

ODNOS POSTURALNOG STATUSA STOPALA I EKSPLOZIVNE SNAGE NOGU ADOLESCENATA

RELATION BETWEEN THE POSTURAL FEET STATUS AND EXPLOSIVE STRENGTH OF LOWER EXTREMITIES IN ADOLESCENTS

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Sažetak: Cilj istraživanja bio je utvrđivanje razlika u ispoljavanju eksplozivne snage nogu i karličnog pojasa u odnosu na stepen spuštenosti svoda stopala i polni dimorfizam. Istraživanjem je obuhvaćeno 90 ispitanika (45 muškog i 45 ženskog pola), Srednje ekonomske škole u Novom Sadu, uzrasta 15 ± 0.5 godina. Status svoda stopala utvrđen je somatoskopskom metodom, a eksplozivna snaga motoričkim testovima skok udalj sa mesta i troskok sa mesta. Za utvrđivanje razlika korišćena je Univarijatna analiza varijanse, χ^2 - test i Student t - test za nezavisne uzorke, na nivou zaključivanja $p \leq 0.00$. Statistički značajne razlike utvrđene su između ispitanika sa dobrim i izrazito lošim statusom stopala ($p \leq 0.00$) i ispitanika sa lošim i izrazito lošim statusom stopala ($p \leq 0.000$). Takođe, utvrđene su statistički značajne razlike u odnosu na polnu pripadnost u statusu svoda stopala i oba motorička testa ($\chi^2=9.867$; $p \leq 0.007$).

Ključne reči: ravna stopala, skok udalj sa mesta, troskok sa mesta, eksplozivna snaga nogu i karličnog pojasa, adolescenti.

Abstract: The aim of this study was to determine the differences in the manifestation of explosive strength of legs and pelvis girdle regarding the degree of drooping medial arch of the feet and also according to gender differences. The research covered 90 respondents (45 males and 45 females), from the Secondary School Economics in Novi Sad, aged 15 ± 0.5 . The status of the foot arch was determined by using the clinical method, and the explosive strength by motoric tests of standing long jump and triple jump. For identifying the differences, One-Factor Analysis of Variance was used, χ^2 - test and Student t - test for independent samples, at the final degree of $p \leq 0.00$. Statistically significant differences were identified between the respondents with good and extremely poor foot status ($p \leq 0.00$) and the respondents with poor foot status ($p \leq 0.000$). Also, when it comes to gender, there were statistically significant differences in foot arch status and both motor tests ($\chi^2=9.867$; $p \leq 0.007$).

Key words: fallen arches, standing long jump, triple jump, explosive strength of legs and pelvic girdle, adolescents.

Uvod

Stopalo kao višezglobni sistem, ima značajnu ulogu u statički i dinamički ljudskog organizma. Ona se ogleda u preuzimanju čitave težine tela i u različitim oblicima kretnih aktivnosti: hodanju, trčanju, skokovima, doskocima i sl. (Ulić, 1997; Živković, 2000). Zajedničko delovanje mišića, tetiva, ligamenata i kostiju stopala, predstavlja kompleksan sistem, koji je u isto vreme i rigidan (nosi čitavu težinu tela) i fleksibilan te prilagodljiv različitim uslovima podloge (Twomey, 2006). Koštane, ligamentarne i mišićne strukture su odgovorne za formiranje i očuvanje svodova stopala, zahvaljujući kojima stopalo

INTRODUCTION

Foot, as a multi-joint system has a significant role in the statics and dynamics of human body. It is reflected in taking the entire body weight and in different forms of motion activities: walking, running, jumping, jump landing, etc. (Ulić, 1997; Živković, 2000). The joint action of the muscles, tendons, ligaments and foot bones represents a complex system which is also rigid (it carries the entire body weight) and flexible and adaptable to different ground conditions. (Twomey, 2006). The bone, ligament and muscle structures are responsible for the formation and preservation of foot arches, thanks to which the foot

obavlja svoje osnovne funkcije: efikasno kretanje, distribuciju pritiska i pravilno trošenje snage.

Stopalo ostvaruje stabilnost i elastičnost zahvaljujući svodovima, transverzalnog i longitudinalnog (medijalnog i lateralnog), koji su određeni ne samo oblikom kostiju već i otpornošću ligamenata. Medijalni longitudinalni svod stopala je najviši i ima najznačajniju ulogu za optimalnu mehaniku stopala (Wilken, 2006), dok je lateralni longitudinalni svod niži i ima tendenciju slabljenja pod telesnom težinom (Kendall, McCreary, i Provance, 1993). Spuštenost medijalnog longitudinalnog svoda stopala označava se kao ravno ili spuštено stopalo. Početak formiranja svodova stopala poklapa se sa prvim opterećenjem, odnosno periodom kada dete počinje da se uspravlja, dok za period definitivnog formiranja još uvek ne postoji saglasnost istraživača.

Generalno, smatra se da se deca rađaju s ravnim stopalima (El et al, 2006), koja se zapažaju već u prvim godinama života, kada ona i počinju da hodaju. Stopalo najbrže raste do treće godine (Volpon, 1994), od koje ima gotovo konstantnu stopu razvoja podjednako za oba pola, sve do 12. godine. Svod stopala počinje ubrzano da se razvija između 2. i 6. godine i strukturalno sazreva oko 12 do 13. godine. Procenat ravnih stopala najveći je kod novorođenčadi pa do 2. godine života. Postojanje fleksibilnog ravnog stopala kod dece od 2. do 6. godine procentualno se javlja između 21% i 57%, a kod dece u osnovnoj školi procenat znatno pada na 13,4% do 27,6% (El, et al., 2006; Lin et al., 2001; Pfeiffer et al., 2006).

Snaga mišića obično se odnosi na silu ili obrtanje koju određena grupa mišića razvija tokom maksimalne voljne kontrakcije pod određenim uslovima (Jarić, 2002), a eksplozivna snaga je sposobnost ispoljavanja maksimalne snage u najkraćem mogućem roku (Petrović et al., 2013). Smatra se da promene posturalnog statusa stopala imaju uticaj na funkcionalne sposobnosti, koje se posmatraju kroz prizmu motoričke sposobnosti ispoljavanja eksplozivne snage nogu i karličnog pojasa. Cilj ovoga istraživanja bio je, stoga, utvrđivanje razlika u ispoljavanju eksplozivne snage donjih ekstremiteta i karličnog pojasa adolescenata, u odnosu na status svoda stopala i pripadnost polu.

MATERIJAL I METOD

Radi utvrđivanja odnosa spuštёnosti svoda stopala i eksplozivne snage donjih ekstremiteta i karličnog pojasa, opredelili smo se za istraživanje transverzalnog tipa.

performs all its basic functions: efficient movement, pressure distribution and proper strength use.

The foot achieves stability and flexibility thanks to the arches, transverse and longitudinal (medial and lateral), defined not only by the shape of bones but also by the resistance of ligaments. The medial longitudinal foot arch is the highest one and has the most important role for the optimal mechanics of the foot (Wilken, 2006), while the lateral longitudinal arch is lower and tends to weaken under the body weight (Kendall, McCreary, & Provance, 1993). Dropping of the medial longitudinal foot arch is marked as a fallen arch or a dropped arch. The beginning of the formation of the foot arches starts with the first load, i.e. the period when a child begins to sit up, while there is still no consensus of the researchers when it comes to defining the period of the definite formation.

It is generally believed that children are born with fallen arches (El et al, 2006), which are noticed in the first years of life, when they start to walk. The quickest growth of foot takes place up to the third year of life (Volpon, 1994), since when it has a constant development rate which is equal for both genders, until the age of 12. The foot arch begins to develop rapidly in children aged between 2 and 6, and its structure matures at the age of 12 and 13. The highest percentage of fallen arches is among infants up to 2 years of age. The percentage of flexible fallen arches in children aged between 2 and 6 is between 21% and 57%, while when it comes to primary school children, the percentage significantly drops to 13.4% up to 27.6% (El, et al., 2006; Lin et al., 2001; Pfeiffer et al., 2006).

Muscle strength usually refers to the force or reversion developed by a certain muscle group during the maximal voluntary contractions under certain conditions (Jarić, 2002), while explosive strength is the ability to manifest the maximal strength in the shortest period of time (Petrović et al., 2013). It is believed that changes in postural foot status influence the functional abilities, which are observed through the prism of motor ability to manifest explosive strength of legs and pelvic girdle. Therefore, the aim of this research was to determine the differences in the manifestation of explosive strength of lower extremities and pelvic girdle in adolescents, according to the foot arch status and gender.

MATERIAL AND METHOD

For the purpose of determining the comparison between the degree of pes planus and the explosive strength of the lower extremities and the pelvic girdle, we selected the research of transversal type.

Uzorak ispitanika

Uzorak ispitanika činilo je 90 učenika Srednje ekonomske škole u Novom Sadu (45 muškog i 45 ženskog pola) uzrasta 15 ± 0.5 godina. Cilj istraživanja je bio je utvrđivanje razlika u eksplozivnoj snazi donjih ekstremiteta i karličnog pojasa u odnosu na status svoda stopala, kao i razlike u odnosu na polnu pripadnost. Ispitanici su na osnovu statusa stopala podeljeni u tri subuzorka: sa dobrim, lošim i izrazito lošim statusom stopala.

Metode merenja

Status svoda stopala utvrđen je kliničkom metodom, vizuelnom procenom u sagitalnoj ravni, gde su ispitanici sa dobrim statusom stopala ocenjeni nulom (0), sa lošim jedinicom (1) i izrazito lošim statusom stopala dvojkom (2). Za utvrđivanje eksplozivne snage donjih ekstremiteta i karličnog pojasa, korišćeni su motorički testovi skok udalj sa mesta i troskok sa mesta.

Metode obrade podataka

Za utvrđivanje razlika u ispoljavanju eksplozivne snage donjih ekstremiteta i karličnog pojasa u odnosu na stepen spuštenosti svoda stopala, korišćena je jednosmerna Univarijatna analiza varijanse (ANOVA). Razlike između polova u odnosu na stepen spuštenosti svoda stopala utvrđene su χ^2 -testom na nivou značajnosti $p \leq 0.05$, a t - testom za nezavisne uzorke, utvrđene su statistički značajne razlike u odnosu na polni dimorfizam u oba motorička testa.

REZULTATI

Zastupljenost spuštenosti svoda stopala u odnosu na polni dimorfizam prikazana je u Tabeli 1. U uzorku ispitanika muškog pola, najveća je zastupljenost normalanog svoda stopala (55,6%), prvi stepen spuštenosti svoda stopala ima 26,7% ispitanika, dok je zastupljenost drugog stepena spuštenosti svoda stopala svega 17,8%.

Kod ispitanika ženskog pola najveći je postotak onih sa drugim (46,7%) i prvim stepenom spuštenosti (44,4%), a najmanja je zastupljenost ispitanica sa normalnim svodom stopala (8,9%).

Analizom razlika među polovima, utvrđeno je da ocenu jedan ima 62,5% a ocenu dva 72,4% ispitanika ženskog pola, dok je ocena nula češća kod ispitanika muškog pola (86,2%).

U Tabeli 2 prikazane su razlike u ispoljavanju eksplozivne snage donjih ekstremiteta i karličnog pojasa u odnosu na polni dimorfizam. Rezultat t – testa za nezavisne uzorke pokazuju da postoje statistički značajne razlike između polova u oba motorička testa ($p \leq 0.00$) u korist ispitanika muškog pola.

Sample of respondents

The sample included 90 pupils of the Secondary School of Economics in Novi Sad (45 males and 45 females) aged 15 ± 0.5 . The goal of this research was to determine the differences in explosive strength of lower extremities and pelvic girdle regarding the status of the foot arch, and the differences regarding the gender. Based on the status of their foot arch, the respondents are divided into three sub-samples: with good, bad and extremely bad foot status.

Method of measurement

The feet arch status is defined by a clinical method, visual assessment in the sagittal plane, where the respondents with a good foot arch status were marked with a zero (0), respondents with a bad foot arch status were marked with one (1) and the respondents with extremely bad foot arch status were marked with (2). To determine the explosive status of lower extremities and pelvic girdle, we used standing long jump and triple jump motor tests.

Method of data processing

To determine the difference in the manifestation of explosive strength of lower extremities and pelvic girdle regarding the degree of fallen arches, we used the One-Factor Analysis of Variance (ANOVA). Differences among the genders regarding the degree of fallen arches were determined by χ^2 -test at the significance degree of $p \leq 0.05$, and t – test for independent samples, showing that there are significant statistical differences regarding the sexual dimorphism in both motor tests.

RESULTS

Incidence of drooping arch of the feet when it comes to the sexual dimorphism is shown in Table 1. In male respondents, the largest percentage had a normal foot arch (55.6%), the first degree of drooping feet arch had 26.7% of the respondents, while the percentage of those with the second degree of drooping feet arch was only 17.8%. When it comes to female respondents, the highest percentage is of those with the second (46.7%) and the first degree of drooping (44.4%), and the lowest percentage is of those with normal foot arches (8.9%).

The analysis among the sexes defined that the mark one had 62.5%, and the mark two had 72.4% of the female respondents, while the mark zero is more frequent in male respondents (86.2%).

Comparing the total sample, the differences between the genders, marks zero (60%) and one (63%) were recorded mostly among the male respondents, while the mark two is with 73% more frequent among the female respondents.

The Table 2 shows the differences in the manifestation of explosive strength of lower extremities and pelvic girdle regarding the sexual dimorphism. The result of the

Tabela 1. Zastupljenost spuštenosti svoda stopala u odnosu na polni dimorfizam / **Table 1.** Incidence of fallen longitudinal medial arch of the feet regarding the gender dimorphism

Ocene posturalnog statusa / Marks of postural status	Broj / Number %	Pol / Gender		Ukupno / Total
		M / M	Ž / F	
	N	25	4	29
0	% unutar pola / within gender	86.2%	13.8%	100.0%
	% statusa svoda stopala / foot arch status	55.6%	8.9%	32.2%
	% ukupno / total	27.8%	4.4%	32.2%
1	N	12	20	32
	% unutar pola / within gender	37.5%	62.5%	100.0%
	% statusa svoda stopala / foot arch status	26.7%	44.4%	35.6%
2	% ukupno / total	13.3%	22.2%	35.6%
	N	8	21	29
	% unutar pola / within gender	27.6%	72.4%	100.0%
Ukupno	% statusa svoda stopala / foot arch status	17.8%	46.7%	32.2%
	% ukupno / total	8.9%	23.3%	32.2%
	N	45	45	90
Ukupno	% unutar pola / within gender	50.0%	50.0%	100.0%
	% statusa svoda stopala / foot arch status	100.0%	100.0%	100.0%
	% ukupno / total	50.0%	50.0%	100.0%

$\chi^2=23.034$

$p=0.00$

Tabela 2. Razlike u ispoljavanju eksplozivne snage donjih ekstremiteta i karličnog pojasa u odnosu na polnu pripadnost / **Table 2.** Differences in the manifestation of explosive strength of lower extremities and pelvic girdle regarding the gender

Varijable / Variables	M / M		Ž / F		t	p
	AS	S	AS	S		
Skok udalj sa mesta / Standing long jump	209.93	18.794	163.69	21.937	10.739	0.00
Troskok sa mesta / Triple jump	604.71	63.053	472.82	55.934	10.497	0.00

U Tabeli 3 prikazani su rezultati ispoljavanja eksplozivne snage donjih ekstremiteta i karličnog pojasa u odnosu na status svoda stopala, ukupnog uzorka ispitanika u oba motorička testa.

t – test for independent samples shows that there are statistically significant differences among both genders in both motor tests ($p \leq 0.00$) in favour of male respondents.

The Table 3 shows the results of explosive strength of lower extremities and pelvic girdle in comparison with the foot arch status of the total sample of respondents in

Tabela 3. Razlike u parametrima eksplozivne snage donjih ekstremiteta u odnosu na status svoda stopala ukupnog uzorka ispitanika / **Table 3.** Differences in the parameters of the explosive strength of lower extremities regarding the foot arch status of the total sample of respondents

Varijable / Variables	Marks	AS	S	F	p
Skok udalj sa mesta / Standing long jump	0	207.14	23.349	12.138	0.00
	1	180.66	31.106		
	2	173.28	27.428		
	Total	186.81	30.873		
Troskok sa mesta / Triple jump	0	591.00	68.177	9.373	0.00
	1	524.88	91.993		
	2	501.86	81.653		
	Total	538.77	88.937		

Kako bi se ustanovile razlike između parova grupa na osnovu podele prema statusu stopala, urađena je LSD post-hoc analiza (Tabela 4). Na osnovu dobijenih rezultata, može se zaključiti da postoje statistički značajne razlike u motoričkoj efikasnosti između ispitanika koji imaju normalan svod stopala i ispitanika koji imaju manje ili više spušten svod stopala. Ove razlike se javljaju u oba motorička testa, međutim ne postoje statistički značajne razlike u motoričkoj efikasnosti između ispitanika sa ocenom 1 i 2.

both motor tests.

In order to define the differences between the group pairs based on the division according to the foot status, the LSD post-hoc analysis was done (Table 4). Based on the received results, it can be concluded that there are statistically significant differences in motor efficiency between the respondents with a normal foot arch and the respondents with less or more drooping foot arch. These differences occur in both motor tests, however there are no statistically significant differences in motor efficiency between the respondents marked with 1 and 2.

Tabela 4. Razlike između parova grupa (razvrstanih prema statusu stopala) u eksplozivnoj snazi donjih ekstremiteta /
Table 4. The differences between pairs of groups (sorted by the feet status) in explosive strength of lower extremities

Variable / Variables	(I)	(J)	AS (I-J)	Sig.
Skok udalj sa mesta / Standing long jump	0	1	26.482	0.00
		2	33.862	0.00
	1	0	-26.482	0.00
		2	7.380	0.30
	2	0	-33.862	0.00
		1	-7.380	0.30
Troskok sa mesta / Triple jump	0	1	66.125	0.00
		2	89.138	0.00
	1	0	-66.125	0.00
		2	23.013	0.27
	2	0	-89.138	0.00
		1	-23.013	0.27

DISKUSIJA I ZAKLJUČAK

Prevalenca ravnog stopala kod dece u odnosu na uzrast, pol, uhranjenost i fizičku aktivnost, problematika je mnogih istraživanja. Zastupljenost ravnih stopala kod dece uzrasta od 7 do 11 godina beleži se kod ispitanika muškog pola u većem procentu nego kod ispitanica (Puzović i sar., 2010). Ovakvu pojavu istraživači tumače time što se kod dečaka sporije povlači masno tkivo (“jastuče”) na tabanu za razliku od devojčica.

U našem istraživanju rezultati pokazuju da ispitanici muškog pola imaju u većem procentu normalan svod stopala, a ispitanice ženskog pola spušten svod stopala I i II stepena. Ovako dobijeni rezultati ukazuju na činjenicu da su ispitanici muškog pola ovog uzrasta fizički aktivniji i češće nego ispitanice uključeni u sportske aktivnosti. Rezultate posturalnog statusa potrebno je tumačiti zajedno sa opštim rastom i razvojem mladih. Tako, neki autori raniji ulazak devojčica u pubertet objašnjavaju kroz zastupljenost ravnih stopala u mlađem uzrastu, za razliku od dečaka. Kod dečaka pubertet počinje nešto kasnije, pa se u skladu sa tim najveći broj poremećaja javlja u starijem uzrastu (Jovović, Čanjak, 2010).

DISCUSSION AND CONCLUSION

Prevalence of the fallen arches in children when it comes to the age, gender, nutritional status and physical activity, is a problem of many studies. The incidence of fallen arches in children aged between 7 and 11, is recorded in male respondents more than in female respondents (Puzović et al., 2010). Such incidence as interpreted by the researchers, is explained by the fact that the adipose tissue of the sole (“pad”) is withdrawn more slowly in boys than in girls.

The results of our research show that the male respondents have a larger percentage of normal feet arches, while the female respondents have a larger percentage of the first and second degree of drooping foot arch. Such results point out the fact that the male respondents of this age are more physically active and more frequently involved in sport activities than female respondents. The results of the postural status should be interpreted hand in hand with the general growth and development of the young.

It is wrong to interpret the results of the postural status separately and in isolation from the overall growth and development. Some authors explain the earlier start of pu-

Zbog ovako različitih mišljenja bilo je neophodno uvrstiti i neki pokazatelj snage nogu kroz motoričke testove. Motoričke testove bolje su uradili ispitanici muškog pola, što je očekivano, a u odnosu na status svoda stopala, efikasniji su bili ispitanici sa fiziološkim svodom. Oba motorička testa izvode se sunožnim odrazom sa mesta gde su pri odskoku angažovani fleksori stopala. Kod osoba sa ravnim stopalima, ovi mišići pokazuju znake insuficijencije, što se odražava na efikasnost skoka.

Rezultati našeg istraživanja razlikuju se od rezultata istraživanja Lizisa. Posadzki i Smita (Lizis, Posadzki & Smith, 2010), koji ukazuju na nepostojanje statistički značajne razlike u ispoljavanju eksplozivne snage nogu u odnosu na posturalni status longitudinalnog svoda stopala kod ispitanika oba pola. Takođe, rezultati se ne podudaraju ni sa istraživanjem Aleksandrovića i Kotarasa (2015), u kojem nije utvrđena statistički značajna razlika u ispoljavanju eksplozivne snage donjih ekstremiteta u odnosu na posturalni status stopala. Spušten uzdužni svod stopala, prema ovim autorima, ne predstavlja prepreku za ispoljavanje eksplozivne snage donjih ekstremiteta. Razlog za nepodudaranje rezultata našeg sa navedenim istraživanjima, verovatno leži u činjenici različitog broja ispitanika u istraživanjima.

Nakon detaljne analize rezultata i poređenja sa prethodnim istraživanjima, može se izneti zaključak da je posturalni status kompleksan, te da se ne može posmatrati izolovano od antropometrijskog i motoričkog statusa. U dalja istraživanja, neophodno je uključiti što više pokazatelja rasta i razvoja, naročito kod dece kod koje on nije završen.

Mnoga istraživanja ukazuju na povećanu incidencu ravnog stopala kod dece mlađe od 18 godina (Đorđević, Jorgić i Stanojević, 2015), naročito kod dece osnovnoškolskog uzrasta. Shodno tome, neophodna je rana intervencija: rano otkrivanje posturalnog poremećaja, uključivanje dece u korektivni program sa pravilnim odabirom vežbi, smanjenje telesne težine dece, izbor adekvatne obuke te pravovremeno uključivanje dece u razne fizičke aktivnosti. Ovo su samo neki od činilaca koji mogu dovesti do prevencije nastanka i razvoja ravnog stopala kod dece.

Izjava autora

Autori pridonijeli jednako.

Konflikt interesa

Mi izjavljujemo da nemamo konflikt interesa

Author's statement

The authors contributed equally.

Conflict of interest

We declare that we have no conflict of interest

erty in girls by the presence of fallen arches at a young age, as opposed to boys. Puberty in boys starts a little later than in girls, and therefore the largest number of disorders occurs in older age (Jovović, Čanjak, 2010).

Due to the differences in opinions it was necessary to include some indicators of leg strength through the motor tests. It was expected that male subjects

The motor tests were done better by male respondents, which was expected, and when it comes to the foot arch status, the respondents with physiological arches were more efficient. Both motor tests were done with a two-foot jump where foot flexors are engaged in the jump. As for those with fallen arches, these muscles show signs of insufficiency, which has an impact on the efficiency of the jump.

The results of our study differ from the results of those by Lizis, Posadzki & Smith (2010), which indicate the absence of statistically significant differences in the manifestation of explosive strength of legs comparing to the postural status of longitudinal foot arch in both male and female respondents. The results do not match the research by Aleksandrović & Kottaras (2015) either, in which there was no statistically significant difference in the manifestation of explosive strength of lower extremities in relation to the postural foot status. Fallen longitudinal medial foot arch, according to these authors, does not represent an obstacle for the manifestation of the explosive strength of lower extremities. The reason of the mismatch of the results of our mentioned research is probably due to the fact that the research has been conducted on a different number of respondents.

After a detailed analysis of the results and comparisons with previous research, we can express the conclusion that the postural status is complex, and cannot be viewed in isolation from the anthropometric and motor status. Further research need to involve as many indicators of growth and development as possible, especially in children, in which it had not been completed.

Many studies point to an increased incidence of fallen arches in children under 18 (Đorđević, Jorgić & Stanojević, 2015), especially in children of primary school age. Accordingly, early intervention is necessary: early detection of postural disorders, involvement of children in corrective programmes with the proper selection of exercises, weight reduction in children, the selection of appropriate footwear, and timely involvement of children in various physical activities. These are just some of the factors that can lead to the prevention of the occurrence and development of fallen arches in children.

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