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Yotov, I., - Bulgaria

PRELIMINARY PROGRAM

26 October 2022, Wednesday

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: **St. Stoytchev**

Raikova, R., Krutki, P., Celichowski, J.,
A review on skeletal muscle models composed of motor units

11:10 – 11:30 **Coffe Break**

11:30 – 12.50 **Session № 1**
Chairman: **S. Nikolov**

11:30 – 11:50 **Angelova, S., Raikova, R., Venev, P.,**
Experimental verification of a feed-forward control of an active elbow orthosis prototype

11:50 – 12:10 **Nikolova, G.S., Dantchev, D. M.,**
Age changes in the basic antropometric characteristics of the average Bulgarian females

12:10 - 12:30 **Kirilova-Doneva, M.,**
Experimental investigation of human fascia- achievements and problems

12:30 – 12:50 **Paunski, Y., Petrov, E., Angelova, S., Raikova, R.,**
Possible ways of controlling an active elbow orthosis using an EMG sensor

12:50 – 14:00 **Lunch Break**

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

14:00 – 14:20 **Avramov, E.,**
Analysis of the game in attack of the Bulgarian national beach handball team at the European Championship for girls under 17 Varna 2021

14:20 – 14:40 **Avramova, M.,**
Somatotypological studies of elite Bulgarian handball players

14:40 – 15:00 **Zaykova, D., Konchev, M.,**
Injury profile of Bulgarian male olympic weightlifters

15:00 – 15:20 **Trenev, L., Tishinov, O.,**
Videometric methodology for biomechanical analysis of baseball batting

15:20 – 15:40 **Trenev, L.,**
Possibilities to enrich the educational content of students in junior high school stage with baseball 5

15:40 – 16:00 **Coffe Break**

16:00 – 17:40 **Session № 3**
Chairman: **I. Yotov**

16:00 – 16:20 **Nejkov, S., Stefanov, L.,**
Applicability of standardized ventilatory measure scores in determining anaerobic threshold

16:20 – 16:40 **Ocheva, G. S.,**
Biomechanical structure of topspin strokes in highly level table tennis players after software data obtained

16:40 – 17:00 **Ignatov, G., Naydenova, K.,**
Characteristics and status of the physical loads of elite football referees

17:00 - 17:20 **Ivanov, I., Zvetkova, E., Ranchev, S., Stoychev, S., Nikolov, S., Yotov, I., Raikova, R., Angelova, S.,**
Biomechanical mechanisms and therapeutic effects of stretching on muscles, tendons, ligaments, joint injuries and hemorheology

17:20 - 17:40 **Ivanov, I., Ranchev, S.,**
Knee intra-articular mechanical alterations after weight loading and isometric stretching

27 October 2022, Thursday

Institute of Mechanics-BAS, hall 510

10:00 – 12:30 **Session № 4**
Chairman: **S. Nikolov**

10:00 – 10:20 **Stoytchev, St., Nikolov, S.,**
Effects of flow-dependent and flow-independent viscoelastic mechanisms on the stress relaxation of articular cartilage

10:20 – 10:40 **Povolotsky, A.M., Pesheva, N.C., Bunzarova, N.Zh.,**
Generalized TASEP on open chains with a modified injection condition

10:40 - 11:00 **Antonova, N., Podtaev, S., Velcheva, I., Paskova, V., Tsiberkin, K., Chaushev, N., Chalakov, H.,**
Diagnostics of functional abnormalities in the microcirculation system using microtest device

11:00 - 11:20 **Ivanov, I., Antonova, N.,**
Hemorheological changes during exercise. Basic factors determining erythrocyte deformability and blood flow

11:20 - 11:40 **Tzoneva, R.,**
Application of biomaterials in medicine

11:50 – 12:30 **Plenary lecture**
Chairman: **St. Stoytchev**

Rachev, A.,
Adaptive and maladaptive remodeling of arteries in hypertension

12:15 – 14:00 **Lunch Break**

Culture program
Sofia free tour -15:30 – 18:00

28 October 2022, Friday

Institute of Mechanics-BAS, hall 510

11:00 – 13:00 **Round Table – 30 yaers Bulgarian Society of Biomechanics and 50 years Biomechanics research in Bulgaria**

Moderator: S. Nikolov

Contributions: A. Baltov, A. Rachev, St. Stoytchev, N. Zlatov

13:00 – 15:00 **Informal contacts**

15:00 – 15:20 **Closing Session**
Chairman: **St. Stoytchev**

Plenary lecture - abstracts

A review on skeletal muscle models composed of motor units

R. Raikova[1], P. Krutki[2], J. Celichowski[2]

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[2] *Poznan University of Physical Education, Department of Neurobiology, Poland*

The realism of mathematical muscle models depends on several aspects of muscle structure and physiology. First, muscle force is the sum of forces of multiple motor units (MUs), which have different contractile properties and play different roles in generating muscle force. Second, whole muscle activity is an effect of excitatory inputs to a pool of motoneurons innervating the muscle, which have different excitability, influencing MU recruitment. In this review, we compare various methods for modeling MU twitch and tetanic forces and then discuss muscle models composed of different MU types. We first present four different analytical functions used for twitch modeling and show limitations related to a low number of twitch describing parameters. We also show that a nonlinear summation of twitches should be considered in modeling tetanic contractions. We then compare different muscle models, most of which are variations of Fuglevand's model, adopting a common drive hypothesis and the size principle. We pay particular attention to integrating previously developed models into a consensus model based predominantly on physiological data from *in vivo* experiments on the rat medial gastrocnemius muscle and its respective motoneurons. Finally, we discuss the shortcomings of existing models and potential applications for studying MU synchronization, potentiation, and fatigue.

Acknowledgement
The study was supported by Joint Polish-Bulgarian Research Project for years 2022-2023

Adaptive and maladaptive remodeling of arteries in hypertension

A. Rachev

Institute of Mechanics, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 4, 1113 Sofia, Bulgaria

Hypertension is one of the most prevalent life-threatening diseases in the civilized world. Quantification of the mechanical and remodeling response of matured arteries to sustained changes in blood pressure is important to understand the normal arterial function and to reveal potential mechanisms involved in vascular disorders such as hypertension. A brief review of the results from continuum mechanics-based studies on passive and active mechanical properties and modes of remodeling of arteries is considered. Special attention is addressed to the contribution of Bulgarian scientists to the topic. Perspectives for extending and refining the current mathematical models are discussed.

List of abstracts

Age changes in the basic antropometric characteristics of the average Bulgarian females

G. S. Nikolova, D. M. Dantchev

Institute of Mechanics, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 4, 1113 Sofia, Bulgaria

The physical features of the human body change throughout one's life span. These changes arise at the whole-body level, cellular level, and tissue level. The rates of change are also not constant through ageing. The two basic characteristics in which these changes are mirrored are the height and weight of the human.

In the current article, we study the age changes in the basic anthropometric characteristics (body height and body weight) of Bulgarian females. We do that after dividing the measures subjects into three age groups: I) 18-25 years, II) 25-30 years and III) 30-40 years. It is usually accepted that the basic physical characteristics of the human's physical dimensions are at their peak from age 20 to 35 years.

The data used in the investigation are gathered through performing our own anthropometric measurements. In group I) we measured 36 objects, in group II) – 19, and in group III) – 51 females.

We present the average values of the height and weight and any of the groups, as well as the corresponding probability distributions of the height and weight in the groups. The inspection of the results shows a small increase in individual height, by about 1 cm, in the range "female aged 25 – 30" and "female aged 30 – 40" in comparison with "female aged 18 – 25". One concludes that, due to the acceleration, the height of the body quickly reaches its maximum. At the same time, however, the weight change is more significant– the average weight of a "female aged 30-40" is about 8 kg heavier than that of the average "female aged 18-25".

Let us note that in order to analyze the change in human motion with the age, one needs, among the others, to understand how the height and weight of the body and its segments develop with the age. If such detailed data were available, they would enable us to quantitatively assess the processes of individual increase of injury risk in daily and sports activities due to a change of internal load caused by anthropometric change. Unfortunately, the necessary detailed data for the segments of the body are currently not available. Yet, the results of the present study provide some basis for the conclusion that this risk indeed increases with the age.

The results obtained can be used when one needs such anthropometric and mass characteristics in problems appearing in rehabilitation, medicine (orthopaedics and traumatology), sports, ergonomics, for investigating criminology cases – body fall, car crash, etc.

Acknowledgements
This work has been accomplished with the financial support by the Grant No BG05M2OP001-1.002-0011-C02 financed by the Science and Education for Smart Growth Operational Program (2014-2020) and co-financed by the European Union through the European structural and Investment funds

Analysis of the game in attack of the Bulgarian national beach handball team at the European Championship for girls under 17 Varna 2021

E. Avramov

National Sports Academy, Department "Basketball, Volleyball and Handball", Studentski Grad, St. Mladenov Str. 21, 1700 Sofia, Bulgaria

Beach handball is a team sport where two teams pass and bounce or roll a ball in an attempt to throw it into the opposing team's goal. The game is similar to standard handball, but played on sand instead of a hard floor. Because the ball loses most of its bounce on sand, there is almost no dribbling

and players instead perform more passing as travel rules still apply. The aim of the present work is to investigate some anthropometric indicators and the offensive game of the European Beach Handball Championship Varna 2021. for girls up to 17 years old. The present study was conducted in June 2021. in the city of Varna at the European Beach Handball Championship Varna 2021. To solve the set goal, we used the following scientific methods: research, analysis and summarization of literary sources; pedagogical observation, recording and analysis of competitive activity; mathematical and statistical methods. When examining the overall efficiency of shooting, the Bulgarian team at the European Championship for girls made a total of 258 attacks in seven matches, of which they realized 202 points from all halves /sets/. The Bulgarian team used much more shooting with acrobatic performances for two points in all the matches played. We can attribute this to tactical instructions from the coach, to realize a greater number of points.

Keywords: beach handball, game efficiency, European Championship

Applicability of standardized ventilatory measure scores in determining anaerobic threshold

S. Nejkov[1], L. Stefanov[2]

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[2]*National Sports Academy, Department "Physiology and Biochemistry", Studentski Grad, Acad. St. Mladenov Str. 21, 1700 Sofia, Bulgaria*

The aim of the present study is to compare the compatibility between the Z-score method for determining the second anaerobic threshold and the D_{max} method for determining the second lactate threshold.
Ten competitors from the National Rowing Team of the Republic of Bulgaria, men, with an average age of 18 years, were studied during spiroergometric, graded incremental exercise test to exhaustion. Ventilatory parameters, intensity and heart rate were recorded bred-by-bred for each subject for each step of the test. We determined the second lactate threshold using the Z-score method applied to the ventilatory measurements of the competitors. As a reference method for determining the second lactate threshold, we used the D_{max} method.

In both approaches for determining the anaerobic threshold, values for heart rate are the same, and the mean values are near at p-value = 0.563 (α=0.05). The coefficients of variation show great uniformity for the two samples. The dispersion for both samples is similar, indicating that the two approaches give near results for heart rate at the anaerobic threshold determined by the two methods. The Bland&Altman scatterplot clearly shows that the difference between the measurements from the two compared methods is within the 95% confidence interval.

Keywords: Z-score, D_{max} method, anaerobic threshold

Application of biomaterials in medicine

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Polymer materials have become widely used as components of medical devices and implants, drug delivery systems, diagnostic assays, bioreactors and bioseparation processes. Most of the devices cannot avoid the blood contact in their use. When the polymer materials come in contact with blood they can cause different undesired host responses like thrombosis, inflammatory reactions, infections and others. Thus the materials must be hemocompatible in order to minimize these undesired body responses. One of the most important problems associated with the blood-contacting biomaterials is surface-induced thrombosis. The first event, which occurs, after exposure of biomaterials to blood, is the adsorption of blood proteins. The type, the amount and the conformational state of the adsorbed proteins determine whether platelets will adhere and become activated or not. The adsorption of fibrinogen (FNG), which is present in plasma, has been shown to be closely related to surface-induced thrombosis. The protein adsorption is an interfacial phenomenon and depends strongly on the physicochemical properties of the polymers, such as surface wettability, surface energy, surface charge density, surface roughness and others. Wettability, however, is believed to play one of the most important role for the amount of adsorbed proteins and their conformational changes during adsorption. Since the thrombus formation begins with protein adsorption, the main efforts in improving the material hemocompatibility have been directed towards controlling protein adsorption. Since the endothelium is the nature's most efficient anti-thrombogenic surface, growing of endothelial cells (EC) on biomaterials is an useful approach, which is believed to be the most ideal solution for making truly blood-compatible materials. One of devices benefiting from the use of such kind of surface modifications are synthetic vascular grafts. Precoating of the grafts with extracellular matrix (ECM) proteins such as fibronectin (FN) and FNG has been shown to enhance EC adhesion, spreading and proliferation. The adhesive proteins bound to a solid surface provide not only a structural support for cell adhesion and spreading but they are also the critical element of the message directing from the substrate to the cell. Therefore, the correlation among surface properties, protein adsorption, and cell responses should be studied in order to increase the knowledge how the biomaterial influences the cell function and to modulate

Biomechanical mechanisms and therapeutic effects of stretching on muscles, tendons, ligaments, joint injuries and hemorheology

I. Ivanov[1,2], E. Zvetkova[3], S. Ranchev[2], St. Stoytchev[2], S. Nikolov[2,4], I. Yotov[1], R. Raikova[5], S. Angelova[5]

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In biomechanical terms, stretching is defined by the authors as a movement applied by an external and/or internal force in order to increase muscle flexibility and/or joint range of motion. The aim of stretching physical exercise is to increase muscle-tendon unit length and to improve joint flexibility, as well as to decrease a risk of injuries.

As a rehabilitation biomechanical method, stretching has been applied mainly to improve and modify the biomechanical parameters and flexibility of muscles, tendons, ligaments and joints.

The acute effects of stretching on the muscle and joint flexibility are related to the joint range of motion: the increased range of motion induces the analgesic effect of stretching. Other biomechanical variables, such as stiffness, rest unaffected, strength could be reduced by stretching. The faster is stretch – the higher will be the muscle stiffness.

The viscoelastic responses of muscles, tendons, ligaments and joints to the slow stretch could evaluate to the less passive tension, than a faster procedure to the same length. Stretching variables and biomechanical parameters (as collagen fiber elasticity, muscle elongation, energy absorption, etc.) could be biomarkers of connective tissue and muscle state which are of importance for healing joint injuries. Recent medical studies recommended stretch technique to be applied in combination with other methods for rehabilitation, such as massage, heat/cold application, warming up procedures, etc. Most stretching techniques (static, ballistique, etc.) are successfully involved in clinical practice - for treatment of osteoarthritis, fasciitis, contractures as Dupuytren.

Our review presents creation of new mathematical and computational models evaluating properties of muscles, tendons, ligaments and joint forces during and after application of stretching. Such information is needed for more efficient joint and muscle rehabilitation and development of programs for injury prevention.

Acknowledgement
This work was supported by the Bulgarian National Science Fund - grant КП-06-Н57/18

Biomechanical structure of topspin strokes in highly level table tennis players after software data obtained

G. St. Ocheva

National Sports Academy, Department "Football and tennis", Studentski Grad, Acad. St. Mladenov Str. 21, 1700 Sofia, Bulgaria

Modern table tennis is unthinkable without a system for analyzing the indicators of sports technique. The development of table tennis in the Republic of Bulgaria needs a modern system for scientific research of the technique. The creation of a scientific methodology will allow to increase the level of technical training and sports results. The subject of the research is offensive technical ele-

ments and their effectiveness in elite athletes. We aimed to study and analyze the biomechanical structure of some basic offensive strokes in table tennis "topspin", the kinematic characteristics - path, time, speed, acceleration. The spatial, speed or, more precisely, the rhythmic structure of the movement of the racket during the performance of those strokes in the studied persons is established. Essential biomechanical characteristics realized by indirect videometric means in three-dimensional mode (3D) are velocities and trajectories in the respective defined planes. If possible, other joint centers of interest to the trainer can be selected, determining the movement parameters of the respective units limited within the joint centers. The criteria for biomechanical expediency require synchronous action of the units of the athlete's kinematic chain.

Research has shown that the required frame rate is 240 frames per second to account for the moment of impact and the "spin" acquired by the ball after impact. The research was carried out in the "Yoto Drenovski" table tennis hall, Sofia, Gurgulyat Street No. 1

From the point of view of biomechanics, table tennis is a sport that consists of being an athlete (motor technique), there is interaction of the ball with the air (speed, trajectory) and interaction of the ball with the racket and with the table. To analyze these three parts it is necessary to use the right methods and equipment. After conducting informational research, we distinguished two main types of scientific methods used: research methods in the field of theoretical mechanics and experimental

research methods. In the conducted research, the registration of the movements was carried out in natural conditions in compliance with all the requirements of the methods.

Characteristics and status of the physical loads of elite football referees

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The level of development of modern professional football imposes increasingly higher requirements regarding physical fitness and, accordingly, physical loads not only on the players but also on the other side of the game, namely football referees. The management of a professional football match is a process that requires a complex of personal and professional qualities that the referee should be able to apply at a specific moment. More and more emphasis is being placed on physical training. The latter is obligatory because a physically well-prepared football referee would more effectively resist fatigue, which is a basic prerequisite for making correct and on-time decisions.

Based on the above, the goal of the present study is to determine the level of physical training of Bulgarian elite football referees by tracking the values of the pulse rate and the zones of physical exertion in which they work during a football match. We set the following research tasks:

1. Study the literary sources related to the problem.
2. Recording the individual indicators of physical exertion during a football match.
3. Statistical processing, analysis, and interpretation of the obtained data.

We processed the results using SPSS v.22 statistical software, applying specific statistical methods. As a result of the research and the subsequent analysis of the data, we found some specifics in the manifestation of physical exertion in elite soccer referees.

Keywords: football, football referees, physical fitness, physical load, heart rate

Diagnostics of functional abnormalities in the microcirculation system using microtest device

N. Antonova[1], S. Podtaev[2], I. Velcheva[3], V. Paskova[1], K. Tsiberkin[2,4], N. Chaushev[5], H. Chalakov[3]

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Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease characterized by hyperglycemia due to a lack of resistance to insulin. Patients develop vascular complications which affect the peripheral blood vessels. These vascular disorders are due to the high blood glucose levels and metabolic products from the glycation of lipids and proteins .

The endothelial dysfunction (ED) plays an important role in prediction of the vascular diseases. One of the methods to assess the microvascular endothelial function is to evaluate the dynamic changes in the cutaneous blood flow by applying stress tests with different stimuli: temperature, mental, orthostatic and occlusive. As non-invasive and easy to perform, temperature tests are the most used. Stress tests are routine functional tests applied in the clinical practice. By applying them, we affect indirectly the subcutaneous vessels. Their effects are vasoconstriction or vasodilation of the blood vessels.

In this study a local heating functional test and cold stress tests ware used for the assessment of microvascular tone regulation. Local cooling induced vasoconstriction, while local heating (up to 35 °C), provoked vasodilation. The purpose is to assess the possibilities of the wavelet analysis of the skin temperature (WAST method) for the diagnosis of impaired regulation of the microvascular tone in patients with type 2 diabetes mellitus during the local heating and cold tests.

Low-amplitude temperature fluctuations on the surface of the skin occur as a result of altered vessel wall tone and velocity of blood flow in the subcutaneous arteries and arterioles. By recording these fluctuations and analyzing them for certain frequency ranges, we analyze the disturbances in the active mechanisms regulating vascular tone. There are five frequency bands corresponding to diferent regulatory mechanisms. The pulse (0.45-1.6 Hz) and respiratory (0.2-0.45 Hz) bands give information about the influence of heart rate and the movement of thorax on the peripheral blood flow. Blood flow oscillations at frequencies 0.05-0.15 Hz characterize the myogenic mechanism of vascular tone. The neurogenic activity induces vessel walls movement with frequency of 0.02-0.05 Hz. The frequency of 0.0095-0.02 Hz reflects the vascular tone regulation due to the endothelium activity.

The possibility of using the Microtest technique in the diagnosis of microcirculation disorders is illustrated using the results of a clinical study conducted to evaluate skin blood flow regulation abnormalities in patients with T2DM and obtained via the wavelet analysis of the skin temperature records. A stepwise protocol for the thermal tests, the original data processing methods and specific data interpretation techniques are presented.

Acknowledgements
The study has been supported by the project Grant № КП-06-Н27/13 "Development of an experimental microfluidic system and methodology for the assessment of the microrheological properties of blood. Analysis of the peripheral vasomotor reactivity and vascular endothelial functions in patients with type 2 diabetes mellitus from" from 2018 and by the grant КП-06-Н57/14 "Investigation of the hemorheological characteristics, the parameters of coagulation and the mechanical properties of the blood cells as a basis for numerical simulations of their role for the blood flow in cerebrovascular, peripheral vascular diseases and Diabetes mellitus type 2" from 16.11.2021 funded by the Bulgarian National Science Fund

Effects of flow-dependent and flow-independent viscoelastic mechanisms on the stress relaxation of articular cartilage

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Articular cartilage is bearing material that lines the ends of the bones of synovial joints. The solid phase of articular cartilage is chiefly composed of complex macromolecules including collagen and proteoglycans. The fluid phase is presented by interstitial fluid which fill in pores of the solid phase. The rheological behavior of articular cartilage depends upon the intrinsic interaction between the deformation of the solid matrix and the motion of the interstititial fluid. Thus, viscoelastic proper-

ties of articular cartilage arise from two mechanisms: (1) the diffusional drag of relative velocity between the interstitial fluid and the solid matrix, or flow-dependent mechanism, and (2) the intrinsic viscoelastic properties of the solid matrix, or flow-independent mechanism. The objective of this study was to assess the contribution of both mechanisms on the stress relaxation of articular cartilage.

The mathematical model of confined compression of articular cartilage was developed using the linear biphasic theory of Mow et al. (J. Biomech. Engng ASME, 102, 73-84, 1980). The stress-time curves were computed from the quasi-linear viscoelastic model of Fung. The assessment procedure was considered on the basis of the experimental data of Soltz and Ateshian (J. Biomech. Engng ASME, 122, 576-586, 2000).

Our findings envisage that solid matrix viscoelasticity (flow-independent mechanism) plays dominant role for stress relaxation after stepwise loading while some authors plead that fluid pressurization can play a major role in the load support mechanism of cartilage. The inter-relation between the intrinsic viscoelasticity and the permeability of the solid matrix is discussed.

Acknowledgement
This work was supported by the Bulgarian National Science Fund - grant КП-06-Н57/18

Experimental investigation of human fascia- achievements and problems

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The study presents experimental investigations of different type of human fascia which exhibits non-linear elasticity, mechanical anisotropy and undergo large deformations under applied loads. The influence of preconditioning, careful specimen preparation for mechanical testing, the storage methods and hydration will be discussed. A particular focus will be paid to the techniques to identify the strain field in which the tissue experiences homogenous deformation. The methods for biomechanical characterizations will be described - static and dynamic one-dimensional and two-dimensional tests. The testing methods have not been standardized and variation of methodology leads to wide range of reported parameters. This leads to difficulties in comparing obtained results.

Experimental verification of a feed-forward control of an active elbow orthosis prototype

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A prototype of an active elbow orthosis has been developed at the Institute of Biophysics and Biomedical Engineering – BAS. The aim is a rehabilitation of the upper arm of disabled people having different neuro-muscle injuries or diseases. The orthosis has one degree of freedom (122^0 elbow flexion/extension) and could be adapted for using by both the right and left hands after repositioning some of the constructing details. It is driven by an electrical actuator and initially its purpose is to accomplish forced elbow flexion/extension motion in the possible range of motion of the patient. The

weight and dimensions of the device, together with the drive mechanism, allow it to be worn, and attachment to the shoulder girdle is enabled out by means of a ready-made, factory brace and belt system.

The aim of the present study was to test the feed-forward control of the orthosis. It is realized from the software according to the initial and final elbow angles and time for motion task – flexion/extension. The study was conducted with the left hand of three healthy volunteers. They performed several times a motor task: flexion-rest-extension. The motor task was carried with different velocities of the motion. The angle values during the motor tasks were stored and processed. The factors affecting movement velocity (arm and forearm length, upper limb weight, joint resistance) and movement smoothness are discussed. Another important emphasis of management is the rate of safety. It is provided on three levels – mechanically by the hard stoppers , electromechanically by the limit switches and by software. We have proven that the software control of the orthosis is reliable enough, but the safety measures are not to be neglected. The conclusions are: the chosen way of attaching the device to the shoulder is enough safety and stable; the power of the actuator is enough to ensure the usually daily range and speed of motion in the elbow.

Acknowledgement
This study was financially supported by the Bulgarian National Science Fund (grant no. КП-06-М47/6)

Generalized TASEP on open chains with a modified injection condition

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The one-dimensional (Totally) Asymmetric Simple Exclusion Process ((T)ASEP) is an important model for understanding many non-equilibrium systems. It was first introduced to model kinetics of protein synthesis [1,2], but later was used to model other non-equilibrium systems as well, e.g., vehicular traffic flow [3], biological transport [4], forced motion of colloids in narrow channels [5] etc.

Its importance stems from the fact that it is one of the few examples of exactly solvable non-equilibrium models. It is also one of the simplest models of self-driven many-particle systems with particle conserving stochastic dynamics, which exhibits non-trivial behavior, i.e., it undergoes phase transitions in one dimension (in the plane of particle input-output rates (α, β)). TASEP is the extremely asymmetric version of ASEP, when particles are allowed to move in one direction only. The model is defined on an open network, in one dimension, in terms of discrete-time, discrete-space stochastic dynamics of hard-core particles.

In the last years the research on non-equilibrium models is intensifying, however, the goal is now to study model systems, which take into consideration more realistic features of real systems.
We report here our preliminary results in the study of a new version of the generalized TASEP (gTASEP) [6]. In the gTASEP an additional interaction between the particles is considered (besides the hard-core exclusion). It is modeled by the introduction of a second hopping probability p_m for the particles, belonging to the same cluster, in addition to the standard hopping probability p, which now applies only for single particles and the head (rightmost) particle of a cluster. We briefly describe how one can obtain analytically solvable version of gTASEP by modifying the left (injection) boundary condition. Short comparison is made with the previously studied version of gTASEP on open tracks [7].

Keywords: non-equilibrium systems, TASEP, phase transitions

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Hemorheological changes during exercise. Basic factors determining erythrocyte deformability and blood flow

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It is known that the immediate physiological response to regular and/or intense physical activity is highly dependent on the type, duration, intensity, cyclicity and duration of physical activity, as well as the individual level of training (training status) of the participants. The analysis of the literature yielded results for the indisputable influence of RE on parameters such as erythrocyte rheological properties, plasma components (fibrinogen, albumin, globulins), blood viscosity, blood volume, endothelial changes of blood vessels, blood pressure.

The purpose of the study is to overview the changes of some of the main hemorheological parameters during and after regular physical activity. As well as to focus on their role and relation with microcirculation and basic factors determining erythrocyte deformability.

The main results are focused on the observed changes during exercise with the biomechanical properties of red blood cells, export of vasoactive mediators from red blood cells during deformation. Factors determining the deformability of erythrocytes as temperature, geometry of erythrocytes, rheological properties of the erythrocyte membrane, changes in membrane proteins, changes in membrane lipids, hemoglobin concentration, calcium concentration, Nitrogen oxide, ATP and age of erythrocytes are discussed.

The reported results contribute to the elucidation of complex processes that determine the ability of the human body to adapt to specific intensive training programs, which is crucial for improving the health status of ordinary people and optimizing sports performance in elite athletes.

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Injury profile of Bulgarian male Olympic weightlifters

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Olympic weightlifting is a power sport which comprises snatch and clean and jerk. These movements generate great power through muscle contractions of great speed when moving the barbell quickly along the vertical. The aim of this study was to analyze locations, type, severity and reasons for the injuries among Bulgarian Olympic weightlifters. The research was done among 32 male Olympic weightlifters from Bulgaria. To assess the injury rate in the previous year (12 months), the participants were made to fill out a questionnaire which included open and closed questions about the type, severity, location, and reasons for the injuries. The calculated injury incidence among the researched male weightlifters was 71.88%, injury rate 2.48/1000 hours of training, and 1.25 injuries per weightlifter over a year. The most often injured anatomical locations were the knee - 20%, shoulder – 17.5%, and lumbar spine – 17.5%. The leading types of severe injuries were strain with 27.5% and contusion with 25%. Most of the injuries were minimal and mild. The missed training time was mostly <1 day and <1 week. The most frequent causes of injuries were reported to be fatigue and excessive load. Detecting and dealing with the causes of injuries in sport will improve sports efficiency and will optimize competitive performance.

Keywords: Olympic weightlifting, injury rate, injury incidence, injury location, type of injuries

Knee intra-articular mechanical alterations after weight loading and isometric stretching

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There is much research on the effects of different types of stretching on the muscle-tendon block. However, the influence of isometric stretching on the functions and biomechanical properties of joints and the processes within them is very poorly studied. The purpose of the present study is to evaluate the change in the distance between the bony cartilaginous surfaces of the tibia and femur inside the knee capsule under different loads and the presence of stretching. To fulfill the purpose, an experimental model was constructed by ultrasound examination of a knee joint. When standing upright at rest, an extra load (10 and 20 kg) was applied longitudinally to the lower limb and the change in the distances between the bones visible with the ultrasound sonographer Vinno 6 (China) - femur and tibia, was measured in millimeters. In parallel, isometric stretching was applied in the same setting and the " knee joint mobility" was determined. The obtained results for the change of the intra-articular geometry under load and stretching serve as a quantitative assessment of the internal joint kinematics and determination of the individual joint mobility of the participants in the experiment (n=12). Quantitative values will serve in an attempt to create a mathematical model of the hydrodynamic and mechanical effects during deformation of the knee joint capsule.

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Possible ways of controlling an active elbow orthosis using an EMG sensor

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A prototype of an active elbow orthosis that aims to rehabilitate disabled people was developed at the Institute of Biophysics and Biomedical Engineering. It has one degree of freedom and is driven by an electrical actuator with reduction gear. A feed-forward control is implemented – the forearm moves with several fixed velocities from a given start position to the end angle, previously set in the patient's range of motion, and back. The present report explores the applicability of commercially available electromyography (EMG) MyoWare 1.0 Muscle Sensor for developing a feedback signal to the controller.

Several experiments were performed with one healthy person. The sensor was placed over the muscle biceps brachii belly. The EMG signal was acquired with a 1 kHz sample rate by two controllers: Aurdino Uno R3 and OpenCM 9.04. Two outputs of the sensor's signal – raw and envelope – were tested. The EMG signals were saved in a text file for further offline processing, which included filtration, rectification, and smoothing. The results of the experiments were:

- Using the envelope signal as a control signal without additional processing is difficult;
- The raw signal is weak, close to a noise level, and needs additional amplification before further processing;

- Using the EMG signal only makes it impossible to identify the phases of flexion and extension. A joint angle encoder data has to be used to develop the further control algorithm.

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Possibilities to enrich the educational content of students in junior high school stage with baseball 5

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In the last ten years, baseball entered the educational programs of schools in Bulgaria. In the school program, it is realized through interests - outside class activities. Baseball 5 has established itself in recent years as a form of practice among teenagers, beginners and fans of the game. It allows the rules of the game to be learned quickly and easily, dynamic and accessible to practice anywhere with the active involvement of all participants.

The lack of large enough halls and specialized fields in schools does not allow the practice of the sport of baseball, but baseball 5, which does not require specialized equipment and space, can be practiced both under the guidance of specialists and as games in every physical education class.

The game of baseball provides an opportunity to improve the physical ability of students, as well as to build skills and habits of young players. The key to successfully mastering game skills at this age largely lies in the approach of teachers and coaches.

Keywords: baseball, training, physical education

Somatotypological studies of elite Bulgarian handball players

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The modern development of sports with its increasingly narrow specialization requires a deepening of knowledge about the structure of the human body. It is related to the need to improve research methods with the creation of model somatotypological characteristics. The purpose of the

present study is to determine the somatotype by position of elite bulgarian handball players based on the registration of certain anthropometric indicators. Nineteen handball players divided into 5 groups according to the playing position were studied. From the studied somatotypological indicators, it is established that the average somatotype by game positions is endo-mesomorphic.

Keywords: handball, somatotype, teenagers, elite handball players

Videometric methodology for biomechanical analysis of baseball batting

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Biomechanical analyzes of baseball players have been developed. The analysis was done for batting after the delivery of the ball using video recording from two high-speed video cameras. For each of the bats, kinematic analyzes of the trajectory of the impact were made from both a high perspective and a perspective normal to the inclination of the ball trajectory to the horizontal plane. The shooting scale covers the athlete with the bat in a general plan. 6 control markers placed on the front of the bat, the middle of the bat, the left wrist, the left elbow, the left shoulder, and the pelvis were used in the top view video recording.

When video recording from the right camera again used 6 control markers located on the front part of the bat, the middle part of the bat, the left wrist, the left elbow, the pelvis and the left foot.
Statistical analyzes were made during batting, including the limit values of the linear velocities of the studied points of the athlete's body. Statistical processing includes variance, correlation and regression analyses. A rating scale is proposed.

Keywords: baseball, batting, biomechanical analysis, videography