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BLOOD PRESSURE, LUNG FUNCTION AND MUSCULAR STRENGTH VALUES IN STUDENTS WITH JOINT HYPERMOBILITY

VREDNOSTI KRVNOG PRITISKA, PARAMETARA PLUĆNE FUNKCIJE I MIŠIĆNE JAČINE KOD STUDENATA SA HIPERMOBILNOŠĆU ZGLOBOVA

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Summary

Introduction. Elastin and collagen are the key components of bones, cartilage, tendons, skin, lungs and arterial walls. Weak connective tissue disorders and joint hypermobility are pathological conditions where the structure of collagen fibers is changed, resulting in a number of symptoms. The objective of this study was to determine the prevalence of weak connective tissue disorder in second- and third-year students of the Faculty of Medicine of the University of Novi Sad, and to compare muscle strength, pulmonary function and blood pressure between individuals with and without hypermobility. **Material and Methods.** The study included 100 students (50 females and 50 males) divided into two groups: Group 1 with weak connective tissue and Group 2 with normal connective tissue. The subjects were assessed according to the Beighton score and the Brighton criteria to diagnose hypermobility. Values of blood pressure, pulmonary function and muscle strength were also measured. **Results.** Analysis of anthropometric parameters and blood pressure values showed significant difference between the groups, including the body height (p=0.014) and body weight (p=0.021) values and systolic (p<0.001) and diastolic (p=0.004) blood pressure values. Dynamometric parameters and lung function values were significantly different between the groups, with vital capacity (p<0.001), forced vital capacity (p=0.05), forced expiratory volume in the 1st second (p=0.025). Lower values were noted in group 1. **Conclusion.** Weak connective tissue was found with high percentage of students of the Faculty of Medicine of the University of Novi Sad (67%). Blood pressure, lung function vales and dynamometric parameters were significantly lower in group 1.

Key words: Joint Instability; Blood Pressure; Spirometry; Muscle Strength; Connective Tissue

Sažetak

Uvod. Elastin i kolagen su ključne komponente kostiju, hrskavice, tetiva, kože, pluća i zidova krvnih sudova. Slabo vezivno tkivo i hipermobilnost zglobova predstavljaju patološka stanja kod kojih postoji izmenjena struktura kolagenih vlakana, što se manifestuje brojnim simptomima. Cilj istraživanja bio je da se utvrdi prevalencija slabog vezivnog tkiva kod studenata druge i treće godine Medicinskog fakulteta Univerziteta u Novom Sadu, kao i poređenje vrednosti mišićne jačine, parametara plućne funkcije i vrednosti krvnog pritiska kod osoba sa slabim vezivnim tkivom i bez njega. **Materijal i metode.** Istraživanje je obuhvatalo grupu od 100 studenata (50 ženskog i 50 muškog pola) koji su bili podeljeni u dve grupe: prva grupa osobe sa slabim vezivnim tkivom i druga grupa bez slabog vezivnog tkiva. Svim ispitanicima dijagnoza je postavljena pomoću *Beighton* skora i *Brighton* kriterijuma. Potom su merene vrednosti krvnog pritiska, parametri plućne funkcije i mišićne jačine. **Rezultati.** Analizirajući vrednosti antropometrijskih parametara i arterijskog krvnog pritiska između ispitivanih grupa uočeno je postojanje statistički značajne razlike. Razlike su evidentirane u pogledu telesne visine (p = 0,014), telesne mase (p = 0,021) kao i u pogledu vrednosti sistolnog (p < 0,001) i dijastolnog (p = 0,004) arterijskog krvnog pritiska. Takođe, postojanje statistički značajne razlike među grupama utvrđeno je i poređenjem vrednosti parametara plućne funkcije, vitalni kapacitet (p < 0,001), forisirani vitalni kapacitet (p = 0,05), forisirani ekspiratorini volumen u prvoj sekundi (p = 0,025) i dinamometrije. Niže vrednosti su prisutne u prvoj grupi. **Zaključak.** Slabo vezivno tkivo je zastupljeno u visokom procentu kod studenata Medicinskog fakulteta u Novom Sadu (67%). U prvoj grupi su evidentirane značajno niže vrednosti arterijskog krvnog pritiska, parametara plućne funkcije kao i dinamometrijskih parametara.

Ključne reči: hipermobilnost zglobova; krvni pritisak; spirometrija; dinamometrija; vezivno tkivo

Introduction

The concept of weak connective tissue was not in use until late 19th century and more significance was given to this term later [1, 2]. The hypermobility syndrome is defined as a condition with an increased degree of joint mobility, which exceeds the physiological limits [3]. This syndrome is characterized by the presence of musculoskeletal symptoms and symptoms by other organs that include connective tissue is their integral part, but systemic rheumatologic disease is not present [4, 5].

The connective tissue is a tissue of mesenchymal origin, and it is made of fibroblasts, matrix, collagen

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Abbreviations
BMI – body mass index
BW – body weight
BH – body height
VC – vital capacity
FVC – forced vital capacity
FEV1 – forced expiratory volume in the first second

and elastic fibers. The pathogenesis of weak connective tissue includes a change in the structure of collagen and elastin fibers, which is manifested through many symptoms [6, 7]. Joint hypermobility is characterized only by an increased degree of joint mobility that exceeds the physiological limits, but without the presence of symptoms by other organs [8], which is the main difference between joint hypermobility and the hypermobility syndrome [9, 10]. Joint hypermobility and hypermobility syndrome are hereditary disorders with the autosomal dominant pattern of inheritance and with polymorphic symptomatology [10, 11]. Differential diagnostics should distinguish this condition from other hereditary disorders of the connective tissue with low incidence such as Marfan syndrome, Ehlers-Danlos syndrome, osteogenesis imperfecta, where severe clinical signs are present [12, 13].

Along with elastin, collagen is a key structural component of the bones, cartilage, tendon, skin, lungs and blood vessel walls. According to the literature, there is a correlation between some respiratory disorders and the weak connective tissue disorder. There has been an increase in the prevalence of asthma and atopy in persons with weak connective tissue [14]. Connective tissue allows for the connection of muscle fibers into an organized unit, thus forming the shape of muscles. Also, elastic and collagen fibers are integral part of all three proper muscle fascia and enable the transmission of force, which is developed due to contraction of muscle fibers, to the tendons [15]. These patients are often susceptible to injuries of ligaments [16, 17].

Different studies show the percentage distribution of week connective tissue syndrome in children and student population [18–21]. It was found that the percentage distribution of week connective tissue varies with age (decreasing with age), gender (the syndrome is more common in women), and ethnicity [22]. Furthermore, doing some sports, such as ballet or rhythmic gymnastics, can lead to hypermobility over time due to active training that involves stretching [23, 24].

The aim of this study was to determine the prevalence of week connective tissue in second- and third-year students at the Faculty of Medicine of the University of Novi Sad, and to compare the values of blood pressure, lung function parameters and muscle strength in students with and without weak connective tissue.

Material and Methods

The study was designed as prospective research. All participants were tested in a functional diagnostics laboratory before noon. The research consisted of four consecutive phases. The first phase included diagnosis, determination of prevalence and division of students into two groups. After establishing the prevalence of week connective tissue in 100 subjects, 20 patients were excluded from further examination due to hypertension (150/100 mmHg) and respiratory diseases. Group 1 included subjects with weak connective tissue (n=67) and the Group 2 was the control group (n=33). Anthropometric measurements and blood pressure values were taken in the second phase of the study. The values of pulmonary function parameters were measured in the third phase. Muscular strength was measured in the final, fourth phase of the study.

This research included 100 (50 females and 50 males) second- and third-year students of the Faculty of Medicine of the University of Novi Sad. Age and anthropometric parameters of the participants are presented in **Table 1.** All the students were healthy and not physically active. It was emphasized to them not to consume cigarettes, coffee or energy drinks before testing as it would affect the measured values of blood pressure. The study was approved by the Ethics Committee of the Faculty of Medicine of the University of Novi Sad (Novi Sad, Serbia; approval no. 01-39/234). Before the research, the concept of the study, risks and benefits of participation were explained to the participants in detail, both orally and in written, as well as what was expected of them, the methods and purpose of the examination, after which they signed the informed consent voluntarily.

The diagnosis was based on the Beighton score and the Brighton criteria. The Beighton score is a nine-point scale and requires the performance of five maneuvers, four passive bilateral and one active unilateral maneuver. It includes nine scoring points, where one point is assigned for the ability to perform each of the four maneuvers bilaterally and one more point for the flexibility of the spinal column beyond the physiological limits. Cutoff of ≥4 points was used for the diagnosis of week connective tissue and joint hypermobility [3].

Table 1. Age and anthropometric parameters
Tabela 1. *Godine života i antropometrijski parametri*

Parameters *Parametri*	Weak connective tissue *Slabo vezivno tkivo*	Control group *Kontrolna grupa*
Age (years)/*Godine života*/Mean ± SD/*Srednja vrednost* ± SD	20.59 ± 0.67	20.67 ± 0.9
Body height (cm)/*Telesna visina (cm)*/Mean ± SD/*Srednja vrednost* ± SD	171.2 ± 8.74	176.24 ± 8.81*
Body weight (kg)/*Telesna masa (kg)*/Mean ±SD/*Srednja vrednost* ± SD	65.62 ± 12.74	72.85 ± 14.41*
BMI (kg/m^2)/*Indeks telesne mase (kg/m^2)*/Mean ±SD/*Srednja vrednost* ± SD	22.38 ± 3.38	23.26 ± 3.14

*p<0.05

Table 2. Blood pressure values in both groups of subjects
Tabela 2. *Vrednosti krvnog pritiska kod obe grupe ispitanika*

Parameters *Parametri*	Systolic blood pressure (mmHg) *Sistolni krvni pritisak (mmHg)*	Diastolic blood pressure (mmHg) *Dijastolni krvni pritisak (mmHg)*
Weak connective tissue/*Slabo vezivno tkivo*	104.49 ± 11.38	66.12 ± 10.57
Control group/*Kontrolna grupa*	114.84 ± 14.8*	72.9 ± 8.64*

*p<0.05

We used the Brighton criteria, consisting of major and minor criteria, to determine the hypermobility syndrome, which is a set of symptoms and signs. The subjects needed to have: 1) two major; 2) one major and two minor; or 3) four minor criteria to be diagnosed with the hypermobility syndrome [5].

The body mass index (BMI) was calculated according to the following formula:

$$BMI=\frac{BW(kg)}{BH(m)^2}.$$

Body weight (BW) was measured using medical weighing scales with sliding weights with precision of 0.1 kg, while the body height (BH) was measured using a stadiometer with a precision of 0.1 cm. Arterial blood pressure was measured on the left hand with the subjects sitting, using the noninvasive auscultation method by the Riester device. The students had to sit for 5-10 minutes before measuring in order to obtain the best possible accuracy of the measurement.

Vital capacity (VC), forced vital capacity (FVC) and forced expiratory volume in the 1st second (FEV1) were measured with use of a spirometer (MIR Spirolab, Enraf-Nonius, Netherlands). The values of Tiffeneau index were calculated using the formula:

$$FEV1\%=\frac{FVC}{FEV1}\ x\ 100.$$

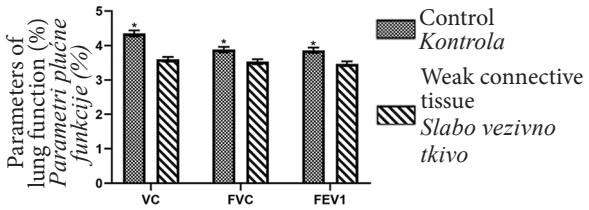
Using the Concept2Dyno (Concept2 Inc., Vermont, USA) isokinetic dynamometer with constant resistance and variable speed, we measured muscle strength in the examined groups. We tested the muscle strength of the leg extensors, flexors and arm extensors. The software system of the device calculated the achieved values of the average and maximum overloaded muscle strength when performing isolated contractions of certain muscle groups.

Mean value ± standard deviation (SD) was calculated for all experimental data. The obtained quantitative data were analyzed in order to determine the existence of statistically significant differences between the groups. Student's t-test was used for this purpose. Data were analyzed using the JASP 0.8.0.1 software. Statistically significant difference was set at $p \leq 0.05$.

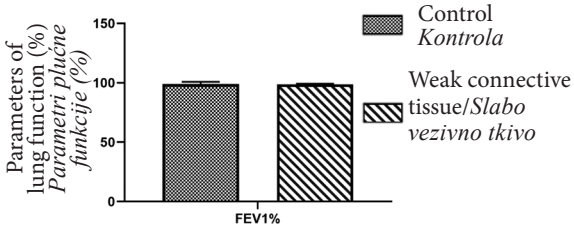
Results

In a group of 100 students (50 females and 50 males), after the diagnosis, 67% were found to be subjects with weak connective tissue.

Analysis of **Table 2** shows the mean values of systolic ($p < 0.001$) and diastolic ($p=0.004$) blood pressure among the examined groups. Lower values of these parameters were found in the group with weak connective tissue.



Graph 1. The means of VC, FVC, FEV1 in the examined groups
Grafikon 1. *Srednje vrednosti vitalnog kapaciteta, forsiranog vitalnog kapaciteta, forsiranog vitalnog kapaciteta u prvoj sekundi kod ispitivanih grupa*



Graph 2. The means of FEV1% in both groups of subjects
Grafikon 2. *Srednje vrednosti forsiranog vitalnog kapaciteta u prvoj sekundi u obe grupe ispitanika*

Comparison of the measured values of lung function parameters (VC, FVC, FEV1) showed a statistically significant difference between the examined groups **(Graph 1).**

Lower values were found in the group with weak connective tissue. The Tiffeneau index values were found not to be significantly different **(Graph 2).**

The mean values and the standard deviation of the dynamometric parameters of the two examined groups are presented in **Table 3**. Analysis of these parameters showed a statistically significant difference in the average and maximum values of muscle contraction strength of leg extensors, arm extensors and arm flexors between the groups. The control group had higher values of all dynamometric parameters.

Discussion

Variation in the prevalence of weak connective tissue and joint hypermobility is the subject of numerous studies [18, 20, 21]. Interest groups were mainly pediatric patients who were referred to different specialist examinations, and school-age children [25, 26]. The

Table 3. Comparison of dynamometric parameters between students with weak connective tissue and the control group
Tabela 3. *Poređenje vrednosti dinamometrijskih parametara između studenata sa slabim vezivnim tkivom i kontrolne grupe*

Parameters *Parametri*		Weak connective tissue *Slabo vezivno tkivo*	Control group *Kontrolna grupa*
Leg extensors *Ekstenzori noge*	Average value (kg)/*Prosečna vrednost (kg)*	95.16 ± 22.8	125.77 ± 36.25*
	Maximum value (kg)/*Maksimalna vrednost (kg)*	104.89 ± 26.06	136.55 ± 36.41*
Arm extensors *Ekstenzori ruke*	Average value (kg)/*Prosečna vrednost (kg)*	37.33 ± 16.25	52.39 ± 20.14*
	Maximum value (kg)/*Maksimalna vrednost (kg)*	40.79 ± 17.20	56.48 ± 20.59*
Arm flexors *Fleksori ruke*	Average value (kg)/*Prosečna vrednost (kg)*	39.90 ± 17.19	53.35 ± 18.99*
	Maximum value (kg)/*Maksimalna vrednost (kg)*	44.51 ± 18.16	59.19 ± 20.24*

*p<0.05

prevalence of weak connective tissue and joint hypermobility in these periods of life ranges from 8.87% to 34% [19–21, 27, 28]. There have been few studies where research was based on student population [29, 30], but none in Serbia.

In a study carried out by Al Jarallah et al. on a group of students in Kuwait with average age of 21 ± 2.2 years, prevalence of weak connective tissue was 22.3% [29], while prevalence was slightly higher (29.8%) among Iraqi students [30]. Contrary to the previous studies, prevalence of weak connective tissue in students of the Faculty of Medicine of the University of Novi Sad is 67%, which is extremely high. These results could be related to the multiethnic population in the territory of Vojvodina.

Type I and type III collagen take part in the structure of joint ligaments and connective tissue of blood vessel walls [31, 32]. Defects of these types of collagens are associated with abnormalities of connective tissue and vascular tissue in subjects with hypermobility [33]. Basically, it is possible to explain the presence of lower systolic and diastolic blood pressure values, which statistically significantly differ in people with the above diagnosis compared to healthy subjects. Engelbert et al. found the presence of lower systolic (100.2 ± 2.4) and diastolic (64.3 ± 1.7) blood pressure values in the pre-puberty group with hypermobility syndrome compared to the control group (110.1 ± 1; 71.6 ± 0.7). There have been no studies that compared the values of systolic and diastolic blood pressure in students with and without weak connective tissue [34].

The values of all measured pulmonary parameters in our study statistically significantly differ among the groups. There was no data so far about lung function parameters in people without respiratory illnesses and with a positive diagnosis of weak connective tissue. Lower values of lung function parameters in our research could be a consequence of a defect in connective tissue in students with the positive diagnosis. Namely, there is a change in the mechanical properties of the airways and the lung parenchyma, resulting in an increase in the airways expansibility and the tendency towards airways collapse, which explains the obtained results [14].

Reduced muscular strength of the upper limbs in adolescents with weak connective tissue was also found by Scheper et al. [35]. In terms of the values of muscle strength of the leg extensors in the students with weak connective tissue, our results comply with earlier studies on the isokinetic dynamometer [36, 37]. However, research by Jensen et al. [38] and Stewart & Burden [39] states that there was no statistically significant difference in muscle strength of leg extensors in subjects with weak connective tissue compared to the control group. In the same study, Stewart & Burden researched male athletes, whereas both sexes with no physical activity were included in our research. The fact that sport has an impact on the development of muscle strength is a possible explanation of these results. According to the literature, the state of hypermobility decreases with age [26, 30, 40], which is consistent with both our and the results of Jensen et al. Our subjects were 20.63 ± 0.77 years old, while subjects in Jensen et al. were older, about 40. The main factor contributing to the reduction of muscle strength is inactivity of the extremities caused by pain, as well as weakness of the ligaments, which is the base of joint instability [41].

Conclusion

Week connective tissue is present in a far greater percentage (67%) among a sample of 100 examined students of the Faculty of Medicine in Novi Sad than in other population groups. Lower values of systolic and diastolic blood pressure were recorded in the group of students with weak connective tissue. Pulmonary function parameters (vital capacity, forced vital capacity, forced expiratory volume in the 1st second) in students with weak connective tissue showed lower values than in the control group. Lower muscle strength of the upper and lower extremities was observed in the student population with weak connective tissue compared to the control group.

The results obtained in our research are important for raising the awareness about the effect of dosed physical activity on the development of muscle strength in persons with weak connective tissue to prevent complications that can have a significant impact on the quality of life.

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