SECTION – EXERCISE SCIENCES

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RHEOLOGICAL PROPERTIES OF THE BLOOD IN PATIENTS WITH SCIATICA

Authors' contribution:
A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
G. Funds collection

Kinga Wisniewska [1 ABCDF], Bartlomiej Ptaszek [2, 3 BDEF], Aneta Teleglow [4 ABDF]

[1] M.A. student, University of Physical Education in Krakow, Poland
[2] Ph.D. student, University of Physical Education in Krakow, Poland
[3] Malopolska Cryotherapy Centre, Krakow, Poland
[4] Department of Clinical Rehabilitation, University of Physical Education in Krakow, Poland

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Abstract

Aim. To examine changes in the rheological properties of the blood (blood count and elongation index) in patients with sciatica.

Basic procedures. The study group consisted of 10 men with sciatica - these patients were from Gabriel Narutowicz Krakow Specialist Municipal Hospital (preliminary study), aged 40-55 years. The control group consisted of blood donors from the Regional Blood Donor and Treatment Centre in Krakow. This group also included 10 men; the age of the donors corresponded to the study group. Blood was drawn from the men in a fasting state in the morning, in the amount of 3 ml from the ulnar vein and put into EDTA tubes. Morphological blood test - measurements were taken using the ABX MICROS 60 (USA) haematology analyzer. Erythrocyte deformability was tested using the LORCA analyzer (Laser-assisted Optical Rotational Cell Analyser, RR Mechatronics, The Netherlands). The results were obtained as the index of elongation and aggregation according to the Hardeman method (2001).

Results. Analyzing the average values of morphological and rheological indicators in men from the control and study group, there was a decrease in the value of: HGB [g/L], MCH [fmol], MCV [fL], MCHC [mmol/L], EI at the shear stress of 4.24-59.97 [Pa] and an increase in the value of EI at the shear stress of 0.58 [Pa].

Conclusions. The changes that occur when pressure is put on the L4, L5, S1 spinal nerves adversely affect the rheological changes of the blood in patients with sciatica, and are most likely caused by associated symptoms such as arthritis, fever or paresis of the lower extremity.

Introduction

Sciatica (ischialgia) is currently defined as a syndrome, most commonly caused by pressure or irritation of the sciatic nerve, which is accompanied by pain in the lumbosacral area of the spine, radiating to the hips, buttocks, along the rear and posterior part of the lower limb, sometimes even up to the foot. This pain is radicular and referred in nature [1]. Patients describe it as a pulling and stinging sensation; it usually occurs unilaterally and is accompanied by sensory disturbances (numbness and tingling); it constitutes 10% of all back pains [2]. It occurs most frequently due to direct pressure on the spinal nerve root caused by displacement of the nucleus pulposus of the intervertebral disc, an extradural tumor or inflammation [3]. The pain may radiate over the entire length of the sciatic nerve and this nerve is the longest and thickest nerve in the human body, the symptom range spreading over a large surface [4]. Referred pain is pain felt in a place other than the source of its origin, usually in specific areas on the body surface (Head's zones). The nature of this pain is diffuse, and the precise determination of its borders is difficult; it is caused by irritation of the nerve fiber endings that innervate the spine and neighboring tissues [3].

Sciatica is a condition from which an estimated 13-40% of the population at different ages suffers from, and the annual incidence is 1-5% [5]. The probable causes of sciatica can include: pressure on the nerve root from a herniated disc, pressure from osteophytes, spinal stenosis, spondylolisthesis, cancer of the spinal canal, muscular problems, disorders of the lymphatic and endocrine systems, stress or abscess surrounding the sciatic nerve [1, 6, 7]. Risk factors that predispose to the formation of sciatica include: cigarette smoking, being over 40, male sex, performing strenuous physical work and genetic factors [7, 8].

Hemorheology specializes in the issue of blood flow and deformation. Research in this field covers many aspects of whole blood, plasma and cellular components [9]. "Factors" affecting blood flow are hematocrit and plasma viscosity, the viscosity of whole blood, the ability of red blood cells to aggregate and deform [10]. Erythrocytes have the ability to deform at moderate and high flow speeds and to aggregate at a slow flow rate [5]. Blood flow affects the physical and physicochemical properties of the blood. To maintain proper body microcirculation, it is necessary for erythrocytes to be able to deform (their membranes) [11]. This phenomenon is very important because the red blood cells must change their shape so as to pass through the capillaries with a diameter of up to two times smaller than the diameter of the resting erythrocytes [12].

The aim of the study was to examine the changes in the rheological and morphological properties of blood in patients with sciatica.

Study design

The study group consisted of 10 men with sciatica - these patients were from Gabriel Narutowicz Krakow Municipal Specialist Hospital (preliminary study), and aged 40-55 years (not immobilized). The control group consisted of donors from the Regional Blood Donor and Treatment Centre in Krakow. This group also included 10 men; the age of the donors corresponded to the study group.

3 ml of blood were drawn from the vein inside the elbow from the participants on an empty stomach in the morning, into EDTA tubes. Blood samples were drawn by a qualified nurse under medical supervision, in accordance with the applicable standards of the Pathology of Locomotion Laboratory at the University School of Physical Education in Krakow, where rheological and morphological parameters of the blood were determined. The study was approved by the Bioethics Committee at the Regional Medical Chamber in Krakow.

Morphological blood test

Measurements were taken using the ABX MICROS 60 (USA) haematology analyzer.

The determined parameters were:

1. Red blood cell count – RBC [10^{12}/L]
2. Hematocrit – Hct [L/L]
3. Haemoglobin – Hgb [g/L]
4. Mean corpuscular hemoglobin index – MCH [fmol]
5. Mean corpuscular volume index – MCV [fL]
6. Mean corpuscular hemoglobin concentration – MCHC [mmol/L]
7. White blood cell count – WBC [10^9/L]
8. Platelet count: PLT [10^9/L]

Determination of elongation index

Erythrocyte deformability was tested using the LORCA analyzer (Laser-assisted Optical Rotational Cell Analyser RR Mechatronics, The Netherlands). The results were obtained as the index of elongation and aggregation according to the Hardeman method [12, 13]. Tests using the above apparatus were conducted within 30 minutes after blood collection, at 37 °C and according to standard protocol.

The results of the elongation index (EI) were given in the range of 0.30 to 59.97 of the shear stress measured in Pascals. The elongation index is a measure of the amount of deformation of red blood cells during their movement in the measuring chamber [12, 13].

Statistical analysis

The data are presented using mean values and standard deviation ($x \pm SD$). We used the t-Student test for independent samples. To determine the occurrence of relationships between selected blood parameters, we used Pearson's linear correlation coefficient. We assumed the following level of significance $\alpha = 0.05$ in the analyzes which were performed using Statistica 10 (StatSoft®, USA) and Excel 2013 (Microsoft®).

Results

Analyzing the average values of the morphological and rheological indicators in males from the control and study group, a decrease in the following values were noted: HGB [g/L] by 9.49%, MCH [fmol] by 16.23%, MCV [fL] by 10.43%, MCHC [mmol/L] by 1.18%, EI at the shear stress of 4.24 [Pa] by 47.61%, EI at the shear stress of 8.23 [Pa] by 43.75%, EI at the shear stress of 15.96 [Pa] by 36.58%, EI at the shear stress of 31.04 [Pa] by 33.33%, EI at the shear stress of 59.97 [Pa] by 31.48%; and an increase in the value of EI at the shear stress of 0.58 [Pa] by 57.69% (Tab. 1; Fig. 1-4).

Table 1. Average values ± standard deviation of morphological and rheological indicators of the blood in the control and study group

Indicator	Control group (n=10)	Study group (n=10)	p
RBC [10^{12}/L]	4.36±0.32	5.68±0.31	0.0877
Hct [L/L]	41.29±2.40	39.74±1.56	0.2159
Hgb [g/L]	15.17±1.07	13.54±0.47	0.0068
MCH [fmol]	34.62±1.60	29.00±1.77	0.0000
MCV [fL]	94.90±4.86	85.00±5.00	0.0028
MCHC [mmol/L]	36.49±1.17	34.06±0.41	0.0007
WBC [10^9/L]	5.68±1.04	5.92±0.92	0.6694
PLT [10^9/L]	198.10±31.79	204.40±30.62	0.7203
EI at shear stress of 0.30 [Pa]	0.14±0.06	0.13±0.01	0.6574
EI at shear stress of 0.58 [Pa]	0.11±0.04	0.25±0.03	0.0000
EI at shear stress of 1.13 [Pa]	0.15±0.22	0.20±0.04	0.6021
EI at shear stress of 2.19 [Pa]	0.12±0.03	0.20±0.25	0.3334
EI at shear stress of 4.24 [Pa]	0.22±0.04	0.11±0.01	0.0001
EI at shear stress of 8.23 [Pa]	0.30±0.10	0.18±0.02	0.0240
EI at shear stress of 15.96 [Pa]	0.41±0.03	0.26±0.03	0.0000
EI at shear stress of 31.04 [Pa]	0.48±0.02	0.32±0.04	0.0000
EI at shear stress of 59.97 [Pa]	0.54±0.01	0.37±0.05	0.0000

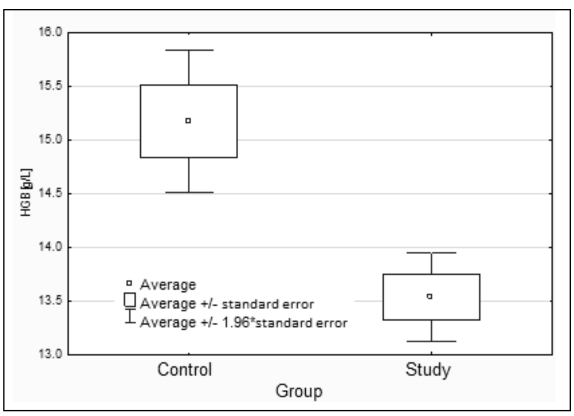

Fig. 1. Chart presenting average HGB [g/L] values in the control and study group

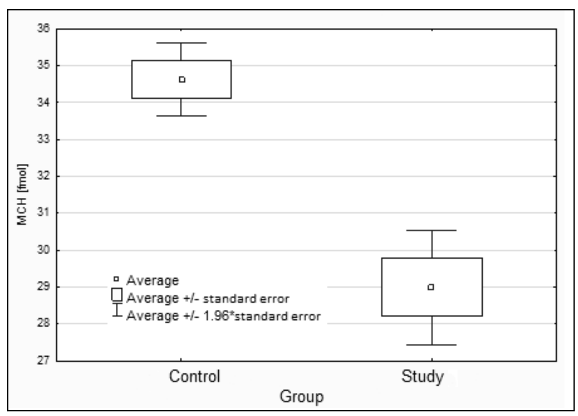

Fig. 3. Chart presenting average MCH [fmol] values in the control and study group

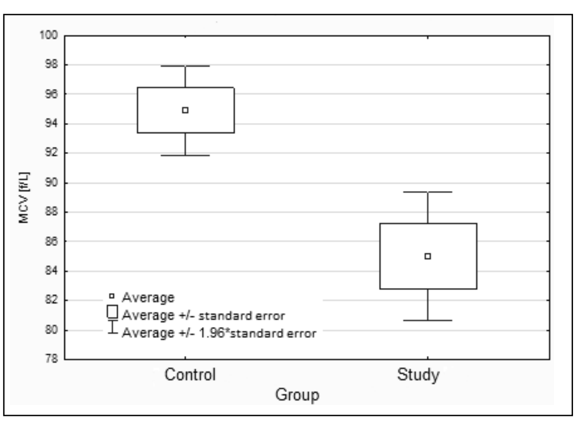

Fig. 2. Chart presenting average MCV [fL] values in the control and study group

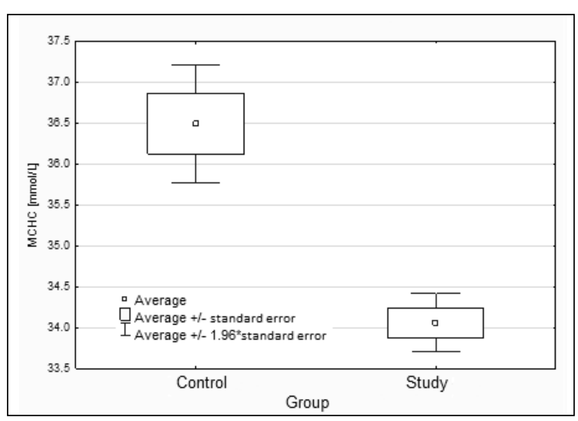

Fig. 4. Chart presenting average MCHC [mmol/L] values in the control and study group

Discussion

The aim of the research presented in this paper was to answer the question whether the changes occurring when pressure is put on the spinal nerves in patients with sciatica adversely affect the rheological properties of the blood.

In our own conducted studies, we noted a decrease in the values of: HGB [g/L], MCH [fmol], MCV [fL], MCHC [mmol/L], EI at the shear stress of 4.24-59.97 [Pa] and an increase in the value of EI at the shear stress of 0.58 [Pa].

Split et al. [14] conducted a study on 26 patients with sciatic lower back pain syndrome lasting from 3 weeks to 3 months. They analyzed the concentration of hemoglobin A_{1c} in erythrocytes. Hemoglobin A_{1c}, or glycated hemoglobin, is hemoglobin which is formed from attachment of non-enzymatic, stable molecules of glucose to the N-terminal amino group of the β-globin chain. In the subjects, an increase was noted in hemoglobin A_{1c} exceeding the accepted norm in the red blood cells, and in more than half of them, the increase exceeded the value of 10%. The researchers explain that was due to, among others, the evolution of adrenalin and glucocorticoids by the adrenal glands occurring under the influence of pain that accompanies patients with this disease. Both of these hormones effect the increase in blood glucose level, and additionally, they increase plasma free fatty acids which leads to impairment of insulin action in the event of excessive concentration. The level of glucose in the blood depends on the glycosylation of hemoglobin. The authors suggest that hemoglobin A_{1c} can determine the effectiveness of treatment [14, 15].

Kowal et al. [10] described hemorrhagic changes occurring in Waldenstrom's disease and multiple myeloma. According to the authors, the increase in plasma viscosity is attributed to the excessive concentration of monoclonal proteins. Rheological blood disorders are regulated by the body though reducing the synthesis of erythropoietin (EPO) and immunoglobulins. People with hypertension have increased blood viscosity, which is caused by impaired flexibility of erythrocytes and increased hematocrit. Increased blood viscosity due to increased plasma viscosity, increased erythrocyte aggregation and impaired erythrocyte deformability were observed in patients with acute ischemic strokes. There was no noted increase in blood viscosity in patients following episodes of ischemia or in patients with clinical silent ischemic foci, due to improved deformability of erythrocytes. It is believed that this is related to the mechanism of autoregulation [10, 16].

Kowal et al. [17] conducted a study, the purpose of which was to show what hemorrhagic changes occur in the blood when removing part of the plasma. Tests were performed on 3 patients, one person with myasthenia gravis, the other with multi-rot nerve inflammation. During the study, they determined hematocrit, plasma viscosity, relative blood viscosity at various shear rates. It was observed that the removal of portions of plasma from the blood lowered the plasma viscosity and caused a reduction in relative blood viscosity at low shear rates [16, 17].

Kowal et al. [17] conducted a study among 80 patients. The first group consisted of 20 patients without neurological disorders, where the average age was 63 years. The second group consisted of 30 patients with acute ischemic stroke, the average age of people was approx. 56 years. The third group consisted of the 30 people, the patients being six months after a stroke, and the average age was 67. The second and the third group were still under medical supervision, and additionally, some patients from both groups were diagnosed with comorbidities: diabetes, hypertension, myocardial infarction. The aim of the study was to compare rheological properties (plasma viscosity, deformability of erythrocytes, hematocrit, red blood cell aggregation, fibrinogen) in all of the groups. During the research it was found that in the first group, the viscosity of blood was higher compared to the other groups, but the viscosity of the plasma was lower. The increase of blood viscosity is influenced by hematocrit, plasma viscosity, red blood cell deformability and the aggregation of red blood cells. In all groups, there were no changes in hematocrit, thus in further analysis it can be excluded as a factor affecting blood viscosity. The differences related to the viscosity of blood and plasma can be explained by changes in the flexibility of erythrocytes and their aggregation. It is believed that the differences are due to the body triggering the mechanism of feedback in a patient with ischemic stroke, that works by changes taking place in the range of rheological parameters and reducing the viscosity of the whole blood. The human body itself can regulate changes in the rheological properties of the blood by e.g. decreasing plasma viscosity, but this mechanism is not precisely known to us [17].

In our study on sciatica, we observed a statistically significant decrease in hemoglobin by 9.49%, the average volume of red blood cells by 10.43%, the average mass of hemoglobin in the red blood cell by 16.23%, and the average concentration of hemoglobin in the red blood cells by 1.18 %. Also, we found a significant decrease in rheological blood indicators: EI at the shear stress of 4.24 [Pa] by 47.61%, EI at the shear stress of 8.23 [Pa] by 43.75%, EI at the shear stress of 15.96 [Pa] by 36.58%, EI at the shear stress of 31.04 [Pa] by 33.33% and EI at the shear stress of 59.97 [Pa] by 31.48%.

The observed changes in patients with sciatica are most likely caused by its associated symptoms such as lower extremity paralysis, arthritis, fever. Our study showed changes in the rheological properties of blood, but the detailed mechanisms are difficult to interpret. Research should be conducted among a larger group of subjects, broadening the study by whole blood viscosity, plasma viscosity, fibrinogen and the aggregation of red blood cells. Despite the fact that there are many studies on hemorheological changes in a variety of disorders, this study is, to our knowledge, the first to have been conducted among patients with sciatica.

Conclusions

The changes that occur when there is pressure on the L4, L5, S1 spinal nerves adversely affect the rheological changes of the blood in patients with sciatica, and are most likely due to associated symptoms such as arthritis, fever or paresis of the lower extremity.

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Author for correspondence:

Bartlomiej Ptaszek
E-mail: bartlomiejptaszek1007@gmail.com