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PART II. PHYSICAL ACTIVITY OF SOCIAL AND PROFESSIONAL GROUPS
DZIAŁ II. AKTYWNOŚĆ FIZYCZNA GRUP SPOŁECZNYCH I ZAWODOWYCH

RELATIONSHIP BETWEEN SPINAL COLUMN HEALTH AND PHYSICAL ACTIVITY AMONG SCHOOLCHILDREN AGED 12-13

ZWIĄZEK MIĘDZY ZDROWIEM KRĘGOSŁUPA A AKTYWNOŚCIĄ FIZYCZNĄ WŚRÓD UCZNIÓW W WIEKU 12-13 LAT

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Summary

Background. This study aimed to investigate the potential correlation between the physiological condition of the spine and posture habits among both adolescent athletes and non-athletes.

Material and methods. In this research, a modified version of the Global Physical Activity Questionnaire (GPAQ) was utilized to assess the exercise routines and sports engagement of the participants. Additionally, the Idiag M360pro Spinal Mouse device was employed for the evaluation of spinal column health.

Results. The findings revealed a statistically significant relationship between negligence and sports participation ($\chi^2(1, n=61)=6.036$, $p=0.018$). Specifically, a smaller proportion of athletes (39.1%, 9 individuals) exhibited careless posture in comparison to non-athletes (71.7%, 27 individuals). Moreover, a statistically significant association was identified between poor posture and involvement in sports ($\chi^2(1, n=61)=7.878$, $p=0.008$). Notably, a smaller percentage of athletes (26.1%, 6 individuals) demonstrated poor posture, contrasted with non-athletes (63.2%, 24 individuals).

Conclusions. The results indicate that within the examined sample, athletes exhibited a lower prevalence of poor posture. Nevertheless, it is noteworthy that half of the entire sample manifested issues related to posture. Consequently, the primary role of physical education instructors and coaches should involve preventive measures through physical activities that foster a passion for sports. This, in turn, can contribute to the development of proper muscle balance and the maintenance of correct posture.

Keywords: Spinal Mouse, posture, spinal column, adolescents, movement

Streszczenie

Wprowadzenie. Niniejsza praca miała na celu zbadanie potencjalnej korelacji między stanem fizjologicznym kręgosłupa a nawykami postawy zarówno wśród nastoletnich sportowców, jak i osób nieuprawiających sportu.

Materiał i metody. W ramach badania wykorzystano zmodyfikowaną wersję Globalnego Kwestionariusza Aktywności Fizycznej (GPAQ), aby ocenić rutynowe ćwiczenia i zaangażowanie sportowe uczestników. Dodatkowo zastosowano urządzenie Idiag M360pro Spinal Mouse do oceny zdrowia kręgosłupa.

Wyniki. Wyniki wykazały statystycznie znaczący związek między zaniedbaniem i uczestnictwem w sporcie ($\chi^2(1, n=61)=6.036$, $p=0,018$). W szczególności, mniejszy odsetek sportowców (39,1%, 9 osób) wykazywał niedbałą postawę w porównaniu do osób niebędących sportowcami (71,7%, 27 osób). Ponadto zidentyfikowano statystycznie istotny związek między złą postawą ciała a zaangażowaniem w sport ($\chi^2(1, n=61)=7,878$, $p=0,008$). Warto zauważyć, że mniejszy odsetek sportowców (26,1%, 6 osób) wykazywał złą postawę ciała, w przeciwieństwie do osób nieuprawiających sportu (63,2%, 24 osoby).

Wnioski. Wyniki wskazują, że w obrębie badanej próby sportowcy wykazywali niższą częstość występowania złej postawy. Niemniej jednak warto zauważyć, że połowa całej próby przejawiała problemy związane z postawą ciała. W związku z tym, podstawową rolą instruktorów wychowania fizycznego i trenerów powinno być podejmowanie działań profilaktycznych poprzez aktywność fizyczną, która sprzyja rozwijaniu pasji do sportu. To z kolei może przyczynić się do rozwoju właściwej równowagi mięśniowej i utrzymania prawidłowej postawy.

Słowa kluczowe: Spinal Mouse, postawa, kręgosłup, nastolatki, ruch

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Introduction

"Posture" is a motor habit formed at a specific morphological and functional level [1]. From this point of view, posture is an indicator of the mechanical efficiency of the kinetic sense, which requires muscle balance and neuromuscular coordination. Others define posture as the optimal body position in which we achieve the best possible biomechanical efficiency with the least possible energy expenditure during our daily activities. In this case, the tension of the joint capsules and ligaments corresponds to the physiological level and the loading of the articular surfaces is uniform [2,3]. Nowadays, correct posture is increasingly rare among children, thanks to prolonged incorrect sitting, ergonomically inappropriate desks, poorly carried school bags and lack of physical activity [4-6]. As a result, muscle balance is upset and posture disorders occur [5,7]. Adolescence is a critical period for the development of posture disorders. In this case, the hormonal balance of children changes, the rate of growth accelerates [6], and as a result of the different rate of development of bones and muscles, dysfunctional posture may occur [1].

Posture represents physical and mental health [8,9]. Optimum posture depends on many factors, but one of the most important of these is physical activity of the right intensity and reducing a sedentary lifestyle [10-12]. Risk factors for the development of increased back kyphosis include incorrect posture habits of adolescents, such as incorrect sitting position or prolonged use of electronic devices [9,13]. In most cases, spinal disorders and vertebral disorders that develop in adulthood are caused by poor posture, primarily the consequences of poor posture in childhood, and can be prevented with adequate exercises [14,15]. The World Health Organization [16] recommends that children and adolescents should do at least 60 minutes of moderate to vigorous intensity physical activity per day. Based on research conducted among school-age children in Hungary, the proportion of non-athletes in boys between the ages of 9 and 15 rose continuously from 15.3% to 31.0%, and in girls of the same age, this proportion rose from 21.0% to 53.8 % [17]. In research [18], it was found that only one in every five adolescents met the recommended guidelines for physical activity (21.2%). These results were reinforced by an epidemiological study involving 1.6 million adolescents from different regions worldwide. It was described that 77.6% of boys and 84.7% of girls do not meet the guidelines for physical activity. Additionally, over the past two decades, gender disparities in adhering to physical activity guidelines have increased in every region of the world [19].

Aim of the work

The aim of the study was to present the relationship between the physiological condition of the spine, posture in the sample of children who are athletes and non-athletes.

Material and methods

In our research, we included seventh-grade students in an elementary school in Western Hungary in the 2020/2021 academic year (n=61, 31 boys, 30 girls; 12.67±0.6 years). We performed our study with the Idiag M360pro Spinal Mouse. The examiner rolls the device along the spinous processes of the C7-S1 vertebrae along the spine. The software the works with the instrument contains the necessary parameters to perform the Matthiass test [20] which can be used to measure the strength of the back muscles [21]. During the measurement, we examined the spine of the children in the sagittal plane while standing, bending forward, and after performing the Matthiass test, also while standing. The examination was carried out in the school's medical room, where only the people performing the examination and the examined student were present. The examined person exposed his/her upper body. The person conducting the examination marked the course of the vertebrae with the help of a felt-tip pen, then guided the instrument along the spinal column of the examined person, starting

from the seventh cervical vertebra. The results measured by the Spinal Mouse device were sent to the computer via Bluetooth, and the software recorded them immediately. The reference values typical for the age group are recorded in the program, and we coded the results based on them. The questionnaire used during the research was adapted from the Global Physical Activity Questionnaire (GPAQ), to examine children's time spent exercising and sports habits.

Statistical analysis

The sample selected based on the category variables (characteristics of the spinal sections measured in prominent body positions, gender, and physical activity) was analyzed using Pearson's chi-square (χ^2) test. In the scale variables (characteristics within, below, and above the reference value in each measured position, considering the different distinguished sections of the spine, were analyzed using the factorial ANOVA method, where $p<0.05$.

Results

Sample characterization

Children aged 12-13 took part in the research (n=61, M=12.67, SD=0.6), average age 12.67±0.6 years, almost half of the boys (31 people, 50.8%) and girls (30 people, 49.2%). Among the children, 23 (37.7%) play sports and 38 (62.3%) do not. We considered an athlete to be someone who, in addition to physical education at school, participates in at least 60 minutes of training at least twice a week (Table 1). Most student athletes go to training twice a week (15 people, 65.2%); seven people three times a week (30.4%), one person five times a week (4.3%). The length of the training session is one hour for six people (26.1%); 11 people (47.8%) spend an hour and a half, while six (26.1%) spend two hours occasionally training (Table 1).

Table 1. Athletes, sports and training time

Sport	Number of people	Number of training sessions per week	Length of training session on occasion
Self-defense sports (judo, krawmaga)	2	2	1 hour in 1 case, 2 hours in 1 case
Dance (hip-hop, jazz ballet)	4	2	1 hour in 3 cases, 1.5 hours in 1 case
Athletics	5	3 in 2 cases, 2 in 3 cases	1.5 hours
Football	4	2 in 2 cases, 3 in 2 cases	1.5 hours in 2 cases, 2 hours in 2 cases
Basketball	1	5	1.5 hours
Handball	1	3	1.5 hours
Riding	3	2	1.5 hours in 1 case, 1 hour in 2 cases
Triathlon	1	3	2 hours
Water polo	1	3	2 hours
Swimming	1	2	2 hours

Spinal Mouse measurement results, standing position

Gender and playing sports did not show a statistically significant relationship ($\chi^2(1, n=61)=3.062$, $p=0.114$). However, based on the frequency data, a higher proportion of girls do not play sports (73.3%, 22 persons), while the proportion of boys is 51.6% (16 people).

Looking at the results of the standing position measurement for the entire sample, the value of dorsal kyphosis was within the reference value in 52.2% of sports children and 57.9% of non-sports children. More non-athletes showed dorsal kyphosis above reference (21.1%) compared to athletes (17.4%). Female athletes had fewer instances of back curvature above reference than males. Non-athletic girls showed a higher rate of excessive dorsal kyphosis compared to non-athletic boys (Table 2).

Examining the lumbar lordosis, in the entire sample we examined, 60.9% of the sports children and 47.4% of the non-athletic children were within the reference value. Nonathletic girls had higher instances above the reference range. Boys, both athletes and non-athletes showed higher proportions within the reference range compared to girls (Table 2).

Among the results measured in the standing position, the sacral angle (the angle enclosed by the vertical plane and the contour line running on the surface of the sacrum) was within the reference for 60.9% of the sports children and 52.6% of the non-athletes. Boys, especially non-athletes, tended to have higher proportions within the normal range compared to girls. Non-athletic girls showed higher rates below the reference value compared to non-athletic boys (Table 2).

Table 2. Spinal Mouse results, standing position

	Reference categories	Complete pattern		Boys		Girls	
		Athlete	Non-Athlete	Athlete	Non-Athlete	Athlete	Non-Athlete
Sac/hip	within the reference value	14	20	10	11	4	9
		60.9%	52.6%	66.70%	68.80%	50.00%	40.90%
	above the reference value	1	4	1	3	0	1
		4.3%	10.5%	6.70%	18.80%	0.00%	4.50%
	below the reference value	8	14	4	2	4	12
		34.8%	36.8%	26.70%	12.50%	50.00%	54.50%
	Reference categories	Complete pattern		Boys		Girls	
		Athlete	Non-Athlete	Athlete	Non-Athlete	Athlete	Non-Athlete
Dorsal kyphosis	within the reference value	12	22	5	9	7	13
		52.2%	57.9%	33.30%	56.20%	87.50%	59.10%
	above the reference value	4	8	4	1	0	7
		17.4%	21.1%	26.70%	6.20%	0.00%	31.80%
	below the reference value	7	8	6	6	1	2
		30.4%	21.1%	40.00%	37.50%	12.50%	9.10%
	Reference categories	Complete pattern		Boys		Girls	
		Athlete	Non-Athlete	Athlete	Non-Athlete	Athlete	Non-Athlete
Lumbar lordosis	within the reference value	14	18	11	10	3	8
		60.9%	47.4%	73.30%	62.50%	37.50%	36.40%
	above the reference value	7	17	3	5	4	12
		30.4%	44.7%	20.00%	31.20%	50.00%	54.50%
	below the reference value	2	3	1	1	1	2
		8.7%	7.9%	6.70%	6.20%	12.50%	9.10%

After the Matthiass test, in a standing position

After performing the Matthiass test, among the results measured with the spinal mouse, examining the entire sample in a standing position with regard to dorsal kyphosis, it can be said that 60.9% of the athletic students and 52.6% of the non-athletic students have results within the reference value. Few athletes (4.3%) and more non-athletes (10.5%) exceeded the reference. 66.7% of athletic boys and 68.8% of non-athletic boys had normal values, but girls showed lower percentages (athletes: 50.0%, non-athletes: 40.9%). Few boys were above the reference (6.7%) and one non-athletic girl (Table 3).

When examining the lumbar lordosis of our entire sample during the measurement performed after the Matthiass test, it can be said that 69.6% of the athletic students and 53.3% of the non-athletic students had results within the reference range, with fewer athletes above (8.7%) versus more non-athletes (26.3%). Male athletes (73.3%) and non-athletic boys (68.8%) had higher within-reference percentages than their female counterparts (Table 3).

Examining the values of the sacral angle after the Matthiass test, in the case of the entire sample, it can be said that 56.5% of the athletes and 65.8% of the non-athletes have values within the reference range. More athletes (17.4%) than non-athletes (2.6%) exceeded the reference. Large gender differences existed, notably with 87.5% of non-athletic boys within reference compared to 37.5% of athletic girls. Only boys manifested values above the reference (Table 3).

Table 3. After the Matthiass test, in standing position

		Complete pattern		Boys		Girls	
Sac/hip	**Reference categories**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**
	within the reference value	13	25	10	14	3	11
		56.5%	65.8%	66.70%	87.50%	37.50%	50.00%
	above the reference value	4	1	4	1	0	0
		17.4%	2.6%	26.70%	6.20%	0 %	0 %
	below the reference value	6	12	1	1	5	11
		26.1%	31.6%	6.70%	6.20%	62.50%	50.00%
Dorsal kyphosis	**Reference categories**	**Complete pattern**		**Boys**		**Girls**	
		Athlete	**Non-Athlete**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**
	within the reference value	14	20	10	11	4	9
		60.9%	52.6%	66.70%	68.80%	50.00%	40.90%
	above the reference value	1	4	1	3	0	1
		4.3%	10.5%	6.70%	18.80%	0.00%	4.50%
	below the reference value	8	14	4	2	4	12
		34.8%	36.8%	26.70%	12.50%	50.00%	54.50%
Lumbar lordosis	**Reference categories**	**Complete pattern**		**Boys**		**Girls**	
		Athlete	**Non-Athlete**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**
	within the reference value	16	21	11	11	5	10
		69.6%	55.3%	73.30%	68.80%	62.50%	45.50%
	above the reference value	2	10	1	2	1	8
		8.7%	26.3%	6.70%	12.50%	12.50%	36.40%
	below the reference value	5	7	3	3	2	4
		21.7%	18.4%	20.00%	18.80%	25.00%	18.20%

Careless posture, poor posture

Negligence and playing sports show a statistically significant relationship ($\chi^2(1, n=61)=6.036$, $p=0.018$). In the sample we examined, the prevalence of careless posture was typical for 71.1% (27 people) of non-sporting adolescents and 39.1% (9 people) of sports children. A similar ratio is more common among girls. This is also true for boys, but the proportion is higher for the non-athletic group, almost 40%, who do not have sloppy posture (Table 4).

Postural weakness and playing sports show a statistically significant relationship ($\chi^2(1, n=61)=7.878$, $p=0.008$). A smaller proportion of athletic adolescents have poor posture (26.1%, 6 people) compared to non-athletes (63.2%, 24 people). In this case, only 13.3% of athletic boys are affected, while 62.5% of non-athletic boys are affected. Among girls, 50.0% of athletes and 63.6% of non-athletes have postural weakness. In girls, postural weakness and playing sports do not show a significant relationship (Table 4).

Table 4. Careless posture, poor posture

		Complete pattern		Boys		Girls	
Careless posture	**Answer**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**
	yes	9	27	6	10	3	17
		39.1%	71.1%	40.00%	62.50%	37.50%	77.30%
	no	14	11	9	6	5	5
		60.9%	28.9%	60.00%	37.50%	62.50%	22.70%
	Answer	**Complete pattern**		**Boys**		**Girls**	
Poor posture		**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**	**Athlete**	**Non-Athlete**
	yes	6	24	2	10	4	14
		26.1%	63.2%	13.30%	62.50%	50.00%	63.60%
	no	17	14	13	6	4	8
		73.9%	36.8%	86.70%	37.50%	50.00%	36.40%

Discussion

In standing position, after measurement

Increased dorsal kyphosis occurs in a slightly lower proportion among athletes, and flatter dorsal curvature occurs in a slightly higher proportion than in non-athletes. In the case of female athletes, we can say that most of them (87.5%) have a normal level of dorsal kyphosis, while in the case of male athletes, this ratio is very low (33.3%) (Table 2). In the case of boys, there is no significant difference between the athlete and non-athlete groups, values below and above the reference value occur in the same proportion as values within the reference [22]. So, we cannot say that the results presented by the athletes are clearly better, only in the case of girls.

In terms of lumbar lordosis, a higher proportion of athletes have values within the reference, but the proportion of results above the reference value is relatively high (athletes: 30.4%, non-athletes: 44.7%) for both groups. This indicates that the lumbar curve is flattened in many cases and does not correspond to physiological values. These relatively "straight" lumbar spine sections affect the structures above and below them, influencing their size. Relatively few students have blood vessels below the reference range, which corresponds to the current state of research, according to which the lumbar curve straightens and flattens due to a sedentary lifestyle and prolonged sitting [23]. Regarding lumbar lordosis, the results presented by the boys and girls are not the same. Physiological lumbar curvature of a normal degree occurs most often among boys (Table 2), looking at both the

athlete and non-athlete groups, while the flattened lumbar curvature with a smaller than normal curve appears most often in girls for both groups. Increased lumbar lordosis affects few children. It was found that athletic adolescents had a higher proportion of lumbar lordosis and sacral angle in the normal range, and their spine had greater mobility in the sagittal and frontal planes, compared to their non-athletic peers [24]. Regarding our own sample, among boys, the athletes produced significantly better results than their non-athlete peers. Opposite results were presented by the girls, where the value of the sacral angle of half of the female athletes is outside the reference range during the first measurement, and after performing the Matthiass test, only 37.5% of them can be said to have a value within the reference range. The result was similar regarding the lumbar lordosis – very few (37.5%) of the female athletes have a normal lumbar curvature.

Regarding the sacral angle, there is a significant difference between the boys and girls, as well as sportsmen and non-sportsmen. While nearly two-thirds of the boys fall within the normal range, less than half of the girls and the other half of the girls fall into the category below the reference value (athletes and non-athletes alike). This can be related to the position of the pelvis, which affects the entire spinal column and with it the posture [25]. Values below the reference range indicate a forward-tilted pelvis. In this case, it is very necessary to change the posture of the pelvis to a normal range, because the lower part of the abdominal muscles stretches and the upper part shrinks, the deep back muscles become inactive as a result of the forward-tilted pelvis, and this part of the spine also loses its flexibility [26]. De Assis et al. [6] found that non-athletic students were at greater risk of scoliosis than athletes. Examining the relationship between sports and the quality of posture, Radaković et al. [5] found that most changes occur in the sagittal plane of the spine during adolescence. Based on their results, it can be said that posture disorders occurred in a similar proportion between athletes and non-athletes. In the sample we examined, a large percentage of male athletes (66.7%) in terms of dorsal kyphosis and female athletes (62.5%) in terms of lumbar lordosis fell outside the reference range, so when examining the physiological state of the spine, it cannot be said that the athletes fared better than their non-athlete counterparts. Therefore, it is recommended for everyone to incorporate posture-improving and mobilizing exercises into the daily routine. Playing sports has many benefits, but excessive strain can also have harmful effects on the spine, especially during adolescence [13,27]. Accordingly, all exercise professionals must monitor proper posture and movement patterns to help develop and maintain a healthy spine.

After the Matthiass test, in standing position

Based on the results of the Matthiass test, dorsal kyphosis is in the normal range for two-thirds of athletic and non-athletic boys. This is a higher proportion than in the case of girls, where the same characteristics can be said for half of the athletes and 40.9% of the non-athletes. It is gratifying that only four of the examined sample (n=61) were in the range above the reference value, indicating weakness of posture. It is an interesting observation that half of the athletic girls and more than half of the non-athletic girls fall into the category below the reference value, less than a third of the athletic boys, and only two of the non-athletic boys. In their case, we can speak of a straighter dorsal spine section, where the degree of kyphotic curvature is smaller than the physiological one. This is not good, because it creates muscle asymmetry, which, if left untreated, can lead to changes in bony structures later.

During the first standing measurement, the percentage of lumbar lordosis results below the reference value was 8.7% among student athletes and 7.9% among non-athletes. After performing the Matthiass test, this rate increased from 8.7% to 21.7%, and from 7.9% to 18.4%. This suggests that postural weakness does not occur everywhere on the back. These adolescents were trying to compensate for the postural and spatial imbalances caused by the weakening of the muscles in the lumbar spine. This can be said for both boys and girls, as well

as athletes and non-athletes. In terms of results within the reference range, there was a higher proportion of athletes among both the boys and girls (boys: 73.3%, girls: 62.5%) with a normal lumbar lordosis compared to non-athletes (boys: 68.8%, girls: 45.5%). 36.4% of non-sporting girls have a milder lumbar curve. They would be advised to regularly perform mobilizing exercises to improve the segmental mobility of the spine in this section.

Regarding the sacral angle, a greater proportion of boys have values within the reference range, while a greater proportion of girls have values below the reference range. The results of the first measurement were similar to the results measured after the Matthiass test. In both groups, a much higher proportion of girls had values below the reference level. For the first measurement: 50.00% and 54.50%, for the second measurement: 62.50% and 50.00%. In the case of the second measurement, the decrease in the value of the sacral angle appears at an even higher rate in the group of female athletes, which indicates a forward tilt of the pelvis after the test. This value can also be associated with an increase in lumbar lordosis. The combined change of these two values indicates the local appearance of postural weakness in the lumbar region of the spine. Low sacral angle values indicate that the pelvis tilts forward, which affects the entire spine and posture. Therefore, it is particularly important that the pelvic position and lumbar lordosis values are in the normal range, as this improves posture and spinal problems. To prevent such problems, regular exercise and proper posture improvement programs are recommended.

Careless posture, poor posture

Athletic boys struggle with poor posture and poor posture to a lesser extent than their non-athletic peers. Athlete girls also have a smaller proportion of sloppy posture, but this is not true with regard to poor posture – 50% of both athletic and non-athletic girls struggle with poor posture. It is therefore particularly important to pay attention to posture among girls, where there is no demonstrable connection between postural weakness and playing sports.

Conclusions

This study examined spinal posture in adolescent athletes and non-athletes. Some differences were observed between the two groups. Female athletes displayed better dorsal kyphosis, while male athletes exhibited superior lumbar lordosis. However, deviations from healthy spinal curvature were prevalent among both genders in certain areas. Contrary to expectations, overall spinal health was not markedly better among athletes. Both athlete and non-athlete groups showed variations in spinal posture, influenced by factors like rapid growth, lifestyle, and sports specialization. Therefore, incorporating posture-improving exercises into daily routines for all adolescents is crucial. Further research is needed to explore the specific causes behind spinal irregularities in adolescents, considering lifestyle habits and sport-related strains. Continuous guidance and tailored interventions are essential for promoting holistic spinal health in this demographic. While sports offer several advantages, excessive strain from certain activities might pose risks to spinal health, especially during the critical phase of adolescence. Professionals should closely monitor posture and movement patterns, ensuring healthy spinal development during adolescence.

Research limitations

The results can be distorted by the fact that we do not know who started from which category during the measurement with the spinal mouse. Because if the person started with a value below the reference in the case of dorsal kyphosis, and after the Matthiass test it was in the normal range, there was also a ROM change in the segmental movement of the spinal column, which could indicate postural weakness.

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