

Abstracts

in an English language of the articles of ch. assistant professor Ivan Mirchev Ivanov for his participation in a competition for the academic position "associate professor" in professional direction 7.6. Sport, Biomechanics specialty, for the needs of the Department of Anatomy and Biomechanics at National Sports Academy "Vassil Levski".

1. Ivanov, I. (2017, December). WHOLE BLOOD VISCOSITY CHANGES AT COAGULATION UNDER COUETTE FLOW. In *Proceedings of the International Scientific Congress "Applied Sports Sciences" of the National Sports Academy–Sofia, Bulgaria* (pp. 1-2).

Abstract

The aim of the study is to observe how blood viscosity was changed in time in Couette blood flow at coagulation and under steady flow at two low shear rates 0,0237 s⁻¹ and 0,0596 s⁻¹. Blood samples from one donor with different hematocrits were used and 2% aqueous solution of CaCl₂ was added to initiate coagulation. The whole blood viscosity increases with the progress of coagulation at Couette flow at both shear rates. For detailed estimation of blood clot structure changing in time, three time parameters were introduced: i) whole time duration; ii) initial clot formation time; iii) clot formation time. All these time characteristics of coagulation reveal shear rate and hematocrit dependence. A higher shear rate determines shorter values for them. Higher hematocrit has a tendency for accelerated coagulation.

Key words: blood coagulation, whole blood viscosity, shear rate, Couette flow

2. Windberger, U., Dibiasi, C., Lotz, E. M., Scharbert, G., Reinbacher-Koestinger, A., **Ivanov, I.**, ... & Lichtenegger, H. (2020). The effect of hematocrit, fibrinogen concentration and temperature on the kinetics of clot formation of whole blood. *Clinical Hemorheology and Microcirculation*, 75(4), 431-445.

Abstract

BACKGROUND: Dynamic mechanical analysis of blood clots can be used to detect the coagulability of blood. **OBJECTIVE:** We investigated the kinetics of clot formation by changing several blood components, and we looked into the clot "signature" at its equilibrium state by using viscoelastic and dielectric protocols. **METHODS:** Oscillating shear rheometry, ROTEM, and a dielectro-rheological device was used. **RESULTS:** In fibrinogen- spiked samples we found the classical high clotting ability: shortened onset, faster rate of clotting, and higher plateau stiffness. Electron microscopy explained the gain of stiffness. Incorporated RBCs weakened the clots. Reduction of temperature during the clotting process supported the development of high moduli by providing more time for fiber assembly. But at low HCT, clot firmness could be increased by elevating the temperature from 32 to 37°C. In contrast, when the fibrinogen concentration was modified, acceleration of clotting via temperature always reduced clot stiffness, whatever the initial fibrinogen concentration. Electrical resistance increased continuously during clotting; loss tangent (D) (relaxation frequency 249 kHz) decreased when clots became denser: fewer dipoles contributed to the relaxation process. The relaxation peak (D_{max}) shifted to lower frequencies at higher platelet count. **CONCLUSION:** Increasing temperature accelerates clot formation but weakens clots. Rheometry and ROTEM correlate well. **Keywords:** Clot stiffness, kinetic, temperature, erythrocytes, fibrinogen, rheometry, thrombelastometry, dielectric test

3. Antonova, N., Riha, P., **Ivanov, I.** Experimental method for the study of blood and RBC suspension conductivity under flow. *Comptes rendus de l'Academie bulgare des Sciences*, ISSN: 1310-1331, 65 (5), 675-682, 2012

Abstract

The study presents an electrorheological method developed for quantification of blood microstructural changes due to RBC aggregation-disaggregation and deformation processes at different shear rates and at different local structure of the flow field. A concurrent measurement system based on the Contraves Low Shear 30 rotational rheometer, a device with data acquisition system, software and the programming unit Rheoscan 100 were used. Three different unsteady flow conditions are simulated: rectangular, trapezium-like and triangular regimes of changes of shear rates. The time variation of blood and RBC suspension conductivity at these unsteady flow conditions under electric field of 2 kHz are presented. The results show that the blood and RBC suspension conductivity is strongly dependent on shear rate, haematocrit, temperature and on the considered blood flow regimes. Key words: viscometric flow, conductivity, blood/RBC suspension microstructural changes

4. Antonova, N., Riha, P., **Ivanov, I.**, & Gluhcheva, Y. (2010). Study of Rheological and Electrical Behaviour of RBC Suspensions in Dextran and PEG under Non-steady Flow. Role of RBC Deformability and Morphology. In 6th World Congress of Biomechanics (WCB 2010). August 1-6, 2010 Singapore (pp. 330-333). Springer, Berlin, Heidelberg. IFMBE Proceedings, Vol. 31

Abstract

A concurrent measuring system, using a Contraves Low Shear 30 rotational rheometer, previously described [1-2], was used in the study. It includes a resin replica of the Couette type measuring system MS 1/1 of the rheometer with a pair of platinum electrodes embedded into the wall; a device, constructed by the conductometric method and software (Data acquisition system) [1]. A method, based on dielectric properties of dispersed systems in Couette viscometric blood flow was applied to investigate the kinetics of RBC aggregation and the formation and break-up of the aggregates. Apparent viscosity and conductivity of normal human red blood cell (RBC) suspensions in dextran 70 (Dx 70) and polyethylenglycol (PEG) with various concentrations were evaluated in vitro under steady and unsteady flow conditions. Conductivity time and shear rate dependences in parallel with the rheological properties of the samples were studied under transient flow regimes at different local structure of the uniform Couette flow. Their dependence on dextrans concentrations were evaluated as well. Low shear viscosity and conductivity of RBC suspensions in dextrans were determined and compared to non-aggregating control RBC suspension in PBS. RBCs were treated with glutaraldehyde (GA) with different concentrations (from 0,01% to 1%). A time course of conductivity of normal RBCs and treated with GA suspended in dextran 70 was recorded under trapezoid change of shear rates. It provides experimental description of RBC aggregation-disaggregation processes and other cell-cell interactions. Dextrans induce morphological alterations in RBC shape and arrangement in the suspensions. Echinocytes are observed at low Dx 70 concentrations while spherocytes are found mainly in smears at higher Dx 70 concentrations. Their morphological characteristics affect blood electrical and mechanical properties.

Keywords— electrorheology, RBC suspensions in dextrans and PEG solutions, conductivity, deformability, RBC morphology.

5. Antonova, N., Riha, P., **Ivanov, I.**, & Gluhcheva, Y. (2011). Experimental evaluation of mechanical and electrical properties of RBC suspensions in Dextran and PEG under flow II. Role of RBC deformability and morphology. Clinical hemorheology and microcirculation, 49(1-4), 441-450.

Abstract

Mechanical and electrical properties of the normal RBCs suspensions and of hardened after treatment with glutaraldehyde (0.01–2.5%) RBCs in isotonic physiological solution and Dextran 70 000 (Dextran 70) and Polyethylene glycol 35 000 (PEG) and adjusted to hematocrit of 40%, were evaluated. Apparent viscosity and conductivity were measured under steady and transient flow regimes at low shear rates and at different local structure of the flow at 37°C. A time course of conductivity was recorded in parallel with the rheological properties of the RBC suspensions and conductivity and apparent viscosity dependences on shear rates were studied and compared at different concentrations of Dextran 70, PEG and glutaraldehyde. Low shear viscosity decreased after RBCs treatment with glutaraldehyde and at 0.5–2.5% it is constant. Echinocytes are observed at low Dextran 70 and PEG concentrations while spherocytes are found mainly in smears treated with higher concentrations. The results show that the apparent viscosity and conductivity of RBCs suspensions in Dextran 70 and PEG are strongly influenced by flow, shear rates, concentration, cell deformability and morphology and the method is sensitive to study the mechanical and electrical properties of RBC suspension and to provide experimental description of RBCs and other cell-to-cell interactions.

Keywords: RBC suspensions, viscosity, conductivity, morphology, glutaraldehyde, Dextran 70 000, Polyethylene glycol 35 000 (PEG)

6. **Ivanov, I.**, Gluhcheva, Y., Petrova, E., & Antonova, N. (2014). Hemorheological changes and hematometric erythrocyte characteristics in rats after sodium nitrite intoxication. *Korea-Australia rheology journal*, 26(2), 225-228.

Abstract

Sodium nitrite (NaNO_2) is a precursor to a variety of organic compounds (pharmaceuticals, dyes and pesticides), but it is best known as a food additive. The aim of the study is to investigate the influence of acute (i.p.) treatment of Wistar rats with NaNO_2 (at the dose of 50 mg/kg b.w.) on the blood rheological properties and erythrocyte hematometric indices (Hb, HCT, RBC, MCV, RDW, MCH, MCHC). The significant differences were not found in the whole blood viscosity (WBV) values of the control and NaNO_2 -treated groups. The changes in the erythrocyte hematometric indices were statistically significant for RDW, MCHC and MCH at the 1st hour, five- and ten days after NaNO_2 administration. Interestingly, at the day 5th of the NaNO_2 treatment we obtained statistically significant lower values for the RBC count, Hb, HCT, RDW, as well as elevated indices MCV (no statistically significant), MCH, MCHC. The results obtained indicate that hemorheological and hematometric parameters examined should be monitored in cases of acute exposure to nitrites - for the purposes of clinical toxicology. The quantitative values of hematometric indices reported in our experimental model could be suitable for predicting NaNO_2 intoxication and methemoglobinemia in animals and humans.

Keywords: sodium nitrite, Wistar male rats, whole blood viscosity, hemorheology, erythrocyte hematometric indices

7. **Ivanov, I.**, Gluhcheva, Y., Petrova, E., & Gikova, M. (2016). FOOD PRESERVATIVES AND SPORT. SODIUM NITRITE (E250)'S INFLUENCE ON HEMATOMETRICAL PARAMETERS OF WHITE BLOOD CELLS AND PLATELETS IN RATS. *Research in Kinesiology*, 44(1), pp. 67-70.

Abstract

The vasodilatory activity of nitrites makes them attractive for athletes in attempt to improve their performance. The aim of the study is to investigate the influence of acute NaNO_2 treatment on white blood cell and platelet hematometrical parameters in experimental rat model. Male Wistar rats were injected i.p. with 50 mg/kg b.w. NaNO_2 . At different time

periods following administration (1 h, 5 h, 24 h, 48 h; days 5, 10 and 20), the animals were sacrificed and the hematological parameters were obtained. Hematometrical data showed that acute in vivo NaNO_2 treatment affects rat white blood cells and platelets. A statistically significant decrease of WBC and Gran one hour after treatment and in PDW five hours after injection was obtained. A significant increase of PCT and PLT one and five hours after injection was observed. These results contribute for the elucidation of NaNO_2 influence on morphological and functional properties of blood cells. Acute treatment with NaNO_2 showed diverse effects on white blood cells and platelet count. The results suggest that exposure to NaNO_2 would have a negative impact on immunity and blood cell aggregation.

Key words: food preservatives, sodium nitrite, white blood cells, platelets

8. **I. Ivanov**, N. Antonova, Y. Gluhcheva, E. Petrova, Ju. Ivanova, 2012. Blood rheological changes in rodents after treatment with different metal salts. Series on Biomechanics, ISSN 1313-2458, Vol.27, No. 3-4, 45-52.

Abstract

The rheological properties of blood are an important marker of changes that occur in various pathological conditions. Changes in the rheological properties of blood and the factors that determine them: number and size of blood cells, their membrane and morphological properties, serve as an indicator for early detection of many diseases. The aim of this study is to investigate the influence on the blood rheological properties of some metal compounds: cadmium acetate $[\text{Cd}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}]$, cobalt chloride ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$) and sodium nitrite (NaNO_2), which are known to be present in the environment or daily absorbed by the body from the atmosphere or food. Plasma viscosity of rats after treatment with NaNO_2 is measured too. Disturbances in the rheological properties, blood and plasma viscosity of the treated rodents are observed in comparison with a control group of non-treated rodents, depending on the type, concentration of metal salts, the animal species and the type treatment. The observed blood and plasma viscosity changes have been confirmed by morphological studies of the same blood samples, performed simultaneously.

Keywords: Rodents, blood and plasma viscosity, metal salts

9. **Ivan Ivanov**, CALIBRATION OF A SYSTEM FOR SIMULTANEOUS MEASUREMENT OF RHEOLOGICAL AND ELECTRICAL LIQUID PROPERTIES, Scientific Proceedings, XXIV, Number/ Брой 1 (187), 415-417, June/Юни 2016.

Abstract

Calibration is a complex operation, which at certain conditions determines the relationship between the value measured by the device and the relevant true value appointed by the etalons. The system for parallel studies of the rheological and electrical properties of liquids consists of a rotational viscometer LS 30 Contraves, a device for data collection and analysis (conductometer) and a computer (PC). With this system viscosity (η) as well as the specific electrical conductivity (σ) of the analyzed liquid are simultaneously determined at different shear rates and temperature. With the present calibration method the equations for correspondence between the obtained relative measurements and the real values of both quantities were determined. The indefiniteness during measurement of the dynamic viscosity using a raison print of the outer cylinder of LS 30 Contraves was determined based on the applied interval statistical evaluation of the obtained data.

KEY WORDS: CALIBRATION, DYNAMIC VISCOSITY, BLOOD SPECIFIC ELECTRICAL CONDUCTIVITY

10. Paskova, V., Antonova, N., **Ivanov, I.**, Velcheva, I., & Chaushev, N. (2019). Rheological and electrical behaviour of blood in patients with diabetes mellitus type 2. *Series on Biomechanics*, Vol.33, No.1 (2019), 51-58.

Abstract

The aim of the study is to investigate the rheological and electrical behaviour of blood in patients with Diabetes mellitus type 2 ($n = 13$) and to compare the results with a group of healthy subjects ($n = 9$). A rotational viscometer Contraves Low Shear 30 (Switzerland) was used with a standard measuring system and the concurrent measuring system connected with conductometric device. Whole blood and plasma viscosity were measured at shear rates from $0,0237 \text{ s}^{-1}$ to $128,5 \text{ s}^{-1}$ in both groups. Blood conductivity and shear stresses were measured at rectangular and trapezoidal regimes at different shear rates with a 2 kHz electric field frequency. The kinetics of the conductivity signal was recorded at shear rate from 0 to $94,5 \text{ s}^{-1}$ and back. The results were processed using the program Origin 61, by approximating the non-linear function at load (growth) and relaxation of the conductivity - time dependences. The obtained parameters can be used as a time characteristic of the processes of disaggregation and aggregation of erythrocytes.

Keywords: Diabetes mellitus type 2, whole blood viscosity, blood conductivity, hemorheological disorders

11. **Ivanov, I.**, Antonova, N., Mitova, V., & Petrov, P. (2015). Rheological and electrical characteristics of erythrocyte suspensions in the presence of linear and micellar polyacrylic acid based species. *Series on Biomechanics*, 29(2-3), 66-72.

Abstract

The study of different types of nanomaterials increases progressively in relation to their huge application in various fields of biology, medicine and technology. The aim of the work is to study the influence of the shape and molecular weight of two types of polymer species on the rheological behavior and electrical properties of red blood cell (RBC) suspensions. The species present: (i) linear poly(acrylic acid) with average molecular weights $M_n=225000 \text{ Da}$, 20000 Da and 6000 Da (PAA) and (ii) stabilized polymeric micelles with a mixed shell of PAA and poly(ethylene oxide) (PEO) blocks. The apparent RBC suspensions viscosity η is measured applying the rotational viscometer LS30 Contraves. RBC suspensions electrical conductivity σ is measured in parallel at a steady flow conditions by means of electrorheological techniques, which includes a resin replica of the Couette type measuring system MS 1/1 of the rheometer with a pair of platinum electrodes embedded into the wall of the measuring cup. These two parameters were considered as characteristics of the changes in the RBC suspensions' structure and cell interactions. The obtained results showed that the addition of the studied PAAs and micellar nanoparticles influences the apparent viscosity and electrical conductivity of RBC suspensions. The rheological and electrical properties of the RBC suspensions display direct relation with the shape, molecular weight, concentrations and the type of the added polymer species.

Keywords: RBC suspensions, polymeric nanoparticles, apparent viscosity, blood conductivity

12. Antonova, N., Koseva, N., Kowalczyk, A., Riha, P., & **Ivanov, I.** (2014). Rheological and electrical properties of polymeric nanoparticle solutions and their influence on RBC suspensions. *Applied Rheology*, 24(3), 25-31.

Abstract

Rheological and electrical properties of polymeric nanoparticle solutions and their influence on the rheological and electrical properties of red blood cell (RBC) suspensions have been studied. Poly(acrylic acid) macromolecules of different architecture and molecular weight were used: (i) a new core-shell type star polymer whose interior forms hyperbranched

polystyrene bearing arms of poly(acrylic acid) with molecular weight $M_n = 56920$ Da and (ii) linear polyacrylic chains with average molecular weights $M_n = 6000, 20000, \text{ and } 225000$ Da. The polymers dissolved in physiological solution with weight concentrations 1 mg/ml and 0.2 mg/ml were used for the experiments. Under physiological conditions the star-shaped macromolecules present spherical nanoparticles while the linear poly(acrylic acid)s adopt an extended chain conformation close to rod-like particles. The apparent viscosity of the nanoparticle solutions and RBC suspensions in the presence and absence (the control) of nanoparticles were measured using a rotational viscometer Contraves Low Shear 30 (LS 30) at a steady flow at shear rates from 0.0237 to 94.5 s^{-1} and temperature 37° C . A method, based on the measurement of dielectric properties of dispersed systems in Couette viscometric blood flow was applied. A concurrent measurement system and data acquisition system implied into the Contraves LS 30 were used to quantify the electrical conductivity. The main advantage of this technique is that blood is subjected to a uniform shearing field in a Couette rheometric cell as well as the information about the mechanical and electrical properties of the fluid is obtained in parallel. The results show that rheological and electrical properties of the nanoparticle solutions and RBC suspensions, namely their electrical conductivity and apparent viscosity, are dependent on the shear rates, shape, concentration and molecular weight of the polymers.

Key words: Nanoparticles and RBC suspensions, poly(acrylic acid), rheology, electrical conductivity

13. **Ivanov, I.** (2017). NEW CRITERION FOR" STABILITY OF SIGHT" WHEN SHOOTING WITH A PNEUMATIC GUN ON THE BASIS OF ELECTRONIC SHOOTING TRAINING SYSTEM" SCATT". Research in Kinesiology 2017, Vol. 45 No. 2, pp. 132-134.

Abstract

Stabilometric resistance of the body in this examination has been evaluated through a platform for the examination of equilibrium resistance whose working algorithm is described in Gikova & Tishinov (2013). Simultaneously with the fluctuations of the GCG, the trajectory of sight at shot has been recorded through electronic shooting training system "SCATT", Russia. Our examination showed a direct link between sagittal hesitations of the GCG and vertical thrill of the sight when shooting "straight" with pneumatic gun. The goal of this examination was to seek and define a new quantitative criterion to assess this relationship. A quantitative criterion has been proposed as well for "stability of sight" on the ground of on an analysis of the shooting through electronic shooting training system "SCATT", Russia. The obtained results are useful in selecting and training of young shooters as well as for the verification and improvement of sports technique of the experienced marksmen.

Keywords: posturology, equilibrium, shooting, GCG

14. **Ivan Ivanov**, Dimitar Zagorski, 2017. Complex methodology for registration and analysis of pose equilibrium stability and the sight effectiveness in shooting sports. Activities in Physical Education and Sport, Vol. 7 No. 2, pp. 139-140.

Abstract

The relation between stability indices and their significance for the different sports disciplines and sports technique is important and its elucidation will improve the training process. The aim of this research is to find the relation between the body kinesthetic stability and the sports technique. The gunner's equilibrium stability obtained by balance platform and the sight oscillations - by electronic shot training system "SCATT" (Russia) were simultaneously recorded. The performed comparatively study between the results obtained by the two methods shows significant correlation between SCATT results at straight position for shot and the body posture parameters.

Keywords: sports technique, body posture parameters, electronic shot training system “SCATT”, shooting sports

15. Stoytchev, St., **Ivanov, I.**, Ranchev, S., & Iotov, I. (2021). A review of the biomechanics of synovial joints with emphasize to static stretching exercise. Series on Biomechanics, Vol.35 No.2 (2021), 3-20.

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. 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, requires more detailed analysis of the 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 includes 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, elastic, 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, poro-visco-elastic material, filtration, diffusional drag

16. Ranchev, S., **Ivanov, I.**, Iotov, I., & Stoytchev, S. (2020). Studies on a paradox in the work of the upper limbs in isometric stretching. Journal of Applied Sports Sciences, 4(2), pp. 80-90.

Abstract

Stretching is a common activity used by athletes, elderly, rehabilitation patients, people involved in fitness programs and many others. In isometric stretching an elongation in the linear dimensions of the kinematic chain of the upper limbs is observed. The aim of this study is to show the importance of intraarticular processes as response of isometric stretching force, as well as to mark the basic factors which define the joint answer to stretching, describing experimental data, relative to these factors. The present work has a programmatic character in terms of the directions in which the answer to the laid aims should be sought. The main focus is on the biomechanical processes in the joints involved in the obtained kinematic chain extension.

Key words: isometric stretching, joint, intra-articular processes.

17. Ranchev, S., **Ivanov, I.**, Iotov, I., & Stoytchev, S. (2019). On the biomechanical processes in human knee joint during active isometric stretching. *Series on Biomechanics*, 33(3), 56-61.

Abstract

The purpose of the present work is to evaluate intra-articular movements in the knee joint during active isometric stretching of the muscle groups of the lower right limb. Our working hypothesis was that, as a result of the muscular contractions of the adjacent locomotor muscles, a change in the distance between the femur and the big tibia would be observed in the knee joint. We conducted experiments with two experienced individuals, football players, after informed consent. The study was performed at resting MRI test and active isometric right leg stretching. The results showed that active isometric stretching causes intracranial processes in the knee joint. A change in the distance between the cartilage surface of the femur and the corresponding end of the tibia during active isometric stretching was observed. The experimental data obtained would allow developing of models of hydrodynamic and mechanical effects in deformation of the joint capsule; the interaction between cartilage deformation and synovial fluid flow; changes in the volume of the joint capsule as a result of simultaneous loading with axial forces, internal pressure and external pressure due to the action of the adjacent knee muscles and tendons.

Keywords: isometric stretching, intracranial knee joint movement, muscle-tendon block biomechanical properties

18. Kostova V., N. Antonova, I. Velcheva, **I. Ivanov**, 2012. Comparative analysis of the rheological properties of blood from patients with type 2 diabetes, *Series on Biomechanics*, ISSN: 1313-2458, vol.27 (3-4), 80-85, 2012

Abstract

The aim of the study is to estimate the rheological properties of blood in patients with type 2 diabetes and to compare the hemorheological parameters with a control group of healthy subjects. Hemorheological variables, including hematocrit (Ht), fibrinogen (Fib) and whole blood viscosity (WBV) at shear rates of $0,0237\text{ s}^{-1}$ to $128,5\text{ s}^{-1}$ were examined in 20 patients with diabetes mellitus type 2 and in 10 control subjects. Whole blood viscosity was measured using a rotational viscometer Contraves Low Shear 30 (Switzerland). Relationship between dynamic viscosity and Ht, Fib, Erythr and MCV were evaluated by coefficient of correlation "r". The results of this study confirm the significant increase of whole blood viscosity in the patients in comparison to controls within the range of shear rates $0,0237\text{ s}^{-1}$ to $128,5\text{ s}^{-1}$, which is due to the increased values of hematocrit, fibrinogen and erythrocytes. Rheological abnormalities such as increased aggregation and decreased deformation of erythrocytes also contribute to increase of blood viscosity which leads to the vascular blood flow changes in diabetes.

Keywords: Type 2 diabetes, hemorheological properties, erythrocyte aggregation and deformation

19. Kostova, V., Antonova, N., Chaushev, N., Velcheva, I., & **Ivanov, I.** (2015). Oscillations in skin temperature after cold test in patients with type 2 diabetes mellitus and rheological properties of the blood. *Series on Biomechanics*, vol. 29 (1), pp. 11 – 16.

Abstract

The aim of the study is to follow the disturbances in the skin temperature after cold stress in patients with type 2 diabetes and evaluate the dynamics of changes of the temperature oscillations corresponding to the myogenic, neurogenic and endothelial regulation of vascular tone in patients with type 2 diabetes. The skin temperature was measured on the palm surface of the distal phalanx of the index finger with two closely-spaced sensors and was continuously measured under basal conditions (10 min), during contralateral hand immersion

in cold water (3 min) and thereafter (10 min). A rotational viscometer Contraves Low Shear 30 (Switzerland) was used to measure whole blood viscosity in the group of patients with diabetes type 2 and in the control subjects. In the diabetic patients significant correlations between the increased whole blood viscosity at the entire range of shear rates and the values of the skin temperature oscillations at the three frequency ranges was found. The spectral analysis of variations in skin vascular tone provides useful additional information about the regulatory mechanisms influencing skin microcirculation.

Keywords: Type 2 diabetes, hemorheological properties, skin temperature fluctuations

20. D. Zagorski, M. Gikova, **I. Ivanov**, 2016. Relationship between kinematic characteristics and morphological parameters in shotokan karate athletes. Research in Kinesiology, Vol. 44, No. 2, pp. 225-228. ISSN 1857-7679

Abstract

The aim of an already conducted experiment was given to represent the relationship between kinematic and anthropometric parameters and the effectiveness of selected combat techniques in a representative study group of elite athletes with specialized measuring equipment and methods and subsequent aim-related analysis of execution, seeking the most significant deviations and dependencies from sport and pedagogical view point. As morphology parameters we chose indicators of body composition (such as body weight, %water content, % body fat, muscle mass, index of internal organs adipose tissue, index of physical condition, bone mass, basic metabolic rate and metabolic age) derived by a body composition scale analyzer (Tanita BC-533), using skin bioimpedance (single-frequency electric current with impedance of 20- 2000ohms, and up to 50 kHz frequency and 500 μ A). The kinematic parameters were registered through a high-speed CASIO-EX-ZR200 video camera with recording frequency of 120 fps using specialized software: SkillSpector. In the initial menu we choose graphics of speed, trajectories or travel time. The experiment was conducted with 22 elite athletes in Shotokan – Karate, the chosen techniques were Gyaku-Tsuki for upper, and Mae-Geri and Yoko-Geri for lower extremity. The correlation analysis showed significant dependencies in karate athletes between body mass, percentage of muscle mass and bone mass and metabolic rate as much as negative correlation between adipose mass and percentage water content-which is understandable. Higher sports qualification defines higher execution speed of specified techniques, in relation to greater height of the athlete. As a result we can summarize a tendency in the physical development of Bulgarian karate athletes-aimed search and development of athletes with optimized height, controlled muscle mass and reduced adipose mass.

Keywords: kinematic characteristics, morphological parameters, correlation analysis, combat techniques, index of internal organs adipose tissue, index of physical condition, basic metabolic rate, metabolic age

21. **Ivan Ivanov**, 2017. ULTRASOUND METHODS APPLICATION FOR ESTIMATION OF AUTOMOBILE OIL CHARACTERISTICS. Scientific Proceedings Year XXV, Number/1(216), 348-351.

Abstract

The aim of the study is to show the possibilities of ultrasound methods for measurement and analysis of different engine oil characteristics. These possibilities are important and understanding them may contribute for considerable benefits as: (i) improvement of the quality of specific auto service, by purchasing and correct usage of ultrasound devices; (ii) expertise improvement of technicians in the auto services; (iii) obtaining important information for oil film thickness in the group piston-cylinder wall, ball and hydrodynamic bearings. The elucidation of different ultrasound methods' applications and analysis of

derived oil parameters broaden the knowledge of the lubrication process in automobile engine, which is a significant factor for the correct preliminary service diagnostics. The paper includes ultrasound methods' description for oil film thickness measurement in the groups piston-cylinder wall, ball and hydrodynamic bearings, tribological and rheological oil properties' measurement, oil level estimation in the engine, temperature measurement and presence of air bubbles in the lubricant oil supply and sump lines, oil viscosity circumference profile in journal bearing in-situ.

KEY WORDS: ULTRASOUND, AUTOMOBILE OIL, OIL THICKNESS, ULTRASONIC SENSOR

22. Alexandrova, A., Antonova, N., **Ivanov, I.**, Kyulavska, M., Velcheva, I., & Zvetkova, E. (2018). Hemorheological and Atomic Force Microscopy studies on the experimental clot formations in patients with type 2 diabetes mellitus. *Series on Biomechanics*, 32(3), 63-73.

Abstract

Type 2 diabetes mellitus (T2DM) induced hemorheological disturbances leading to pathological changes in the whole blood viscosity (WBV), in blood coagulation and to the clots' formation. The study aims to investigate kinetics of the induced in vitro blood clots in T2DM patients and in healthy donors and morphological characteristics of the experimentally induced blood clots by means of atomic force microscope (AFM). The kinetics of blood coagulation was examined at a steady shear flow at low shear rate 0,0596 s⁻¹ by means of the rotational viscometer LS30 Contraves and WBV was evaluated. AFM scanning of the formed under shearing clots have been performed. The topography of the blood clots was examined using Force Modulation mode by means of AFM "Dimensional ICON Bruker NanoScope V9 Instrument". The results showed that clot formation in diabetic patients is accelerated in comparison to the controls at the applied low shear rate. The WBV at complete coagulation in T2DM patients is higher than in healthy donors. The morphological characteristics and functional transformations of erythrocytes (RBCs) and platelets in the experimentally formed under shearing clots, examined by AFM, showed that mainly "activated" platelets formed the experimentally induced clots in diabetic patients. Atypical erythrocytes (echinocytes, stomatocytes, target-like erythrocytes, etc.), poikilocytosis and anisocytosis of RBCs were also observed in clot formations from patients with T2DM.

Keywords: type 2 diabetes mellitus, whole blood viscosity, kinetics of blood coagulation, platelets (PLT, thrombocytes), erythrocytes (red blood cells, RBCs), atomic force microscope (AFM)

23. Gluhcheva, Y., **Ivanov, I.**, Atanasov, V., Antonova, N., Ivanova, J., & Mitewa, M. (2011). Hematological changes in case of chronic cadmium intoxication and monensin detoxication. Relationship with rheological variables. *Clinical hemorheology and microcirculation*, 49(1-4), 417-422.

Abstract

The study evaluated the affect of chronic cadmium (Cd) and monensin treatment on some hematological parameters and its relationship with the rheological variables. Adult male mice were subjected to chronic treatment with cadmium acetate [Cd(CH₃COO)₂ × 2H₂O] (group 1), Cd(CH₃COO)₂ × 2H₂O followed by treatment with low dose monensin (group 2) and Cd(CH₃COO)₂ × 2H₂O followed by high dose monensin treatment (group 3). Cd(CH₃COO)₂ × 2H₂O and deprotonated monensin were dissolved in distilled water and given daily to the experimental animals. Mice drinking distilled water served as a control group (group 4). Hematological parameters and erythrocyte morphology were evaluated in parallel with whole blood viscosity (WBV). Cd treatment reduced Hb and increased RDW. The addition of high dose monensin significantly improved erythrocytic indices compared to the control. Erythrocyte anisocytosis was observed in blood smears of Cd-treated mice

corresponding to the increased RDW. WBV was significantly elevated in the experimental groups in the whole range of shear rates compared to the control group and in groups 2 and 3 was lower than in group 1 but remained higher compared to group 4. Correlations were found between WBV and RBC, Hb, Hct, MCV and RDW. The results suggest that hemorheological parameters such as WBV should be monitored in parallel with the hematological parameters when monensin is applied and heavy metal intoxication is suspected.

Keywords: Cadmium, hematological indices, whole blood viscosity, monensin

24. Dimitrov, I., Hodzhaoglu, F., & **Ivanov, I.** (2013). In vitro dissolution of insulin crystal polymorphs at model conditions relevant to in vivo environment. *Dissolution Technologies*, 20(4), 11-16.

Abstract

In vivo dissolution of crystalline insulin formulations is an important step for insulin absorption in the subcutaneous therapy of diabetes, which is the most widespread. Here, data on the in vitro dissolution of three different crystalline forms of commercial porcine insulin are reported. The aim of this study was to create a model framework of in vivo dissolution of insulin crystalline formulations. In situ insulin crystal dissolution was studied at conditions of continuous undersaturation (i.e., in the absence of any free insulin around the crystals) in several types of model flood liquids, at different flooding flow rates relevant to blood capillary flows, and at a dissolution system temperature of 36 °C. Insulin crystal dissolution rate depends strongly on the flooding liquid composition and crystal type, the effects of pH and flooding flow rate being less pronounced. Results of the present study suggest a possibility for purposeful control over in vivo dissolution rates through development of particular insulin crystalline-based formulations.

KEYWORDS: Dissolution, insulin crystal polymorphs, diabetes therapy, insulin crystalline-based formulations, physiological conditions

25. Y. Gluhcheva, **I. Ivanov**. In vitro effect of temperature and cobalt chloride treatment on human red blood cells' morphology and indices. *Acta Morphol. Anthropol.*, 21, 2015 38-41
ISSN 0861-0509

Abstract

Changes of erythrocyte morphology induced by exposure of blood to cobalt chloride (CoCl₂) and/or various degrees of temperature are poorly studied. The aim of the study was to investigate the in vitro effect of CoCl₂ on erythrocyte morphology and indices of red blood cell suspensions after incubation at different temperatures. Human erythrocyte (RBC) suspensions were treated with 50 µM or 500 µM CoCl₂ and incubated for one hour at 4 °C, room temperature and 40 °C. After incubation the morphological changes were studied. Morphological studies showed RBC aggregates at 4 °C while elyptocytes were mainly observed at 40 °C. Thermal treatment induced anisocytosis leading to increased RDW and decreased MCV. The results indicate that both CoCl₂ and temperature affect erythrocyte morphology and indices of RBC suspensions possibly by inducing structural, biomechanical and biochemical changes in the erythrocyte membrane.

Key words: RBC suspensions, in vitro treatment, cobalt chloride, erythrocyte morphology, temperature incubation

26. Gluhcheva Y., **Ivanov I.**, Petrova E., Pavlova E., Vladov I. Sodium nitrite-induced hematological and hemorheological changes in rats. *Series on Biomechanics*, 27 (3-4), 2012, ISSN 1313-2458

Abstract

The aim of the present study is to investigate the effect of acute sodium nitrite (NaNO_2) treatment on the hematological and hemorheological parameters in rats. Mature rats were subjected to NaNO_2 exposure by a single intraperitoneal injection of 50 mg/kg body weight. The animals were sacrificed 1h, 5h, 24h, 48h and 5, 10, 20 days following the administration. Hematological and hemorheological parameters were measured. Preliminary results showed significantly reduced red blood cell count (RBC), while mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were significantly increased one and five hours after NaNO_2 administration compared to controls. MCHC remained significant until day 20 after treatment. According to the rheological studies plasma viscosity (PV) was the highest in the controls indicating possible biochemical changes in the treated samples. The highest whole blood viscosity (WBV) was measured 10 days after injection which corresponds to the increased RBC count. Acute treatment with NaNO_2 induces significant hematological and rheological changes therefore monitoring of these parameters is necessary when exposed to high doses or prolonged treatment with the compound.

Keywords: Sodium nitrite, hematological and hemorheological parameters, rats