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PRELIMINARY PROGRAM

29 October 2020, Thursday

Institute of Mechanics-BAS, hall 510

9:30 – 10:00 **Registration**

10:00 – 10:20 **Opening Session**
Welcome addresses

10:30 – 11:10 **Plenary lecture**
Chairman: S. Nikolov

St. Stoytchev, I. Ivanov, S. Ranchev, I. Iotov
A review of the biomechanics of synovial joints with emphasize to static stretching exercise

11:10 – 11:30 **Break**

11:30 – 12.50 **Session № 1**
Chairman: **St. Stoytchev**

11:30 – 11:50 **R. Raikova, V. Krasteva, P. Krutki, H. Drzymała-Celichowska, K. Kryściak, J. Celichowski**
Influence of synchronization of motor units firings on muscle force variability

11:50 – 12:10 **G. S. Nikolova, M. Tsveov, D. Dantchev**
CAD design of a new 3D geometrical model of the human body

12:10 - 12:30 **M. Kirilova-Doneva, D. Pashkouleva**
Methods for experimental characterization of mesh explants

12:30 – 12:50 **D. Chakarov, I. Veneva, P. Venev**
Simulation and experiments of a hybrid actuated exoskeleton for assistance and rehabilitation

12:50 – 14:00 **Lunch Break**

14:00 – 15:40 **Session № 2**
Chairman: **I. Yotov**

14:00 – 14:20 **M. Avramova, E. Avramov**
Analysis and assessment of the sports readiness of handball players (12-14 years) from the Sports School “Gen. Vladimir Stoychev"

14:20 – 14:40 **V. Panayotov**
Comparative analysis of body composition and dimensions of experienced Olympic weightlifters, powerlifters and bodybuilders

14:40 – 15:00 **L. Trenev**
Impact through the activities with different types of sports included in the "Children's camp on arts and sports 2020" organized by the student district on the physical activity of children 9-12 years old after the pandemic by COVID 19

15:00 – 15:20 **S. Ilieva- Sinigerova, K. Kolev, M. Konchev, B. Zlatev**
Research of morpho-anthropometric signs at 13-18 years of taekwon-do competitors

15:20 – 15:40 **S. G. Nikolov, M. Nenov, J. Vera**
Investigation of a kinetic model reproduced the mechanisms of oligodendrocytes differentiation

15:40 – 16:40 **Session № 3**
Chairman: **G. Nikolova**

15:40 – 16:00 **I. Ivanov, N. Antonova**
Kinetics of blood coagulation and the electrical conductivity as a marker for the properties of the blood clot

16:00 – 16:20 **V. Paskova, N. Antonova, I. Velcheva, N. Chaushev, H. Chalakov**
Non-invasive assessment of blood flow disorders and regulation of microvascular tone during local heating and cooling by wavelet analysis of the skin temperature fluctuations in patients with type 2 diabetes mellitus

16:20 - 16:40 **A. Alexandrova, N. Antonova, A. Muravyov, K. Khristov, I. Velcheva**
Effects of erythrocyte aggregation and deformability on the adhesion of leukocytes in patients with type 2 diabetes mellitus

16:40 – 17:00 **Closing Session**
Chairman: **St. Stoytchev**

30 October 2020, Friday

Culture program
Sofia free tour -10:30 – 14:00

Plenary lecture - abstract

A review of the biomechanics of synovial joints with emphasize to static stretching exercise

S. Stoytchev[1], I. Ivanov[1,2], S. Ranchev[1], I. Iotov[2]
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[2]*National Sports Academy "Vassil Lefski", 1700 Sofia, Bulgaria*

Abstract

Stretching is defined as movement applied by an external and/or internal force to increase muscle flexibility and/or range of motion of the joint. Numerous studies have found that static stretching affects both the mechanical and neurological properties of the muscle-tendon block, leading to increased musculoskeletal flexibility, rigidity, Yung's modulus, and relaxation of stress in the system. The use of MRI in research has made it possible to clarify *in vivo* some processes in the joint capsule, such as reducing the thickness of cartilage when the knee is loaded with a force of up to 150% of body weight. On the other hand, however, what happens inside the joint during active isometric stretching, as far as we know, has not been studied and clarified. Recently, Ranchev et al. *(On the biomechanical processes in human knee joint during active isometric stretching. Series on Biomechanics, Vol. 33, No. 3, 56-61, 2019*) reported a preliminary study for changes in the volume of the knee joint capsule during active isometric stretching. The results showed a change in the distance between the cartilage surface of the femur and the corresponding end of the tibia during active isometric 2-minute stretching. This change of the distance between the femur and the tibia bones might be attributed to certain processes inside the joint cavity and, therefore, needs of more detailed analysis of biomechanical processes inside the joint cavity. This review aims to clarify some of them, to formulate new boundary-value problems and to design mechanical methods for evaluating the muscle forces during the stretching exercise.

The review involves: rheological behavior of synovial fluid, composition of articular cartilage, mechanical behavior of articular cartilage, permeability of articular cartilage, constitutive modeling of articular cartilage, effects of stretching exercises on skeletal muscles, and dynamic interaction problems inside articular cartilage. These problems involve the utilization of classical fluid mechanics of viscoelastic, biphasic porous mixture, and filtration. Finally, we outline some unresolved problems in the experimental verification and modeling of articular cartilage and synovial fluid in their dynamic interactions.

Keywords: biomechanics of synovial joint, stretching exercise, poroviscoelastic material, filtration

List of abstracts

Effects of erythrocyte aggregation and deformability on the adhesion of leukocytes in patients with type 2 diabetes mellitus

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[1]*Dept. of Biomechanics, Institute of Mechanics, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[2]*Dept. of Medicine and Biology, State Pedagogical University, Yaroslavl, Russia*
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[4]*Clinic of Nervous Diseases, University Hospital, Panagyurishte, Bulgaria*

The aim of study was to investigate *in vitro* the possible relationships between the microrheological properties of blood (erythrocyte aggregation and deformability) and leukocyte adhesion, in patients with type 2 diabetes mellitus (T2DM) and in healthy individuals, using a system with flow microchamber (FMC).

Whole blood samples from patients with T2DM (n=15) and healthy donors (n=15) were used to prepare diluted suspensions from erythrocytes in solution of Dextran 250 (Dx 250). These samples

were used to determine the erythrocyte aggregation index (EAI) and erythrocyte elongation index (EEI). Diluted suspensions (in Dx 250) from leukocytes were explored for measurement of leukocyte adhesion index (LAI) and diluted suspensions - containing both erythrocytes and leukocytes, were used for evaluation of the effects of erythrocyte aggregation and deformability on the leukocyte adhesion.

The results obtained show that in patients with T2DM the EAI was increased, the EEI was decreased and the LAI was increased - at shear rates in the range from 0 s^{-1} to 0,61 s^{-1}.

As a result of a parallel study of erythrocyte aggregation and leukocyte adhesion in suspensions of the two cell types - erythrocytes and leukocytes, a stimulating effect of the erythrocyte aggregation on the leukocyte adhesion was established. This effect was more pronounced in patients with T2DM, than in healthy subjects and is associated with increased leukocyte adhesion as a result of increased erythrocyte aggregation. The opposite effect is also observed - the increased leukocyte adhesion leads to a decrease in erythrocyte aggregation. This effect is also more pronounced in patients with diabetes than in healthy individuals in suspensions of both cell types – erythrocytes and leukocytes.

There was an effect of the erythrocyte deformability on the leukocyte adhesion - this effect is expressed in an increase in leukocyte adhesion, as a result of reduced erythrocyte deformability, in patients with T2DM. The opposite effect, which is associated with the effect of leukocyte adhesion on erythrocyte deformability, was weakly expressed in both diabetic and control patients.

Acknowledgements: The financial support of the Bulgarian National Science Fund (Project for Basic Research – 2018; No. КП-06-Н27/13): "Development of experimental microfluidic system and methodology for assessing microrheological properties of blood. Analysis of the peripheral vasomotor reactivity and vascular endothelial function in patients with type 2 diabetes mellitus" is gratefully acknowledged.

Analysis and assessment of the sports readiness of handball players (12-14 years) from the Sports School "Gen. Vladimir Stoychev "

M. Avramova, E. Avramov
National Sports Academy "Vassil Lefski", Dept."Basketball, Volleyball and Handball", 1700 Sofia, Bulgaria

Abstract

In recent years, modern handball requires a high level of mastery of basic technical and tactical techniques, handball athletics and mental resilience. The skillful combination of these important components of the game requires from an early age to overcome the difficulties in the constantly changing game situations.

The permanent control of the physical development and the specific readiness of the adolescent handball players gives an opportunity to receive information about the current state of the main signs of physical development and technical-tactical readiness. On this basis, through comparative analysis there is an opportunity for rational optimization of the training process.

The purpose of this study is to improve the sports training of students from the sports school "Gen. Vladimir Stoychev "- Sofia through analysis and evaluation of the main parameters of their specific performance.

Keywords: handball, physical fitness, specific working capacity

Simulation and experiments of a hybrid actuated exoskeleton for assistance and rehabilitation

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Abstract

In this paper, an upper arm exoskeleton for assistance and rehabilitation is studied. An appropriate solution is sought for the exoskeleton design and actuation that provides transparency and

natural safety as well as sufficient force and performance. To achieve this, a hybrid actuation with back-drivable electric and pneumatic drives is used. A hybrid actuation controller is introduced, in which pneumatic drive takes care of the initial force response, and the electric drive complements the pneumatic drive. The paper presents mechanical structure and actuation of exoskeleton with parallel pneumatic and electric drive. An approach for dynamic estimation of elastic propulsion in the second joint through imposed motions is used. The influences of the inertial, frictional, gravitational, and elastic forces that resulted from the hand and the exoskeleton impedance are reported. Harmonic motion with a uniform frequency in the second joint is simulated. In the passive mode, the resistive torque of the device impedance is seen as the interaction force that is applied to the patient's hand. The low values of this force, that are obtained without active control guarantee security and transparency. In the active mode, the resistive torque is used to assign force commands to the electric drive to perform feedforward compensations. Experimental evaluations of the interaction force between the patient and the exoskeleton are performed. Here, the force of the interaction as a result of the gravity and the elastic properties of the exoskeleton are evaluated. Transparency is assessed in different cases, depending on active or passive control modes. Finally, conclusions and future work are given.

Research of morpho-anthropometric signs at 13-18 years of taekwon-do competitors

S. Ilieva- Sinigerova, K. Kolev, M. Konchev, B. Zlatev
National Sports Academy "Vassil Levski", 1700 Sofia, Bulgaria

Abstract

The purpose of the present study was to define the morpho-anthropometric signs of 13-18 years old taekwon-do ITF athletes. The study included 68 taekwon-do athletes (male n=42 and female n=26) at the age 13-18 years (males 14,49±1,96 years and females 14,48±1,93 years) and years of training 1 to 10 from 8 local taekwondo clubs in Bulgaria. Parameters were assessed as: absolute amount and percentage of body fat, active body mass, absolute amount of body weight, hip and cheekbone corrected circumference and arm and hip muscular circumference.

The mean values of indexes at 13-18 years old males are: amount of muscular mass (21,17±1,79), active body mass (3,91±4,72), absolute amount of body weight (62,64±16,72), arm muscular circumference (25,50±5,57), hip muscular circumference (49,34±5,99). The mean values of indexes at 9-12 years old females are: amount of muscular mass (21,11±2,98), active body mass (5,80±4,10), absolute amount of body weight (57,43±11,09), arm muscular circumference (23,37±2,86), hip muscular circumference (48,87±5,41).

At the age 13-18 taekwon-do athletes (males and females) had demonstrated almost equal level of development of morpho-anthropometric indicators.

Keywords: anthropometry, morphological features, 13-18 year old athletes, taekwon-do

Kinetics of blood coagulation and the electrical conductivity as a marker for the properties of the blood clot

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[2]*National Sports Academy "Vassil Lefski", 1700 Sofia, Bulgaria*

Abstract

The time development of the thrombus microstructure is associated with a significant change in the viscoelastic properties of the blood (a measure of the viscous and elastic blood properties). Clot viscoelastic properties are among the most sensitive measures for fibrin polymerization and thrombus structure **(**Weisel, 2004). The coagulation process changes the physical properties of blood from a viscoelastic fluid to a viscoelastic solid. The important point between these two conditions has been previously defined as the gel point (GP) (Blomback, Bark, 2004; Evans et al., 2010). Before getting

the GP, blood behaves as a non-Newtonian fluid. After the GP, the blood clot under flow exhibits both fluid (viscosity) and solid (elasticity) properties (Ranucci, 2014). The aim of this paper is to show the relation between these inner blood transformations with the measured blood electrical conductivity data of the coagulated samples. We found that a kinetics of blood clot is closely represented by the time trajectory of sample electrical conductivity data. The major factors, which influence on the blood clot kinetics are hematocrit, shear conditions, temperature and fibrinogen concentration. These factors influences were assessed with blood clot conductivity measurement.

Methods for experimental characterization of mesh explants

M. Kirilova-Doneva[1,2], D. Pashkouleva[2]
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[2]*Institute of Mechanics, Bulgarian Academy Sciences, Acad. G. Bonchev Str. Bl. 4, 1113 Sofia, Bulgaria*

Abstract

The changes in hernia meshes which occur *in vivo*, can be described by morphological, chemical and mechanical methods. The objective of this study is to present methods for experimental characterization of explanted hernia meshes in order to understand mechanisms of mesh degradation. After *in vivo* exposure to physiological conditions changes in pore size, surface modification, crystallinity and stiffness of the material during mesh degradation are investigated by photogrammetric methods, differential scanning calorimetry, X-ray diffraction and mechanical tests. Reduced pore size, stiffness and mesh contraction are observed mainly in mesh explants from patients with infection.

Experimental characterization included also i*n vitro* simulated mesh degradation in buffer solution. The effect of buffer on material changes of meshes is described and discussed using the most available brand of meshes in the country. Material properties of hernia mesh explants and implants are compared to explore the impact of physiological conditions on degradation mechanisms of hernia meshes.

CAD design of a new 3D geometrical model of the human body

G. S. Nikolova, M. S. Tsveov, D. M. Dantchev
Institute of Mechanics, Bulgarian Academy of Sciences, Acad. G. Bonchev Str. Bl. 4, 1113 Sofia, Bulgaria

Abstract

The human movement is a matter of analysis since ancient times. In order to make this analysis scientifically grounded one apparently requires an understanding of the geometric and mass-inertial characteristics of the body as a whole, as well as of the separate human body segments. In the present research a new 20-segmental geometrical model of the human body of the Bulgarian male is proposed and its 3D model realization in CAD environment SolidWorks is performed. The geometrical data needed is taken from a detailed anthropological investigation of the Bulgarian population [1]. One of the goals of the current work is to improve the 16-segmental mathematical model of the human body described in [2], shaping the body with 20 instead of 16 segments. The suggested CAD model of the human body of men is verified against the analytical results from our previous investigation [2], as well as through comparison with data available in the provided reports. We observed a very good agreement between our model results and data reported in the literature. Hence, our model and the mass-inertial characteristics obtained may be applied in studies of orthotics and prosthetics design, ergonomics, for investigating criminology cases – body fall, car crash, etc. The model is suitable for performing computer simulation in medicine, robotics, sports, and other areas.

Acknowledgments: The financial support by the Bulgarian National Science Fund: Contract DN-07/5 “Study of anthropometric and mass-inertial characteristics of the Bulgarian men and women via mathematical models of the human body” is gratefully acknowledged.

References

[1] Y. Yordanov et al. *Anthropology of the Bulgarian population at the end of the 20th century (30-40 years old persons),* Prof. Marin Drinov Academic Publishing House, Sofia, Bulgaria, 2006.

[2] G.S. Nikolova and Y.E. Toshev. Estimation of male and female body segment parameters of the Bulgarian population using a 16-segmental mathematical model. *J. Biomech*, 40: 3700–3707, 2007.

Investigation of a kinetic model reproduced the mechanisms of oligodendrocytes differentiation

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Abstract

Oligodendrocytes are the glial cells of the central nervous system (CNS) that generate myelin. Fundamental biological aspects of oligodendroglial cells are their proliferation, migration, differentiation, myelination and membrane/RNA trafficking. Numerous publications in last decades have reported that the presence of myelin on axons speeds up conduction velocities.

In [1] a mathematical model of 14 ODEs was developed. The model describes the intricate dynamics regulating the oligodendrocytes differentiation process. In our study, we investigate a reduced version of this model. The reduced mathematical model of *Sox9-Sox10-Olig2-Tcf7l2-Myrf-miR-17/335/338/155* regulatory circuit of the neural tube has four nonlinear ODEs. They are treated as nonlinear dynamical systems. The evolution of the reduced model's behavior is studied. Depending on the parameter's values, the system demonstrates very different dynamic behaviors such as: stabilities, instabilities (including limit cycles (isolated periodic solutions)) and bistability.

References

[1] Cantone, M., Kuspert, M., Reiprich, S., Lai, X., Eberhardt, M., et al., A gene regulatory architecture that controls region-independent dynamics of oligodendrocyte differentiation, Glia, 67(5), 825-843, 2019.

Comparative analysis of body composition and dimensions of experienced Olympic weightlifters, powerlifters and bodybuilders

V. Panayotov

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Abstract

In this article, the author studies the differences in body composition and body dimensions in competitive athletes of the three most popular strength sports – bodybuilding, Olympic weightlifting, and powerlifting. 42 athletes in total participated, all of them competitors at the national level in their sports. Five parameters were measured and compared – body mass index (BMI), percentage of adipose tissue, lean body mass, thigh circumference and arm circumference. The somatotypes of the participants were also calculated and graphed. We found statistically significant differences only in arm circumference: as opposed to the popular belief, overall, we did not find evidence that bodybuilders posses the most hypertrophied musculature. On the other hand, the somatotypes' variables of the three groups of athletes showed statistically significant differences. Being a well established integral measure of human body shape and physique type, the somatotype takes into consideration some additional components apart from the ones used in this study. In our opinion, data about BMI, lean body mass and percentage of adipose tissue gives insufficient information about body shape and composition in strength-trained athletes.

Keywords: Olympic weightlifters, powerlifters, bodybuilders, body composition, lean body mass

Non-invasive assessment of blood flow disorders and regulation of microvascular tone during local heating and cooling by wavelet analysis of the skin temperature fluctuations in patients with type 2 diabetes mellitus

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[4]*Department of Endocrinology and Metabolic Diseases, University Hospital, Panagyurishte, Bulgaria*

Abstract

The aim of the study is to investigate the possibility of assessing disorders in the regulatory mechanism of the microcirculatory vascular tone in patients with type 2 diabetes mellitus (DM-2) by applying a wavelet analysis of skin temperature fluctuations (WAST). Using this approach for non-invasive assessment, the temperature fluctuations of the skin surface - in the range of oscillations from 0.0095 to 0.02 Hz, were examined. The study showed that in patients with type 2 diabetes mellitus impairment of skin vasodilation and vasoconstriction - in response to local heating and cold tests**,** was evaluated.

Keywords: type 2 diabetes mellitus (DM-2), cold test, local heating test, skin temperature fluctuations, WAST method.

Acknowledgements: The financial support of the Bulgarian National Science Fund (Project for Basic Research – 2018; No. КП-06-Н27/13): "Development of experimental microfluidic system and methodology for assessing microrheological properties of blood. Analysis of the peripheral vasomotor reactivity and vascular endothelial function in patients with type 2 diabetes mellitus" is gratefully acknowledged.

The study is also supported by the National Program "Young Scientists and Postdoctoral Students" of the Ministry of Education and Science, Project: "Development of non-invasive methodology and tools for assessment of regulatory mechanisms in patients with metabolic syndrome", Research division: Information and Communication Sciences and Technologies.

Influence of synchronization of motor units firings on muscle force variability

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Abstract

The muscle force is a sum of forces of all active motor units (MUs) of three physiological types: fast fatigable (FF), fast resistant to fatigue (FR), and slow (S). The smoothness of the output muscle force depends on the firing of all active MUs. The degree of oscillations of the force, observed as physiological tremors, depends on the degree of synchronization between MU's firings. To investigate the effect of synchronization on the muscle force a model of the rat medial gastrocnemius muscle was designed based on the actual proportion and physiological properties of MUs and motoneurons innervating the muscle. The muscle consists of 57 MUs (8 S, 23 FR, and 26 FF MUs). The isometric muscle and MU forces were simulated applying non-synchronized firings for a maximum excitatory signal when all MUs were recruited. The synchronization of firings of individual MUs was simulated using four different modes and inducing the synchronization within three time windows (± 2, ± 4, and ± 6 ms) for four different combinations of MUs. The synchronization was estimated using two parameters, the correlation coefficient and the cross-interval synchronization

index. The four scenarios of synchronization increased the values of the root-mean-square, range, and maximum force in parallel with the increase of the time window. Increasing synchronization index resulted in higher root-mean-square, range, and maximum of force outcomes for all MU types as well as for the whole muscle output; however, the mean spectral frequency of the forces decreased, whereas the mean force remained nearly unchanged. The range of variability and the root-mean-square of forces were higher for fast MUs than for S MUs; meanwhile, the relative values of these parameters were highest for S MUs, indicating their important contribution to muscle tremor, especially during weak contractions.

Impact through the activities with different types of sports included in the "Cchildren's camp on arts and sports 2020" organized by the student district on the physical activity of children 9-12 years old after the pandemic by COVID 19

L. Trenev
National Sports Academy "Vassil Levski", Department of Football and Tennis, 1700 Sofia, Bulgaria

Abstract

The annual children's art and sports camp allows children to learn and practice various sports such as baseball, cricket, rugby, field hockey, basketball, handball, tennis, table tennis, squash, fencing and football. Exercise and sports help both physical development and increase the capacity of the functional capabilities of all organs and systems that make up the human body. Mastering the basic technical techniques in individual sports and the development of physical qualities, improves physical activity, fosters team spirit and creates positive emotions in adolescents. The activities contribute to the full use of sports in the formation of motor skills, building motor habits, creating conditions for sustainable development and a healthy lifestyle in children after the restrictive measures given the situation of COVID 19.

Keywords: sports, training, physical education