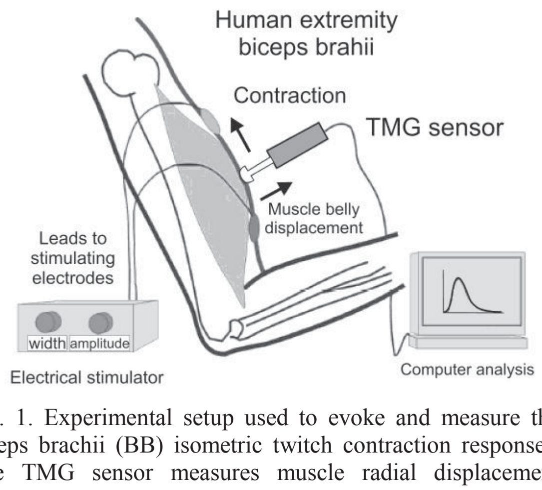


Fig. 1. Experimental setup used to evoke and measure the biceps brachii (BB) isometric twitch contraction responses. The TMG sensor measures muscle radial displacement during twitch contractions induced by short electrical stimuli. The stimulating electrodes are placed directly onto the skin.

Muscle contraction is elicited by single-twitch electrical stimuli. Two self-adhesive electrodes is placed symmetrically around the TMG sensor. The anode is placed distally and the cathode proximally, 20-50 mm from the measuring point. Bipolar ES consisted of a single DC pulse of 1 ms in duration. A typical TMG record with parameters and definitions is shown in Figure 1. The measured parameters are shown in Figure 2. These parameters are the maximal amplitude of the signal (Dm), the delay time from the stimulation to 10% of the maximal contraction (td), the time of contraction from 10% to 90% of the maximal contraction (tc), the time of sustained contraction from 50% contraction to 50% of the relaxation (ts) and the relaxation time from 10% relaxation to 50% relaxation (tr).

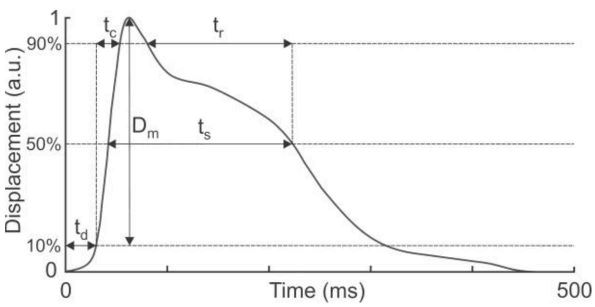


Fig. 2. (a) The parameters that were measured with the TMG signal: Dm – maximum amplitude (displacement), td – initial delay time, tc – contraction time, ts – sustained contraction time and tr – half relaxation time.

4. Evaluation of tensiomyography concerning low back pain

Tensiomyography can be used as an accurate noninvasive predictor of the %MHC-I in a muscle [11] this is one of the crucial conditions for prevention of low back pain since information on muscle fiber type composition is of great importance in muscle physiology.

Tensiomyography is fast, user friendly was and repeatable diagnostic [12] [13] [14].

Tensiomyography was used to monitor pre and post operative muscles adaptation of ACL reconstruction rehabilitation process. The resoults demonstrates different pattern of adaptation for each skeletal muscle necessary to assure knee joint stability. It is very important to have selective information about skeletal muscles when evaluating low back pain patients, since we need a model to explain the alterations of back muscle recruitment due to low-back pain. It is proposed that motor control changes in patients are functional in that they enhance spinal stability.

It is important for tensiomyography that information can be obtained through a non-invasive method, without any effort of the subject. Regarding the low back pain, it can be even better by optimizing the process of rehabilitation to dose the load and intensity of work, or to detect local muscle fatigue as a changed ability to activate muscle fibres. Moreover, one can control the muscle properties and to detect any change in the same muscle, due to a recent injury or an inadequate amount of work demonstrated as local muscle fatigue. This information can be of great interest in the process of postoperative recovery.

5. Conclusion

Tensiomyography can be used to detect critical indication points to diminish conditions for low back pain. Furthermore Tensiomyography can contribute to optimize the process of rehabilitation and physical recovery of patients. A simple methodology is an important factor for the feasibility of the method. In addition, it is objective, non-invasive, rapid and selective, and can give repetitive information. The characteristics of the equipment allow assessing the data with great mobility and interpretation of resouolts can be made automatically. Further studies are needed in order to implement Tensiomyography as a helpful tool to improve prevention and management of low back pain.

References:

1. Woolf, A. D., &Pfleger, B. (2003). Burden of major musculoskeletal conditions. *Bulletin of the World Health Organization*, 81(9), 646–656.
2. Coyte, P. C., Asche, C. V., Croxford, R., & Chan, B. (1998). The economic cost of musculoskeletal disorders in Canada. *Arthritis Care and Research: The Official Journal of the Arthritis Health Professions Association*, 11(5), 315–325.
3. Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., Buchbinder, R. (2012). A systematic review of the global prevalence of low back pain. *Arthritis and Rheumatism*, 64(6), 2028–2037.
4. Choi, B. K., Verbeek, J. H., Tam, W. W.-S., & Jiang, J. Y. (2010). Exercises for prevention of recurrences of low-back pain. The Cochrane Database of Systematic Reviews, (1), CD006555.
5. Chou, R., Qaseem, A., Snow, V., Casey, D., Cross, J. T., Shekelle, P., American Pain Society Low Back Pain Guidelines Panel. (2007). Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Annals of Internal Medicine*, 147(7), 478–491.

6. Guild, D. G. (2012). Mechanical therapy for low back pain. *Primary Care*, 39(3), 511–516.
7. Sahar, T., Cohen, M. J., Uval-Ne'eman, V., Kandel, L., Odebiyi, D. O., Lev, I., Lahad, A. (2009). Insoles for prevention and treatment of back pain: a systematic review within the framework of the Cochrane Collaboration Back Review Group. *Spine,* 34(9), 924–933.
8. Williams, C. D., Salcedo, M. K., Irving, T. C., Regnier, M., & Daniel, T. L. (2013). The length-tension curve in muscle depends on lattice spacing. *Proceedings. Biological Sciences / The Royal Society*, 280(1766), 20130697.
9. Valencic, V., &Knez, N. (1997). Measuring of skeletal muscles dynamic properties. *Artificial Organs*, 21(3), 240–242.
10. Dahmane, R., Valencic, V., Knez, N., &Erzen, I. (2001). Evaluation of the ability to make non-invasive estimation of muscle contractile properties on the basis of the muscle belly response. *Medical & Biological Engineering & Computing*, 39(1), 51–55.
11. Simunič, B., Degens, H., Rittweger, J., Narici, M., Mekjavić, I. B., &Pišot, R. (2011). Noninvasive estimation of myosin heavy chain composition in human skeletal muscle. *Medicine and Science in Sports and Exercise*, 43(9), 1619–1625.
12. Krizaj, D., Simunic, B., &Zagar, T. (2008). Short-term repeatability of parameters extracted from radial displacement of muscle belly. *Journal of Electromyography and Kinesiology*, 18(4), 645–651.
13. Tous-Fajardo, J., Moras, G., Rodríguez-Jiménez, S., Usach, R., Doutres, D. M., &Maffiuletti, N. A. (2010). Inter-rater reliability of muscle contractile property measurements using non-invasive tensiomyography. *Journal of Electromyography and Kinesiology*, 20(4), 761–766.
14. Simunič, B. (2012). Between-day reliability of a method for non-invasive estimation of muscle composition. *Journal of Electromyography and Kinesiology*, 22(4), 527–530.

Corresponding authors address
Jure Jemec is CEO of TMG-BMC d.o.o., Splitska 5, 1000 Ljubljana, Slovenia, Europe,
e-mail:jure.jemec@tmg.si web: www.tmg.si ;
Srđan Đorđević is head of R&D of TMG-BMC d.o.o., Splitska 5, 1000 Ljubljana, Slovenia, Europe,
e-mail:srdjandj@tmg.si

Voluntary vs Non-voluntary muscle contractile explosivity: RFD vs RMTD as a possible new TMG parameter

Milivoj Dopsaj[1], Jelena Ivanović[2], Nemanja Ćopić[3]
[1] *University of Belgrade Faculty of Sport and Physical Education, Serbia*
[2] *Serbian Institute of Sport and Sport Medicine, Belgrade, Serbia*
[3] *Faculty of Sport, Belgrade, Serbia*

Abstract. The aim of the study was to examine correlation between isometric Rate of force development (RFD) as a voluntary, and Rate of muscle tension development (RMTD), as a non-voluntary, explosive contractile muscle characteristics variables. Sample of 49 healthy and high fitness level adults were tested using by two standard procedures: TMG and isometric dynamometric methods - unilateral leg press test. Five RFD variables and five RMTD muscle groups' variables was correlated. According to the males, results showed statistically significant positive correlation between RMTD at vastus lateralis and medialis, and rectus femoris with early rate RFD variable (up to 200 ms muscle contraction interval), while at the females results showed statistically significant negative correlation between RMTD at vastus lateralis and medialis, rectus and biceps femoris, and gluteus maximus with early, as well as, with late RFD variable (up to 200 ms, and over to 200 ms muscle contraction interval, respectively).
Key words: *Muscle tension,isometric, force development, tensiomyography, force explosivity*

1. Introduction

One of the physical ability characteristics dominant to achieving top sports results in most sports is the ability of muscle to achieve the most possible intense contraction.

The intensity of muscle contraction in isometric muscle working regime we can describe as a achieved level of isometric muscle force in relation of time and it can be calculated from F-t relation. The intensity of isometric muscle contraction should be measured by variable RFD – rate of force development, and it is expressed in N/s.

New technology for detecting skeletal muscles' contractile properties, well known as TMG – tensiomyography, belongs to the unique non invasive technological procedure [6]. TMG standard technological procedures allow measuring the following five standard non voluntary muscle contraction characteristics variables as following: delay time of muscle contraction – Td; muscle contraction time – Tc; muscle contraction sustain time - Ts; muscle contraction relaxation time – Tr, all of it's expressed in ms; and maximal muscle displacement – Dm, expressed in mm.

The aim of the study is to define relations between voluntary and non-voluntary explosive contractile properties of leg muscle.

We hypothesized that mechanic muscle contractile mechanism should be strongly related, no matter of whether the muscle contraction process initiated by voluntary or non voluntary electrical impulses.

2 Methods

2.1 Subjects sample

The subjects sample consisted of 49 healthy and high fitness level adults, where 30 was a males (Ages = 28.2±6.9 yrs., BH = 186.8±6.4 cm, BM = 87.1±10.0 kg, and BMI = 24.9±2.2 kg•m^{-2}), and 19 was a females (Ages = 24.4±3.8 yrs., BH = 177.9±11.7 cm, BM = 67.6±9.1 kg, and BMI = 21.2±1.5 kg•m^{-2}).

The male structure of the sample was as follow: 17 were Physical education students, 9 was high level athletes and 4 was well trained non-athletes. The female structure of the sample was as follow: 4 were Physical education students, 11 was high level athletes and 4 was well trained non-athletes. In line with the Helsinki Declaration and ACSM's guidelines for exercise testing and prescription [1], the participants formally agreed to participate in this research and signed informed consent approved by the Faculty of Sport and Physical Education Ethics Committee for Testing Trails (University of Belgrade, Belgrade, Serbia).

2.2 Testing procedures

The isometric muscle force F-t characteristics were measured through a standard unilateral leg press test [3, 5]. We selected the isometric leg press test instead of the frequently applied standard unilateral isokinetic and isometric tests of individual muscle groups for two main reasons. First, it measured the F-t characteristics of leg extensors through a single unilateral maximal trial, which is very similar to the maximum stimulation of the muscle contraction with the TMG method. Second, in addition to its relative simplicity, single leg press position could also have the property of ecological validity because of the leg position that closely corresponds to the leg posture during most common sports movement, as well as, running, one leg hop jumping, changing movement direction during agility running, one leg vertical jumping, etc. [7].

Subjects were seated on a bench of a custom-designed leg press device with their hip, knee, and ankle extension angles at 110°, 120°, and 90°, respectively. They were specifically instructed to exert their maximal force both as strong and as quickly as possible. Subjects performed 4 consecutive trials of force exertion lasting maximally 4 seconds with 1 minute of rest between them. The trial with the highest maximum isometric voluntary force (F) was taken for other analyses. Straingauge transducers recorded the force-time series at a rate of 2,000 Hz [3, 5]. The data were digitized (National Instruments) and recorded for further analysis.

The TMG skeletal muscles contractile characteristics were measured through a standard manufacturer procedure [6].

2.3 Variables

The isometric F-t variables used in this study were selected according to the previous theory of different muscle force explosivity characteristics, as well as: early and late RFD variables [2, 3, 4, 5]. RFD variables was:

Late RFD variables -

1. RFD_{Fmax}, rate of force development at maximal muscle force, for right (R) and left (L) leg, expressed in Newton's per seconds (N/s);
2. $RFD10\_90_{Fmax}$, rate of force development calculated from the 10 to 90% intercept of F_{max} and the proportional time for that particular force intercept interval, for right (R) and left (L) leg, expressed in Newton's per seconds (N/s);

Early RFD variables -

3. $RFD_{50\%}$, rate of force development at 50% of achieved maximal muscle force, for right (R) and left (L) leg, expressed in Newton's per seconds (N/s);
4. RFD_{100ms}, rate of force development realized at 100 ms of maximal isometric muscle contraction, for right (R) and left (L) leg, expressed in Newton's per seconds (N/s);
5. RFD_{max}, maximal achieved level of rate of force development realized during maximal unilateral leg press, for right (R) and left (L) leg, expressed in Newton's per seconds (N/s).

The TMG variable used in this study were calculated as a ratio from following two: muscle contraction maximal displacement variable – Dm (expressed in mm), and muscle contraction time – Tc (expressed in ms). The experimental variable was named as: rate of muscle tension development – RMTD (expressed in mm/ms), and hypothetically should assess non voluntary provoked intensity of muscle tension as analogy for intensity of muscle contraction.

Muscles which were under the TMG measurement was those one dominantly involved in leg pres position, as well as following:

1. Right and left Biceps femoris – BF_R, and BF_L;
2. Right and left Gluteus maximus – GM_R, and GM_L;
3. Right and left Vastus lateralis – VL_R, and VL_L;
4. Right and left Vastus medialis – VM_R, and VM_L;
5. Right and left Rectus femoris – RF_R, and RF_L;
6. Right and left Gastrocnemius – GC_R, and GC_L.

2.4 Statistical analyses

All row data's were undergo to basic descriptive analysis for calculating variables mean values and standard deviation. For defining relations level between RFD and RMTD variables we used the Pearson's correlations analysis. All statisticall procedures were carried out by the Microsoft Office Excel and SPSS for Windows, Release 17.0, where p values vas set at 0.05.

3. Results

The Table 1 show descriptive statistical data's for all variables. Tables 2, 3, 4 and 5 show results of correlation analyses between RFD and RMTD variables.