

The influence of Examinations Stress on Changes in Heart Rate regulatory Mechanism indicators in Students of the First to Third Grades Talented High School

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Abstract: Examinations are of the most important stressful factors in schools and universities and have different psycho-physiologic consequences; however, their effects in students have been less focused. To study the effects of educational pressures and examinations stress on changes in the mechanism of heart function, a test was conducted on 120 students, age range of 15-17 years of both genders. Divided in two groups, each consisting 20 students of first to third grades of high school, 60 boys and 60 girls from two high schools (one boys high school and one girls high school) in three stages (2 months before the examination(normal), 1hour before and 1hour after the examinations) in the same educational conditions in the city of Sari. Activity of heart rate regulatory mechanisms was recorded of ECG and next was processed by the method of Baevsky pulsometry variation. The statistical elaboration of the obtained data from the three stages of test has been carried out using Biostat computer programmer. Based on the results of this study, the least stress effects on changes in the heart function was during 2 months before the examination(normal) and affected activity of vagotonic and normotonic systems and the highest stress effects was observed during 1hour before the examination and affected activity of normotonic and sympathetic systems. The effects were significant at differences experimental stages ($P < 0.001$). The effects decreased during 1hour after the examination influenced normotonic system activity. The highest stress effects were observed in examination time in the first grade and third grade high school students. It showed that course volume and pressure, type of course and stress of examination time caused sympathetic system activity which influenced on changes in the mechanism of heart rate function. In comparison, in all test stages, stress effects in boys group were higher than in girl students. The results of this search shows that the factors like age, gender, personality, psychophysiological status, course volume and pressure, type of course, examination time and anxiety, individual typological characteristics and the state of autonomic nervous system affected on changes in the mechanism of heart rate function in students

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1. Introduction

Examinations are of the most important stressful factors in schools and universities and have different psycho-physiologic consequences; however, their effects in students have been less focused. As the wAw anxiety become one of the subjects that call for particular attention. Stress has significant effects in the educational progress and the physiological, mental and psychological conditions of student. In addition, several studies have shown that students suffer from several behavioral and psychological disorders and there are many factors in schools that cause stress in students (Dudnik, Ye. N.et.al.2007). Examinations stress is factor of disease in the students, the important ones are: the development and intensifying of previous cardiac diseases and increase of hypertension (Khatami,S and B.S.Moradmand. 1992). The process of adaptation of students to an

academic load is accompanied by the periods of recession and a pressure parameters of hemodynamic, activity regulators mechanisms of a rhythm of heart and parameters of state of health, activity and mood (Minasian,SM.et.al.2006). During an examination session, the schoolchildren were ascertained to develop emotional stress characterized by a complex of psychophysiological and autonomic nervous changes (Minasian,SM.,ES, Gevorkian., and NN. Ksadzhihian. 2005.The heart rate reactions on the examination stress depended on the individual typological characteristics and the state of autonomic nervous system (Gevorkian, ES.et.al.2003) The resistance of the students to the examination stress and the type of their vegetative reactions, to a large extent, determined by both the individual-typological peculiarities of the higher nervous activity and the initial psychological state (Makarenko, MV., VS,

Lyzohub., and LI. Iukhyemenko. 2003). Since examination stressor influences blood pressure, heart beats, heart functions, the physiologic, mental and psychological situations and educational progress of students, therefore, this subject demands special attention.

2. Material and Methods

This project was carried out on 120 (60 male and 60 female) students age range of 15-17 years in three educational programs of both genders and divided in girls and boys groups. Each group consist 20 students from two high schools (one of boys and one of girls) in three stages of education program. The first test was carried out 2 months before the examination (normal), the second 1hour before the examination and the third test was taken 1hour after the examination from the same students in the same educational conditions in the city of Sari. In this test, 20 students in one classroom from each group were selected randomly in similar conditions. Also consent letter was obtained from them. In each three stages of examinations, some parameters including HR¹, AHRI², RAI³, ABI⁴, SI⁵, R-Interval, in both groups were measured and the data recorded (Baevsky, R.M.,O.I, Kirillov and S.Z. Klitskin). To measure and determine the electric activities and heart rate function, the monitoring electrocardiograph apparatus (Biphasic model, 200 joulesma, made in the USA, Zoll Company) was used and so were processed by the method of Baevsky pulsometry variation (1984) and that's result obtained some indicator that showed heart rate function.

To determine the AHRI, the special following formula was used:

$AHRI = 1/ MO.\Delta X$; where,

MO= highest percent of number of time R-Interval
 ΔX ; Difference between the most and least percent of time R-R-interval

The RAI is obtained from following equation:

$RAI=AMO/MO$

AMO= highest percent of R-Interval

The ABI is calculated from following equation:

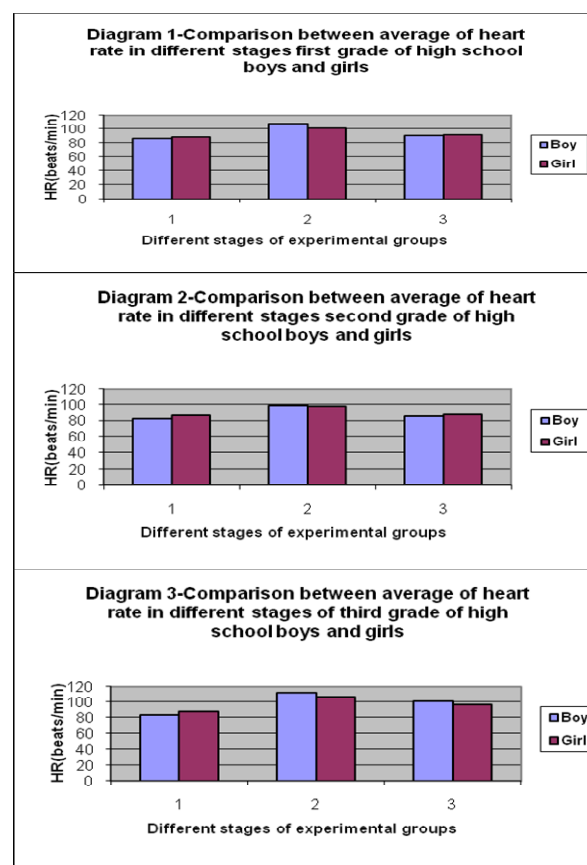
$ABI=AMO/\Delta X$

The SI is obtained from following equation:

$SI=AMO/2.\Delta X.MO$

Finally, the statistical elaboration of the obtained data from the three stages of test has been carried out using Biostat computer program

The obtained data from this study in different test stages indicated that in terms of HR, in first to third grades boys and girls groups, significant differences were observed in various test stages ($P<0.05$). This difference was higher in the 1hour before the examination and lower in the 2 months before the examination. It was revealed that boy students have some higher levels of indicators of heart rate. The HR was higher in both groups during 1hour before the examination. The reason of increase in HR related to examination time and tired of course and so sympathetic system activity (diagram 1 to 3).



As the examination time approaches, the effects of anxiety, stress and physical and psychological status cause increase in HR. Findings of this study agree with the data obtained by Gevorkian et al. (2003), loft et al. (2007) and Zeller et al. (2004). Minasian et al. (2006) showed that periods of the highest pressure of physiological systems of an organism of students are the beginning of the first semester and examination period (Minasian, SM.et.al. 2006). Gevorkian et al.(2003) showed that heart rate reactions on the examination stress depended on the individual typological characteristics and the state of autonomic nervous system (ANS) (6). Dimitriev et al. (2008) in an

¹ Heart Rate

² Autonomic Heart Rhythm Index

³ Regulation Adequacy Index

⁴ Autonomic Balance Index

⁵ Stress Index

experiment during education and immediately before the examination observed change in heart rate, blood pressure and anxiety status by examining stress in students. Before the examination, more students showed increase in anxiety status, diastolic blood pressure and heart rate (Dimitriev, D.A.et.al.2008). Data of the literatures indicate that adaptive capacity of such regulatory mechanisms could be exceeded by stress. Their failure may result in the development of pathology (Andrianov, V and N.A.Vasilyuk.2001, Nidekker, I.G and B.M.Fedorov.1993). Makimbetova (2007) in a study made on 15-17 years age groups showed a decrease level (Makimbetova, C. 2007). Minasian et al. (2010) showed that boy students have some higher levels of integral indicators of heart rate and it was agrees with the results of this research (Minasian, SM et.al.2010). In terms of AHRI, there was significant difference between different test stages in the first, second and third grades boys and girls groups ($P<0.001$). In the three grades in the 1hour before the examination it was higher than the other stages and lower in the 2 months before the examination (table 1 to 3). In during before the examination was higher AHRI indicator and was lower parasympathetic indicator (Mo), homoral (ΔX) and cardiointervals variation (Vk) than the normal stages in both groups. The reason is examinations stress that increased the sympathetic activity effects and regulatory center mechanisms of heart rate.

Makarenko et al. (2003) studied the reactions of heart rhythm in the students with their personal

Table 1-Changes of cardiac performances at different stages of first grade high school boys and girls

Parameters	Girls			Boys		
	Normal	Before the examination	After the examination	Normal	Before the examination	After the examination
HR(beats/min)	89.16±4.31	102.12±1.86 $p<0.05$	92.36±2.89	86.75±3.72	108.64±3.14 $p<0.01$	91.17±2.34
SI (abr.units)	98.55±9.04	146.23±12.12 $p<0.001$	114.8±3.06 $p<0.05$	121.25±10.41	226.38±16.32 $p<0.001$	157.61±20.6 $p<0.01$
AMo (%)	41.56±2.34	48.22±1.81 $p<0.05$	46.61±2.02 $p<0.05$	44.65±3.21	53.47±2.9 $p<0.05$	51.50±2.69 $p<0.05$
Mo (s)	0.81±0.021	0.71±0.023 $p<0.05$	0.76±0.01 $p<0.05$	0.82±0.032	0.67±0.021 $p<0.01$	0.60±0.03 $p<0.01$
ΔX (s)	0.26±0.02	0.23±0.01 $p<0.05$	0.28±0.02	0.22±0.01	0.18±0.01 $p<0.01$	0.27±0.02 $p<0.01$
AHRI (abr.units)	4.72±0.48	5.99±0.26 $p<0.05$	5.10±0.56 $p<0.05$	5.49±0.56	8.33±0.62 $p<0.001$	6.35±0.60 $p<0.05$
ABI (abr.units)	159.85±11.32	209.65±16.68 $p<0.001$	168.0±13.12	202.95±13.61	297.05±17.23 $p<0.001$	192.87±26.07 $p<0.001$
RAI (abr.units)	50.74±3.05	67.63±4.14 $p<0.01$	62.6±4.48 $p<0.01$	53.93±3.12	79.57±4.64 $p<0.001$	84.40±9.3 $p<0.001$
R-R av. (s)	0.80±0.01	0.69±0.02 $p<0.05$	0.72±0.01 $p<0.05$	0.76±0.03	0.66±0.02 $p<0.05$	0.68±0.03 $p<0.05$
R-R min. (s)	0.64±0.02	0.51±0.01 $p<0.01$	0.56±0.01 $p<0.05$	0.67±0.02	0.53±0.01 $p<0.01$	0.56±0.02 $p<0.05$
R-R max. (s)	0.88±0.01	0.76±0.02 $p<0.05$	0.82±0.02 $p<0.05$	0.90±0.02	0.72±0.02 $p<0.01$	0.78±0.03 $p<0.05$

features and difference in gender during examinations stress. The results of the test showed decrease of parasympathetic effects and increase of sympathetic effects on heart rate, it agrees with the results of this research (12). Makimbetova (2007) showed that the parasympathetic effects on cardiac rhythm is higher in higher wages in boys and 15-17 years old girls and the increase was significantly higher in boys (Makimbetova, C. 2007). In terms of RAI in the first to third grades of high school boys and girls and in each grade there was significant difference between different test stages ($P<0.001$). In the three grades in the 1hour before the examination it was higher than the other test stages and lower in the 2 months before the examination (table 1 to 3).

The RAI in each three grades was higher in both groups during 1hour before the examination than the other test stages. The reason is increase of sympathetic system activity that attributed to higher percent of R-R-interval than percent of time in R-R-interval and lower Mo. The results of this research agree with the data given by Makimbetova (2007). Goliskardi et al. (2010) showed increase of AMo, SI, AHRI, RAI and ABI was more evident in boys and while tonus of the parasympathetic part of vegetative nervous system (VNS) significantly decreased (Goliskardi, R., SM, Minasian and ES. Gevorkian. 2010).

Table 2-Changes of cardiac performances at different stages of second grade high school boys and girls

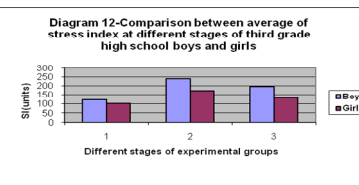
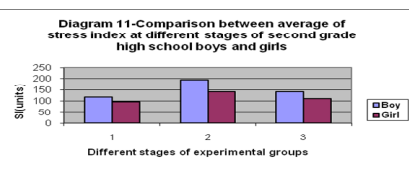
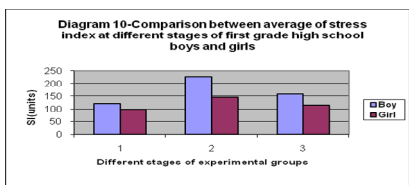
Parameters	Girls			Boys		
	Normal	Before the examination	After the examination	Normal	Before the examination	After the examination
HR (beats/min)	86.62±2.44	97.48±2.86 p<0.05	88.31±3.44	82.36±3.68	98.86±4.32 p<0.02	85.48±4.72
SI (abr.units)	96.24±5.32	139.54±18.6 p<0.001	110.6±6.32 p<0.05	116.8±7.4	192.96±8.6 p<0.001	140.84±4.26 p<0.01
AMo (%)	31.82±1.69	47.17±2.04 p<0.001	37.4±1.82 p<0.05	38.6±2.02	54.2±2.4 p<0.001	44.3±1.8 p<0.05
Mo (s)	0.65±0.02	0.60±0.01 p<0.05	0.66±0.02	0.70±0.01	0.65±0.01 p<0.05	0.68±0.03
ΔX (s)	0.28±0.02	0.25±0.04 p<0.05	0.29±0.03 p<0.05	0.25±0.02	0.22±0.02 p<0.05	0.24±0.03
AHRI (abr.units)	5.95±0.48	6.15±0.02	6.05±0.36	5.76±0.52	7.24±0.62 p<0.001	6.72±0.24 p<0.05
ABI (abr.units)	126.61±6.82	167.10±8.94 p<0.001	142.3±8.36 p<0.05	159.42±12.14	246.38±12.2 p<0.001	186.32±11.3 p<0.05
RAI (abr.units)	47.69±3.21	78.64±4.05 p<0.001	62.98±2.84 p<0.05	58.6±4.48	82.6±5.32 p<0.001	67.96±4.6 p<0.05
R-R av. (s)	0.69±0.2	0.67±0.01	0.71±0.02	0.73±0.04	0.65±0.03 p<0.05	0.67±0.03 p<0.05
R-R min. (s)	0.53±0.02	0.57±0.04 p<0.05	0.60±0.04 p<0.05	0.57±0.01	0.53±0.02 p<0.05	0.51±0.01 p<0.05
R-R max. (s)	0.79±0.01	0.84±0.03 p<0.05	0.88±0.06 p<0.05	0.82±0.03	0.74±0.02 p<0.05	0.74±0.04

The ABI in first to third grades high school showed significant differences between boys and girls in different test stages ($P<0.001$) and in all grades during 1hour before the examination it was higher than the other stages and lower in the 2 months before the examination(table 1 to 3). In during before the examination was higher ABI indicator than the normal stages in both groups. The reason is effects of regulatory center systems on heart rate that attributed to the lower ΔX and effects of the highest percent of number and time of R-Rintervals. It is because of examinations stress, examination volume and course learning that affect on ABI. The data of this research agree with the data of Makarenko et al. (2003).

There is a statistically significant relationship between SI regulatory systems of cardiac rhythm in first to third grades high school students ($P<0.001$) and in both groups in all grades during 1hour before the examination it was higher than other stages and was lower in the 2 months before the examination(table 1 to 3) (diagram 10 to 12).

Table 3-Changes of cardiac performances at different stages of third grade high school boys and girls

Parameters	Girls			Boys		
	Normal	Before the examination	After the examination	Normal	Before the examination	After the examination
HR (beats/min)	87.98±5.64	106.12±4.76 p<0.001	96.32±4.48 p<0.05	82.80±4.22	112.24±8.04 p<0.001	101.20±6.72 p<0.01
SI (abr.units)	102.40±8.62	172.84±12.3 p<0.001	132.84±9.6 p<0.001	121.82±10.4	240.22±14.6 p<0.001	196.36±8.8 p<0.001
AMo (%)	41.61±2.3	52.30±3.1 p<0.01	48.20±2.6 p<0.05	42.82±2.4	62.41±1.6 p<0.001	56.20±2.0 p<0.001
Mo (s)	0.65±0.04	0.60±0.05 p<0.05	0.65±0.02	0.70±0.01	0.64±0.02 p<0.05	0.65±0.01 p<0.05
ΔX (s)	0.32±0.01	0.24±0.02 p<0.01	0.29±0.01 p<0.05	0.24±0.02	0.19±0.01 p<0.05	0.22±0.01 p<0.05
AHRI (abr.units)	5.13±0.68	6.94±0.41 p<0.001	5.46±0.36	5.95±0.81	8.09±1.8 p<0.001	6.68±1.2 p<0.05
ABI (abr.units)	136.67±9.1	216.42±13.8 p<0.001	165.52±8.9 p<0.01	175.66±10.2	326.8±12.8 p<0.001	243.47±11.3 p<0.001
RAI (abr.units)	63.07±0.8	86.66±4.61 p<0.001	73.85±2.2 p<0.05	60.21±1.4	98.82±3.9 p<0.001	84.92±4.1 p<0.001
R-R av. (s)	0.69±0.03	0.66±0.04	0.67±0.01	0.72±0.03	0.58±0.02 p<0.05	0.68±0.01
R-R min. (s)	0.54±0.01	0.56±0.02	0.54±0.01	0.57±0.01	0.53±0.01 p<0.05	0.56±0.01
R-R max. (s)	0.84±0.03	0.80±0.06	0.83±0.03	0.81±0.01	0.72±0.01 p<0.05	0.79±0.02



On basis heart stress indicators the reason of higher SI in boys group in second stage (1hour before the examination) is for the lower MO and ΔX and higher sympathetic system activity ($180 \leq SI \leq 250$) (average in three grades 61.2%) and it affected on changes in heart rate mechanisms activity and in girls group is because of lower MO and ΔX and higher normotonic system activity ($60 \leq SI \leq 180$) (average in three grades 58.3%).

In first stage (normal) and third stage (1hour after the examination) in both groups, the SI was lower than second stage (1hour before the examination) and lower SI is because of vagotonic and normotonic systems activity ($60 \leq SI \leq 180$) and sympathetic and parasympathetic systems activity were in balance (table 4 to 6, diagram 4 to 9).

Table 4-Percentage of vagotonic, normotonic and sympathetic at different stages of first grade high school boys and girls

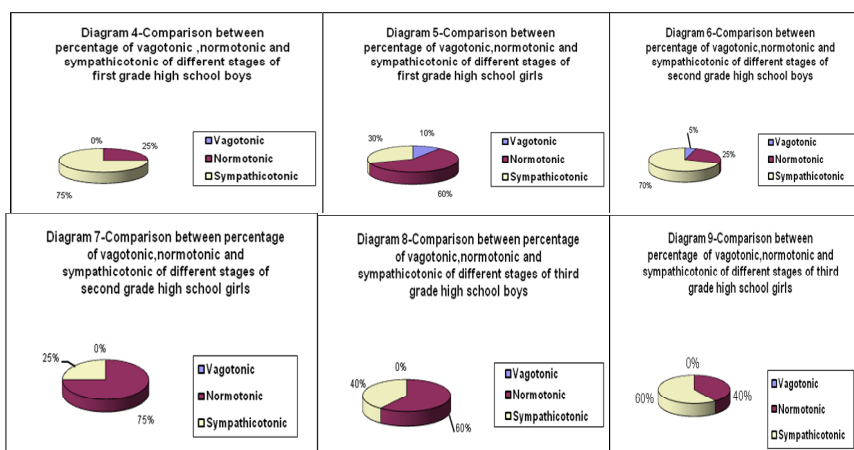
	Girls			Boys		
	Normal	Before the examination	After the examination	Normal	Before the examination	After the examination
Vagotonics	70%	10%	15%	10%	-	-
Normotonics	30%	60%	85%	80%	25%	65%
Sympathicotronics	-	30%	-	10%	75%	35%

Table 5- Percentage of vagotonic, normotonic and sympathetic at different stages of second grade high school boys and girls

	Girls			Boys		
	Normal	Before the examination	After the examination	Normal	Before the examination	After the examination
Vagotonics	40%	-	5%	10%	-	-
Normotonics	50%	40%	75%	65%	60%	55%
Sympathicotronics	10%	60%	20%	25%	40%	45%

Table 6- Percentage of vagotonic, normotonic and sympathetic at different stages of third grade high school boys and girls

	Girls			Boys		
	Normal	Before the examination	After the examination	Normal	Before the examination	After the examination
Vagotonics	50%	-	30%	20%	5%	-
Normotonics	35%	75%	60%	70%	25%	70%
Sympathicotronics	15%	25%	10%	10%	70%	30%



Dudnik et al. (2007) in a study reported that changes in cardiac function are under the effects of sympathetic and parasympathetic regulations, which agrees with the results of our study in both groups. The observed changes indicate that the autonomic balance shifted towards a marked predominance of the sympathetic division of the autonomic nervous system (ANS), which is known to reflect an increasing centralization of HR control and an enhanced modulating effect of the hypothalamus (Baevsky, R.M. et al. 1984, Dotsoev, L.Ya et al. 2003, Nozdrachev, A.D and Yu.V. shcherbatykh. 2001, Shcherbatykh, Yu.V. 2000, Yumatov, E.A. et al. 2001). Goliskardi et al. (2010) in a study showed there is a statistically significant relationship between SI regulatory systems of cardiac rhythm and level of anxiety of the study participants. It was found that examination psycho-emotional stress has a significant effect on sympathetic-vagal balance of the heart rate regulation and anxiety level of students (Goliskardi, R. et al. 2010).

In before the examination stage, the increasing of sympathetic mechanisms activity indicators was resulted to higher in stress index (SI) in boy and girl groups. In comparison with normal stage, the stress index (SI) was increased in students of the first, second and third grades boys high school consecutively; 86.7 percent ($P < 0.001$), 65.2 percent ($P < 0.001$) and 97.2 percent ($P < 0.001$) and in girls consecutively; 48.4 percent ($P < 0.001$), 44.9 percent ($P < 0.001$) and 68.8 percent ($P < 0.001$).

The average of R-R interval time in the first to third grade students in each grade and different stages of test significant differences were observed ($P < 0.05$). In both groups, R-R interval time was lower in the 1 hour before the examination than 1 hour after the examination (table 1 to 3).

In this study HR was higher in the 1 hour before the examination which resulted in decreasing of R-R interval time in the 1 hour before the examination.

Makimbetova (2007) found that in 15-17 years old boys group, with increases of age the distance between RR becomes significantly longer while in lower age girls group, the distance of RR was longer. Lucini et al. (2002) studied the educational stress period of the university students and found that during stress, the RR distance lowered and the artery pressures increased significantly.

In terms of comparison, in first stage (normal), measured parameters in both groups were lower in all grades than other test stages, and most measured parameters were higher in boys group.

In second stage (1 hour before the examination) most measured parameters were higher in different grades of boys and girls than other test stages and it was a significant differences ($P < 0.001$). Most

measured parameters were higher in boys group in all grades.

In third stage (1 hour after the examination) most measured parameters were higher in different grades of boy and girl groups than first stage (normal) and was lower than second stage (1 hour before the examination) and it was a significant difference ($P < 0.05$). Most measured parameters were higher in boys group in all grades than in girl students. The most measured changes indicators of regulatory systems of cardiac rhythm in all test stages in both groups were higher in the first and third grade high school students.

3. Conclusions

The results of this study showed the highest stress effects in the 1 hour before the examination in the first grade and third grade high school students and affected sympathetic system activity. The most measured changes indicators of regulatory systems of cardiac rhythm at different stages of experiment were higher in boys group in all grades than in girl students. The factors of age, gender, and type of course, course volume and pressure, psychophysiological status, personality, individual typological characteristics, examination time and anxiety affected on educational pressure, examination stress and the state of autonomic nervous system as a results changes in the mechanism of heart rate function in the study subjects.

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