Original Article

Haematological Characteristics, Body Metabolites, Electrolytes And Enzymes As Predictors Of Physical Fitness Variable Explosive Leg Strength Among Hockey Players

Om Prakash[1], **Dr. Sanjay Sharma**[2]

[1]Research Scholar, Department of Physical Education, Himachal Pradesh University, Shimla
Email ID: omprakashhpu@gmail.com
[2]Professor, Department of Physical Education, Himachal Pradesh University, Shimla
Email ID: sanjay.sports2010@gmail.com
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Abstract

This study aimed to investigate the predictive capacity of haematological characteristics, body metabolites, electrolytes and enzymes on physical fitness variable explosive leg strength among sub-junior male hockey players in Himachal Pradesh. Twenty players aged 14-16 years, who had participated in Sub-Junior National Level Championships during 2022-2024, were assessed. The study employed a non-experimental, correlational research design to analyze the relationships and predictive strength of 25 physiological markers with the physical fitness component explosive leg strength. The data was collected using SAI Physical Fitness Tests and laboratory blood analyses. Pearson correlation and regression analyses were conducted. The findings revealed that red blood cells (RBCs) and haemoglobin exhibited a significant positive relationship with explosive leg strength, while white blood cells (WBCs) showed a non-significant negative association. Among body metabolites, no significant correlations were found. Potassium demonstrated a significant negative relationship among electrolytes, contributing meaningfully to the regression model. None of the enzymes studied significantly correlated with explosive leg strength. The regression models confirmed that haematological traits and electrolytes, particularly RBCs and potassium, were significant predictors of explosive leg strength, accounting for 60.5% and 67.5% variance respectively. These insights emphasize the role of internal physiological factors, especially blood and electrolyte markers, in determining physical fitness characteristics important for athletic performance in hockey.

INTRODUCTION

The origins of sport trace back to the earliest human civilizations, where purposeful, sportive, and energetic behaviour helped individuals better understand and adapt to their natural surroundings. Over time, sport evolved from a basic survival skill to a structured social activity, reflecting broader societal transformations and embodying the cultural values of different communities. Studying the history and development of sport offers valuable insights into human progression and the intricate relationship between performance, health, and environment. In contemporary times, the level of performance in elite sports competitions has increased remarkably, with only marginal differences separating the top contenders. This high level of competitiveness, especially evident during international events such as the Olympics, has elevated sports into a domain of intense scientific scrutiny. The growing admiration for athletes, their performances, and their associated financial rewards has fostered a deeper interest in the mechanisms underlying sports success. As a result, scientific approaches to training, performance assessment, and talent identification have become indispensable in modern sports.

Athletic performance is now understood to be the product of a complex interaction between physical, psychological, and physiological variables. While talent is often innate, optimal performance requires the right environment, long-term training, and scientific guidance. In fact, it is widely acknowledged that modern sports competitions are no longer merely contests between individuals but between scientific systems. Athletes today must undergo rigorous training regimes and physiological assessments to reach the pinnacle of their sports. Various factors including heredity, body composition, nutrition, social background, and psychological traits have been identified as key determinants of performance.

Hockey, in particular, holds a special place in the Indian sports psyche. Often referred to as the soul of Indian sport, hockey has captivated audiences through its speed, rhythm, and artistry. The origins of hockey can be traced to ancient civilizations, but modern field hockey is recognized today as a global sport played in over 118 countries. According to Hughes and Bartlett (2002), hockey is a goal-oriented invasion game requiring tactical and technical proficiency. Anders and Myers (2008) describe hockey as a team sport involving two teams of eleven players, one of whom is the goalkeeper, played on a rectangular field measuring 90 meters by 55 meters.

The primary objective in hockey is to score goals by hitting a ball approximately 9 inches in diameter into the opponent's goal using specially designed sticks. Key features of modern hockey include the attacking circle (16 yard's radius) and the penalty corner system, which play crucial roles in goal-scoring. A standard team comprises of various positions, such as goalkeepers, defenders, midfielders, and strikers, each with distinct responsibilities. Notably, the sport has undergone significant transformations, especially since the 1970s with the adoption of synthetic turf. Recent rule changes, such as the removal of the offside rule and unlimited substitutions, have further enhanced the pace and appeal of the game. Field hockey demands a high level of physical fitness and energy system utilization. Players cover approximately 8,000 to 10,000 meters per match (Konarski et al., 2006), engage in high-speed sprints, execute complex turns, and make rapid decisions. Boyle et al. (1994) found that players often reach near-maximal heart rates during competition, illustrating the sport's physiological intensity. Additional research (Elferink et al., 2007) emphasizes the importance of tactical awareness, anticipation, and refined motor skills in achieving success in the sport.

Exercise physiology, a key sub-discipline of sport science, focuses on understanding how acute and chronic bouts of exercise affect the human body. Physiological variables such as vital capacity, haemoglobin levels, blood pressure, and pulse rate are central to evaluating athletic potential. According to Rikli and Jones (1999), functional fitness involves the ability to perform daily tasks efficiently and safely without excessive fatigue. Similarly, physical fitness encompasses components such as strength which is critical to hockey performance. Despite hockey's prominence in India, limited scientific research has been conducted on the physiological and biochemical profiles of Indian hockey players, especially at the sub-junior level. While international studies have explored various physiological predictors of performance, Indian literature on the subject remains sparse. This gap is particularly notable in areas such as haematological characteristics, body metabolites, electrolytes and enzymes activities in relation to fitness parameters. Given the above context, the present study seeks to address this research gap. The investigator, himself a former hockey player, recognised the need for a scientific inquiry into the physiological predictors of fitness performance among young Indian hockey players. The findings of this study are expected to aid coaches, trainers, and sports scientists in identifying talent, designing training programs, and enhancing the performance of future hockey players through evidence-based strategies.

OBJECTIVE OF THE STUDY

To examine the relationship and predictive capacity of selected haematological characteristics, body metabolites, electrolytes and enzymes on physical fitness component explosive leg strength among sub-junior male hockey players in Himachal Pradesh. It was hypothesised that the selected haematological characteristics, body metabolites, electrolytes and enzymes would have a significant relationship with the physical fitness variable explosive leg strength among the sub-junior male hockey players. Furthermore, it was also hypothesised that the physical fitness attribute explosive leg strength of the hockey players could be significantly predicted on the basis of selected haematological characteristics, body metabolites, electrolytes and enzymes.

RESEARCH DESIGN AND METHODOLOGY

The present study adopted a non-experimental quantitative research design utilizing a complex correlational approach for examining the relationship between selected haematological traits, body metabolites, electrolytes, and enzymes (independent variables) and the physical fitness component explosive leg strength (dependent variable) among sub-junior national-level male hockey players. Furthermore, the study aimed to identify significant physiological predictors influencing explosive leg strength performance. The research was carried out in two Government Sports Hostels located in Sundernagar and Una, Himachal Pradesh, India. The target population comprised male hockey players from Himachal Pradesh who had participated in Sub-Junior National Level Championships. A purposive sample of 20 male athletes aged between 14 and 16 years was selected based on recommendations from team coaches. All participants were active national-level competitors during the 2022-23 and 2023-24 academic sessions. Explosive leg strength was assessed using the Sports Authority of India (SAI) Physical Fitness Test Battery, while blood samples were collected and analysed for the independent variables using haematological and biochemical analyzers. The haematological and biochemical assessments were conducted at SRL Diagnostics, Civil Hospital Sundernagar, Zonal Hospital Mandi, and Zonal Hospital Una in Himachal Pradesh.

Statistical analysis of the collected data was performed using IBM SPSS Version 26.0. Descriptive statistics, including means and standard deviations, were used to summarize the data. Pearson's Product-Moment Correlation Coefficient was employed to assess the relationships between the independent and dependent variables. Multiple regression analysis was conducted to identify significant predictors of the explosive leg strength component based on haematological and biochemical variables. A significance level of $p < 0.05$ was set for hypothesis testing.

RESULTS OF THE STUDY

The coefficient of correlation calculated between selected haematological traits, body metabolites, electrolytes, and enzymes with physical fitness characteristic speed of hockey players and the predictors of physical fitness characteristic speed of hockey players on the basis of selected haematological traits, body metabolites, electrolytes, and enzymes are presented in the tables 1 to 13.

The correlation coefficients between selected haematological traits, body metabolites, electrolytes, and enzymes and the physical fitness characteristic explosive leg strength among national level sub-junior hockey players, along with the predictors of explosive leg strength based on these physiological variables, are presented in tables 1 to 14.

Table-1 Relationship of Haematological Traits with Physical Fitness Characteristic i.e. Explosive Leg Strength of Hockey Players (N = 20)

Sr. No.	Traits Correlated with Physical Fitness Characteristic i.e. Explosive Leg Strength	Co-efficient of Correlation 'r'
1.	Haemoglobin	.478*
2.	RBCs	.646**
3.	WBCs	-.266
4.	Platelets	.240

*Significant at .05 level (r = .443), **Significant at .01 level (r = .561), df = 18

Table no.1 illustrates that the RBCs (r = .646, p<.01) and haemoglobin (r = .478, p<.05) of hockey players have a positive and significant relationship with explosive leg strength, while platelets (r = .240) has shown positive but non-significant correlation. Furthermore, haematological traits WBCs (r = -.266) has shown negative and non-significant relationship with explosive leg strength variable of physical fitness among hockey players.

Table-2 Model Summary of Haematological Traits to Explosive Leg Strength of Hockey Players

R	R Square	Adjusted R Square	Std. Error of Estimation
.778	.605	.500	.140

Table no. 2 reveals that the correlation coefficient (R) between the traits is .778 (77.8 percent) while the coefficient of determination is .605 (60.5 percent). Thus, the outcomes establish that the haematological characteristics account for 60.5% of the variance in the physical fitness attribute explosive leg strength among hockey players.

Table-3 Analysis of Variance of Haematological Traits on Explosive Leg Strength of Hockey Players

Source of Variance	Sum of Square	Df	Mean Square	F	Sig.
Regression	.451	4	.113	5.745	.005
Residual	.295	15	.020		
Total	.746	19			

Table no. 3 shows that the p-value for the F-test is .005, which is lesser than .05 and hence, significant. Accordingly, the model explains the large variations in the physical fitness attribute explosive leg strength of sub-junior hockey players by indicating towards the roles played by haematological characteristics i.e. haemoglobin, RBCs, WBCs and platelets. Hence, the model is significant.

Table-4 Regression Coefficients Associated with Explosive Leg Strength of Hockey Players

	Unstandardized Coefficient	T-Value	P-Value	Remarks
(Constant)	.709	1.656	.118	Not Significant
Haemoglobin	.034	1.264	.225	Not Significant
RBCs	.199	3.281	.005	Significant
WBCs	-.045	-1.506	.153	Not Significant

Platelets	.001	1.605	.129	Not Significant

From the table no. 4 it is clear that, haemoglobin is positively related to the physical fitness characteristic explosive leg strength of the hockey players as apparent from the score of its coefficient (.034) which implies that if haemoglobin increases by one unit, explosive leg strength of the hockey players will increase by (.034) units, while keeping other predicting characteristics constant. However, it is also observable from the table that the relationship of haemoglobin with explosive leg strength of the hockey players is not significant (p-value = .225).

RBCs are positively correlated with the physical fitness characteristic explosive leg strength of the hockey players as clear from the score of its coefficient (.199) which indicates that if RBCs increase by one unit, explosive leg strength of the hockey players will increase by (.199) units, while keeping other predicting features constant. Moreover, it is also evident from the table that the association of RBCs with explosive leg strength of the hockey players is significant (p-value = .005).

WBCs are negatively related to the physical fitness characteristic explosive leg strength of the hockey players as apparent from the value of its coefficient (-.045) which infers that if WBCs decrease by one unit, explosive leg strength of the hockey players will decrease by (-.045) units, while keeping other predicting variables constant. Nonetheless, it is also visible from the table that the relationship of WBCs with explosive leg strength of the hockey players is not significant (p-value = .153).

Platelets are positively correlated with the physical fitness characteristic explosive leg strength of the hockey players as observable from the score of its coefficient (.001) which indicates that if platelets increase by one unit, explosive leg strength of the hockey players will increase by (.001) units, while keeping other predicting features constant. However, it is also evident from the table that the association of platelets with explosive leg strength of the hockey players is not significant (p-value = .129).

Therefore, it can be established that with reference to the physical fitness characteristic explosive leg strength of the hockey players the most contributing haematological characteristic is RBCs followed by haemoglobin and platelets.

The Regression Equation

On the basis of above table, the Regression Equation is:
Explosive Leg Strength of the Hockey Players = .709 + .034Hb + .199RBCs - .045WBCs + .001PLT.

Table-5 Relationship of Body Metabolites with Physical Fitness Characteristic i.e. Explosive Leg Strength of Hockey Players (N = 20)

Sr. No.	Traits Correlated with Physical Fitness Characteristic i.e. Explosive Leg Strength	Co-efficient of Correlation 'r'
1.	Blood Glucose	-.177
2.	Uric Acid	.014
3.	Total Protein	-.033
4.	Bilirubin	-.086
5.	Albumin	.083
6.	Serum Creatinine	-.024
7.	Cholesterol	.227
8.	Triglycerides	.132
9.	HDL	.117
10.	LDL	.177

*Significant at .05 level (r = .443), **Significant at .01 level (r = .561), df = 18

Table no. 5 exhibits that the uric acid (r = .014), albumin (r = .083), cholesterol (r = .227), triglycerides (r = .132), HDL (r = .117) and LDL (r = .177) of hockey players have a positive but non-significant relationship with explosive leg strength. While, others body metabolites i.e. blood glucose (r = -.177), total protein (r = -.033), bilirubin (r = -.086) and serum creatinine (r = -.024) have a negative and non-significant relationship with physical fitness variable explosive leg strength among hockey players.

Table-6 Model Summary of Body Metabolites to Explosive Leg Strength of Hockey Players

R	R Square	Adjusted R Square	Std. Error of Estimation
.587	.344	-.384	.233

Table no. 6 unveils that the correlation coefficient (R) between the traits is .587 (58.7 percent) while the coefficient of determination is .344 (34.4 percent). Thus, the outcomes establish that the body metabolites account for 34.4% of the variance in the physical fitness attribute explosive leg strength among hockey players.

Table-7 Analysis of Variance of Body Metabolites on Explosive Leg Strength of Hockey Players

Source of Variance	Sum of Square	Df	Mean Square	F	Sig.
Regression	.257	10	.026	.473	.871
Residual	.489	9	.054		
Total	.746	19			

Table no. 7 predicts that the p-value for the F-test is .871, which is greater than .05 and hence, not significant. Accordingly, the model does not explain the large variations in the physical fitness attribute explosive leg strength of sub-junior hockey players by indicating towards the roles played by body metabolites i.e. blood glucose, uric acid, total protein, bilirubin, albumin, serum creatinine, cholesterol, triglycerides, HDL and LDL. Hence, the model is non-significant.

Table-8 Relationship of Electrolytes with Physical Fitness Characteristic i.e. Explosive Leg Strength of Hockey Players (N = 20)

Sr. No.	Traits Correlated with Physical Fitness Characteristic i.e. Explosive Leg Strength	Co-efficient of Correlation 'r'
1.	Sodium (Na^+)	.091
2.	Potassium (K^+)	-.651**
3.	Chloride (Cl^-)	-.086
4.	Calcium (Ca^{2+})	-.018
5.	Phosphorus (P)	-.377

*Significant at .05 level (r = .443), **Significant at .01 level (r = .561), df = 18

Table no. 8 explains that the potassium (K^+) of hockey players have a negative but significant relationship (r = -.651, p<.01) with explosive leg, whereas with sodium (Na^+) (r = .091) it has a positive and non-significant relationship. However, other electrolytes i.e. phosphorus (P) (r = -.377), chloride (Cl^-) (r = -.086) and calcium (Ca^{2+}) (r = -.018), show a negative but non-significant relationship with variable explosive leg strength of physical fitness among hockey players.

Table-9 Model Summary of Electrolytes to Explosive Leg Strength of Hockey Players

R	R Square	Adjusted R Square	Std. Error of Estimation
.822	.675	.559	.131

Table no. 9 elucidates that the correlation coefficient (R) between the traits is .822 (82.2 percent) while the coefficient of determination is .675 (67.5 percent). Thus, the outcomes establish that the electrolytes account for 67.5% of the variance in the physical fitness attribute explosive leg strength among hockey players.

Table-10 Analysis of Variance of Electrolytes on Explosive Leg Strength of Hockey Players

Source of Variance	Sum of Square	Df	Mean Square	F	Sig.
Regression	.504	5	.101	5.824	.004
Residual	.242	14	.017		
Total	.746	19			

Table no. 10 demonstrates that the p-value for the F-test is .004, which is lesser than .05 and hence, significant. Accordingly, the model explains the large variations in the physical fitness attribute explosive leg strength of sub-junior hockey players by indicating towards the roles played by electrolytes i.e. sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{2+}) and phosphorus (P). Hence, the model is significant.

Table-11 Regression Coefficients Associated with Explosive Leg Strength of Hockey Players

	Unstandardized Coefficient	T-Value	P-Value	Remarks
(Constant)	4.724	.846	.412	Not Significant
Sodium (Na^+)	.032	.591	.564	Not Significant
Potassium (K^+)	-.388	-4.452	.001	Significant
Chloride (Cl^-)	-.076	-2.128	.052	Not Significant
Calcium (Ca^{2+})	.309	1.980	.068	Not Significant
Phosphorus (P)	-.066	-1.178	.258	Not Significant

From the table no. 11 it is clear that, sodium (Na^+) is positively related to the physical fitness characteristic explosive leg strength of the hockey players as understandable from the value of its coefficient (.032) which implies that if sodium (Na^+) increases by one unit, explosive leg strength will increase by (.032) units, while keeping other predicting characteristics constant. However, it is also evident from the table that the relationship of sodium (Na^+) with explosive leg strength is not significant (p-value = .564).

Potassium (K^+) is negatively related to the physical fitness characteristic explosive leg strength of the hockey players as evident from the value of its coefficient (-.388) which indicates that if potassium (K^+) increases by one unit, explosive leg strength will decrease by (.388) units, while keeping other predicting characteristics constant. But it is also visible from the table that the association of potassium (K^+) with explosive leg strength is significant (p-value = .001).

Chloride (Cl^-) is negatively related to the physical fitness characteristic explosive leg strength of the hockey players as noticeable from the value of its coefficient (-.076) which infers that if chloride (Cl^-) increases by one unit, explosive leg strength will decrease by (.076) units, while keeping other predicting characteristics constant. Even though, it is also evident from the table that the relationship of chloride (Cl^-) with explosive leg strength is not significant (p-value = .052).

Calcium (Ca^{2+}) is positively related to the physical fitness characteristic explosive leg strength of the hockey players as evident from the value of its coefficient (.309) which indicates that if calcium (Ca^{2+}) increases by one unit, explosive leg strength will increase by (.309) units, while keeping other predicting characteristics constant. However, it is also evident from the table that the association of calcium (Ca^{2+}) with explosive leg strength is not significant (p-value = .068).

Phosphorus (P) is negatively related to the physical fitness characteristic explosive leg strength of the hockey players as observable from the value of its coefficient (-.066) which implies that if phosphorus (P) increases by one unit, explosive leg strength will decrease by (.066) units, while keeping other predicting characteristics constant. Though, it is also evident from the table that the relationship of phosphorus (P) with explosive leg strength is significant (p-value = .258).

Therefore, it can be established that with reference to the physical fitness characteristic explosive leg strength of the hockey players the most contributing electrolyte is potassium (K^+) followed by calcium (Ca^{2+}) and chloride (Cl^-).

The Regression Equation

On the basis of above table, the Regression Equation is:

Explosive Leg Strength of Hockey Players = 4.724 + $.032Na^+ - .388K^+ - .076Cl^- + .309Ca^{2+}$ - .066P.

Table-12 Relationship of Enzymes with Physical Fitness Characteristic i.e. Explosive Leg Strength of Hockey Players (N = 20)

Sr. No.	Traits Correlated with Physical Fitness Characteristic i.e. Explosive Leg Strength	Co-efficient of Correlation 'r'
1.	Alkaline Phosphatase	-.041

2.	S.G.O.T. (AST)	-.089
3.	S.G.P.T. (ALT)	.082
4.	Amylase	-.127
5.	CPK-Total	-.286
6.	Lipase	.161

*Significant at .05 level (r = .443), **Significant at .01 level (r = .561), df = 18

Table no. 12 discloses that the S.G.P.T. (ALT) (r = .082) and lipase (r = .161) of hockey players have a positive and non-significant relationship with explosive leg strength. Whereas, other enzymes i.e. alkaline phosphatase (r = -.041), S.G.O.T. (AST) (r = -.089), amylase (r = -.127) and CPK-Total (r = -.286) demonstrate a negative and non-significant relationship with explosive leg strength variable of physical fitness among hockey players.

Table-13 Model Summary of Enzymes to Explosive Leg Strength of Hockey Players

R	R Square	Adjusted R Square	Std. Error of Estimation
.411	.169	-.215	.218

Table no. 13 displays that the correlation coefficient (R) between the traits is .411 (41.1 percent) while the coefficient of determination is .169 (16.9 percent). Thus, the outcomes establish that the enzymes account for 16.9% of the variance in the physical fitness attribute explosive leg strength among hockey players.

Table-14 Analysis of Variance of Enzymes on Explosive Leg Strength of Hockey Players

Source of Variance	Sum of Square	Df	Mean Square	F	Sig.
Regression	.126	6	.021	.440	.840
Residual	.620	13	.048		
Total	.746	19			

Table no. 14 illustrates that the p-value for the F-test is .840, which is greater than .05 and hence, not significant. Accordingly, the model does not explain the large variations in the physical fitness attribute explosive leg strength of sub-junior hockey players by indicating towards the roles played by enzymes i.e. alkaline phosphatase, S.G.O.T. (AST), S.G.P.T. (ALT), amylase, CPK-Total and lipase. Hence, the model is non-significant.

CONCLUSIONS

The findings of the research offered valuable insights into the correlation and predictive influence of various haematological and biochemical parameters on the explosive leg strength of sub-junior hockey players, as outlined below:

1. **Haematological Characteristics:**
   - RBCs had the strongest positive and significant correlation ($r = .646, p < .01$) with explosive leg strength.
   - Haemoglobin also showed a significant positive correlation ($r = .478, p < .05$).
   - The regression analysis confirmed RBCs as a significant predictor ($\beta = .199, p = .005$), contributing notably to the variance ($R^2 = 60.5\%$).
   - This aligns with the known role of RBCs and haemoglobin in oxygen transport, essential for muscular performance and strength.
2. **Body Metabolites:**
   - No metabolite demonstrated a statistically significant relationship with explosive leg strength.
   - The regression model yielded an insignificant F-ratio ($p = .871$), with low variance explained ($R^2 = 34.4\%$).
   - This suggests that, in this cohort, body metabolite levels may not directly influence leg strength performance.
3. **Electrolytes:**
   - Potassium showed a significant negative correlation ($r = -.651, p < .01$), and its regression coefficient was also significant ($\beta = -0.388, p = .001$), indicating that higher potassium levels might impair explosive leg strength.

- The model was highly significant (F = 5.824, p = .004), explaining 67.5% of variance.
- Sodium, calcium, and chloride had positive or negative associations, but none reached statistical significance.

4. **Enzymes:**
   - None of the enzyme markers (ALT, AST, amylase, etc.) were significantly associated with explosive leg strength.
   - The model's F-value was non-significant (p = .840), explaining only 16.9% variance.
   - This implies that muscle enzyme activity or damage markers may not have a direct influence on lower-body strength in adolescent hockey players.

Thus, the study concludes that amongest the physiological markers studied, RBC count and potassium level are the most influential in determining explosive leg strength in sub-junior hockey players. While haemoglobin also contributes positively, and electrolytes like sodium and calcium show potential, their statistical insignificance necessitates further research. Body metabolites and enzymes, however, demonstrated weak associations, suggesting limited impact on explosive muscular performance in this specific athletic population.

RECOMMENDATIONS FOR FURTHER RESEARCH

Coaches and sports trainers should monitor haematological and electrolyte profiles, particularly RBC and potassium levels, during training cycles to optimize strength performance. Dietary strategies should consider micronutrient and electrolyte balance, especially potassium intake, to avoid adverse effects on muscle function.

Future studies should involve larger and more diverse samples (age, gender, competitive level) to validate and generalize the findings. Tracking changes in physiological markers across training phases could offer deeper insights into their influence on strength adaptations. Moreover, multivariate approaches combining physiological, biomechanical, and psychological variables can yield holistic predictors for performance profiling in hockey and similar sports.

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