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Real and perceived motor competence according to the stage of peak height velocity (PHV) in Chilean fifth and sixth-grade primary school students

Competencia motriz real y percibida según etapas de la velocidad máxima de altura (VMA) en estudiantes chileno de quinto y sexto año grado de educación primaria

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Abstract
This research aims to compare and relate actual and perceived motor competence according to peak height velocity (PHV) stages among Chilean students in fifth and sixth grade. The sample consisted of 84 Chilean students from the city of Chillán, aged 10 to 12 years, including 45 girls and 34 boys. Data collection involved the use of the MOBAK and SEMOK tests to measure real motor competence (RMC) and perceived motor competence (PMC), respectively. Somatic maturation was determined by calculating PHV. ANOVA tests with covariate adjustments (ANCOVA) for body mass index (BMI) and sex were performed based on PHV status and motor competence. Additionally, a partial correlation test between PHV and RMC and PMC, adjusting for BMI and sex, was conducted. The results indicate no significant differences when comparing children by PHV stage in both actual and perceived motor competence tests ($p>0.05$). However, the partial correlation tests revealed a relationship between PHV stages and RMC ($r=0.3$; $p=0.01$) and body control ($r=0.27$; $p=0.02$). Somatic maturation did not affect motor competence in boys when adjusted for BMI and sex; however, there was a relationship with total RMC and body control. No relationship was found with object control tests. It is noteworthy that other factors, such as genetics, physical activity level, and lifestyle habits, may have influenced the results.
Keywords: biological maturation, motor competence, somatic maturation, mobak test, semok test.

Resumen
Esta investigación busca comparar y relacionar la competencia motora real y percibida según estadio de velocidad máxima de altura (VMA) en estudiantes chilenos de quinto y sexto año básico. La muestra fue de 84 estudiantes chilenos de la ciudad de Chillán entre 10 a 12 años, de los cuales 45 son niñas y 34 niños. La recopilación de datos implicó el uso de las pruebas MOBAK y SEMOK para medir la competencia motriz real y percibida respectivamente. La maduración somática se obtuvo mediante el cálculo del VMA. Se realizó pruebas de ANOVA con ajustes de covariables (ANCOVA) índice de masa corporal (IMC) y sexo, según estado de VMA y competencia motriz. Se realizó además una prueba de correlación parcial entre VMA y competencia motriz real (CMR) y percibida (CMP) ajustando IMC y sexo. Los resultados indican que no existe diferencias significativas al comparar a los niños según estadio de VMA en las pruebas de competencia motriz (CM) tanto real como percibida ($p>0,05$). Por otra parte, al realizar las pruebas de correlación parcial se encontró una relación entre los estadios del VMA y CMR ($r=0,3$; $p=0,01$) y CMR control de cuerpo ($r=0,27$; $p=0,02$). La maduración somática no afectó la CM en los niños cuando está ajustada a IMC y sexo, sin embargo, existe una relación con la CMR total y control de cuerpo. Mientras que no hubo relación con las pruebas de control de objeto, sin embargo, cabe señalar que existen otros factores que pudieron afectar los resultados como la genética, nivel de actividad física y hábitos de vida.
Palabras claves: maduración biológica, competencia motriz, maduración somática, test mobak, test semok

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Introduction

Motor competence (MC) has been the focus of numerous studies worldwide, both in theoretical models (Stodden et al., 2008; Robinson et al., 2015; Barnett, 2016) and empirical research (Barnett et al., 2022). It can be defined, in the case of real motor competence (RMC) measurement, is the ability to efficiently execute a wide range of movements across various contextual manifestations of motor skills (Robinson et al., 2015). These movements encompass locomotor tasks and object manipulation in everyday activities as well as sports-related tasks such as running, jumping, catching, dribbling, throwing, and stability skills (Hermann et al., 2019; Muratori et al., 2013). Meanwhile, perceived motor competence (PMC) is an individual's subjective assessment of their ability to perform specific motor or sports skills and is influenced by personal evaluation (Estevan and Barnett, 2018).

Studies have demonstrated the relationship between motor competence and cognitive, social, physical, and psychological variables (Morano et al., 2020; Pavez-Adasme et al., 2024), highlighting its impact on educational settings, particularly in physical education (PE) (Carcamo-Oyarzun et al., 2023)classes, as well as in the motor development and health of children and adolescents (Stodden et al., 2008). For instance, PMC has shown a positive correlation with age, attributed to learning and experience gained through daily activities during childhood (Ramos et al., 2022). Gender differences have been identified, with boys excelling in object control tasks and girls in body control activities such as jumping and balancing (Müller et al., 2022). In the case of RMC, individuals with higher levels are more likely to remain physically active into adulthood (Barnett et al., 2016).

While basic motor skills, such as walking and object manipulation, develop through a combination of factors, including practical activity and biological maturation (Vandoni et al., 2024), individual variability in the maturation process leads to differences in size, body composition, and motor and cognitive performance among children and adolescents of similar ages (Brown et al., 2017). Biological maturation can be assessed using four indicators: sexual, skeletal, somatic, and neural (Palma et al., 2024). From a somatic maturation perspective, peak height velocity (PHV) refers to the maximum rate of growth in height, characterized by an increase of approximately 8 to 9

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centimeters and aligns with sexual maturation (Carranza-García et al., 2024). Research has shown that PHV is associated with motor competence; schoolchildren near PHV tend to perform better in jumping, strength, and speed tests compared to those further from PHV (Carranza-García et al., 2024).

Given these complexities, studies emphasize the importance of understanding how motor skills can yield variable outcomes during pre-, peri-, and post-biological maturation stages, particularly concerning gender differences (Peña-González et al., 2019). The aim of this research is to compare and relate real and perceived motor competence according to the stage of peak height velocity (PHV) in Chilean fifth and sixth-grade primary school students.

Design and partipants

A cross-sectional study employing a comparative-analytical correlational design was conducted, utilizing a quantitative approach. The sample was selected through non-randomized convenience sampling methods (Wang & Cheng, 2020). Eighty students (45 girls) from 5th and 6th grades of primary education from two schools in the city of Chillán, Chile were included in the study. Prior to their involvement, the study obtained informed consent from guardians and assent from the participants (minors) to ensure voluntary participation, thereby adhering to the ethical guidelines outlined in the Helsinki Declaration (World Medical Association, 2013). Furthermore, the research received approval from the scientific ethics committee of the University of La Frontera, under Approval Act No. 88_21, as part of the research project DIUFRO DPF21-0007 (2021-2025).

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Instruments

Real motor competence (RMC)

The MOBAK 5-6 test battery (Motoriche Basiskompetenzen in German) (Herrmann et al., 2019). was used to assess CMR. The MOBAK Battery has been validated to Spanish as a reliable tool (r=0.81) for diagnosing and tracking the development of motor skills within physical education (PE) classes (Carcamo Oyarzun et al., 2022).

This battery comprises eight motor tasks categorized into two groups: i) object control motor competence, encompassing tasks such as ball throwing, ball catching, hand dribbling, and foot dribbling, and ii) body control motor competence, comprising tests such as balancing on a seesaw, navigating obstacles while rolling, performing rhythmic rope jumping, and running (Herrmann et al., 2019).

In the throwing and catching tasks, children are allowed six attempts without any trial attempts. Scoring is based on the number of successful attempts: 0 to 2 attempts succeeded earn 0 points, 3 to 4 successes earn 1 point, and finally, 5 to 6 successes earn 2 points. In the hand dribbling tests, two attempts are permitted without any trial attempts. Scoring is as follows: achieving the task 0 times results in 0 points, achieving it once earns 1 point, and achieving it twice earns 2 points (Herrmann & Seelig, 2018).

Perceived Motor Competence

To measure perceived motor competence, we employed the SEMOK questionnaire (Herrmann & Seelig, 2017), validated in Spanish (Cárcamo Oyarzún & Herrmann, 2020). This is an 8-item instrument that assesses a total score between the perception of motor competence in object control and body control, in which students must indicate whether they believe they are capable or not of performing certain actions using a scale of 1 to 5 (1 = totally disagree, 3 = neutral, 5 = totally agree).

Somatic Maturation

One method for assessing biological maturation involves utilizing the PHV, which serves as a somatic indicator during adolescence (Gallant et al., 2023; Palma et al., 2024). To determine somatic maturation the years of PHV were estimated through anthropometric evaluations (Heras, 1997). The following anthropometric measurements

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were assessed to estimate PHV: body mass, height (measured using a Seca® scale, model 803, and a Seca® stadiometer, model 213), and seated height on an anthropometric box measuring 40 cm in height, 50 cm in width, and 30 cm in depth. These evaluations were conducted following standardized protocols, with participants wearing shorts, a t-shirt, and no footwear (López et al., 2016).

The anthropometric data obtained were then processed using formulas established by Mirwald et al. (2002) for both boys and girls. Please refer to Table I for details.

Table 1. PHV formula according to sex of children

PHV (boy)	-9.232 + 0.0002708 (length of the lower limb* cephalic trunk height) – 0.001663* (year* length of the lower limb) + 0.007216 (year* cephalic trunk height) + 0.02292*(weight/height).
PHV (girl)	-9.37 + 0.0001882 (length of the lower limb * cephalic trunk height) + 0.0022 (year * length of the lower limb + 0.005841 (year * cephalic trunk height) – 0.002658 (year * weight) + 0.007693) weight / height).

PHV= Peak Hight velocity

Stage of peak height velocity (PHV)

Once the values were obtained using the formulas shown in Table 1. The PHV stage in which they were found was classified using the following metrics: Pre-PHV (offset < −1 years), circa-PHV (≤±1 years), or post-PHV (offset > +1 years) (Łuszczki et al., 2021).

Instruments

Real motor competence (RMC)

The MOBAK 5-6 test battery (Motoriche Basiskompetenzen in German) developed in 2015 by Herrmann et al. was used to assess CMR. The MOBAK Battery has been validated to Spanish as a reliable tool (r=0.81) for diagnosing and tracking the development of motor skills within physical education (PE) classes (Carcamo Oyarzun et al., 2022).

This battery comprises eight motor tasks categorized into two groups: i) object control motor competence, encompassing tasks such as ball throwing, ball catching, hand dribbling, and foot dribbling, and ii) body control motor competence, comprising

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tests such as balancing on a seesaw, navigating obstacles while rolling, performing rhythmic rope jumping, and running (Herrmann et al., 2019).

Score

In each of these described items, students are given two attempts (without practice trials), except for the items "catch" and "throw," for which they have six attempts. Item scoring is conducted on a dichotomous scale (0 = not achieved, 1 = achieved), where the number of successful attempts is recorded (never achieved = 0 points; achieved once = 1 point; achieved twice = 2 points). For the task's "throw" and "catch," students have six attempts, and the score is based on the number of successful attempts (0–2 successes = 0 points; 3–4 successes = 1 point; and 5–6 successes = 2 points). Each item can receive a minimum score of 0 points and a maximum of 2 points, so each competence area (Object Control or Body Control) can achieve a maximum score of 8 points.(Carcamo-Oyarzun et al., 2024).

Perceived Motor Competence (PMC)

To measure perceived motor competence, we employed the SEMOK questionnaire (Herrmann & Seelig, 2019), validated in Spanish (Cárcamo Oyarzún & Herrmann, 2020). This is an 8-item instrument that assesses a total score between the perception of motor competence in object control and body control, in which students must indicate whether they believe they are capable or not of performing certain actions using a scale of 1 to 5 (1 = totally disagree, 3 = neutral, 5 = totally agree).

Anthropometric and somatic maturation

Body mass (Seca® scale, model 803), height Seca® stadiometer, model 213), and seated height on an anthropometric box measuring 40 cm in height, 50 cm in width, and 30 cm in depth) were measured following standardized protocols. Participants rere measured wearing shorts, a t-shirt, and no footwear (López et al., 2016). Based on the anthropometric measurements, Body Mass Index (BMI, kg·m−2) was calculated.

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The PHV was used as a measure of somatic maturation (Gallant et al., 2023; Thompson et al., 2003). The PHV was calculated from anthropometric measurements and the formulas established by Mirwald et al. (2002) for both boys and girls. (Table 1)

Procedures

Before the evaluations commenced, a meeting was held with several schools in the city of Chillán to introduce the project and elucidate the objective of data collection. Subsequently, upon acceptance from the schools to evaluate their students, parent meetings were conducted to engage with students, parents, and guardians. During these meetings, assent and consent forms were distributed and duly signed.

The evaluation sessions were structured across four Physical Education classes. In the initial session, demographic data for sample characterization (including name and date of birth) and anthropometric measurements (weight and height) were collected. The second session involved the administration of the Perceived Motor Competence Questionnaire (SEMOK), which lasted approximately 10-15 minutes. In the third and fourth sessions, the MOBAK test battery was administered.

All evaluators underwent comprehensive training conducted by the research team, who possessed prior experience with the MOBAK test battery. Additionally, evaluators were familiarized with anthropometric techniques and the administration of the SEMOK questionnaire by experienced researchers before commencing data collection.

Statistical Analysis

To characterize the sample, descriptive statistics, including means, standard deviations for anthropometric variables (age, weight, height, BMI, and PHV) and Real Motor Competence, and Perceived Motor Competence according to the subjects' gender, were utilized. Normality and homoscedasticity of the data were assessed using the Kolmogorov-Smirnov test.

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To compare actual and perceived motor competence across different PHV stages, an ANCOVA analysis was conducted, adjusting for BMI and sex. Effect sizes were interpreted using the following benchmarks: small ($\eta^2p = 0.01$), medium ($\eta^2p = 0.06$), and large ($\eta^2p = 0.14$) (Lakens, 2013).

Finally, partial correlation test was performed between PHV and motor competence. Correlation strength was evaluated as follows: no correlation when the value is 0, weak correlation when ± 0.20, moderate correlation when ± 0.50, strong correlation when ± 0.80, and perfect correlation when ± 1 (Papageorgiou, 2022).

All statistical analyses were performed using Jamovi software version 2.3.21. The significance level was set at $p < 0.05$ for all analyses

Result

Table 3 presents the general characteristics of the sample, with a mean age of 11.51 ± 0.63 years. Regarding body mass index (BMI), boys had an average value of 21.12 ± 4.02, while girls showed a slightly higher mean of 21.44 ± 4.01. In terms of biological maturation, as assessed by proximity to PHV, girls were on average 0.08 years from achieving their PHV, whereas boys were, on average, 2.61 years prior to this milestone. Additionally, the mean scores for actual motor competence were 0.71 ± 0.41 for body control and 0.78 ± 0.41 for object control. Perceived motor competence (PMC) in object control was 3.35 ± 0.83 in boys and 3.36 ± 0.78 in girls, while PMC in body control was 4.22 ± 0.84 in boys and 3.66 ± 0.82 in girls.

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Table 3. General characteristics of the sample in anthropometry, real motor competence and perceived motor competence according to the sex of the subjects.

	Boy		Girl		Total	
Variables	n	$\bar{x}$± SD	n	$\bar{x}$± SD	n	$\bar{x}$± SD
Anthropometry						
age (years)	35	11.51±0.58	45	11.50±0.68	80	11.51±0.63
Weight (Kg)	35	46.85±11.14	45	48.76±10.52	80	47.78±10.83
Height (m)	35	1.48±0.08	45	1.5±0.06	80	1.49±0.07
BMI (kg/m2)	35	21.12±4.02	45	21.44±4.01	80	21.28±4.02
PHV (years)	35	-2.61±0.67	45	0.08±0.81	80	-1.30±0.74
RMC Body control (points)	35	0.68±0.38	45	0.74±0.44	80	0.71±0.41
RMC Object control (points)	35	0.89±0.49	45	0.67±0.33	80	0.78±0.41
PMC Body control (point)	35	3.35±0.83	45	3.36±0.78	80	3.35±0.81
PMC Object control (points)	35	4.22±0.84	45	3.66±0.82	80	3.94±0.83

RMC: Real motor competence; PMC: Perceived motor competence.

Table 4 indicates that no significant differences were observed in actual or perceived motor competence for body control and object control across the stages of the PHV, after conducting an ANCOVA adjusted for BMI and gender.

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Table 4. Anthropometric values and perceived and real motor competence according to PHV

Variables	PHV			F	P	η^2P
	Pre (N=46)	During (N=19)	Post N=15)			
Percibed Motor competence Body control (point)	3.37±0.76	3.65±3.88	3.09±0.94	2.46	0.09	0.06
Object Control (points)	4.04±0.89	3.81±0.95	3.65±0.68	0.35	0.70	0.01
Real motor competence Body control (points)	0.70±0.41	0.72±0.33	0.77±0.54	0.11	0.89	0.00
Object Control (points)	0.80±0.49	0.76±0.33	0.68±0.29	0.92	0.40	0.02

An ANCOVA test was performed, and the results were adjusted for the covariates BMI and sex of the children.

Table 5 presents the correlation between PHV and both object control and body control motor competence. Following a partial correlation analysis adjusted for sex and BMI, moderate correlations were observed between PHV and total real motor competence ($r = 0.31$, $r^2 = 0.09$, $p = 0.01$), as well as real motor competence in body control ($r = 0.27$, $r^2 = 0.07$, $p = 0.02$). No significant differences were found for the remaining variables ($p > 0.05$).

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Table 5. Partial correlation between PHV and motor competence.

Variables	r	r^2	p
Percibed Motor competence			
Total percibed Motor competence (points)	0.13	0.02	0.25
Body control (points)	0.08	0.01	0.48
Object Control (points)	0.12	0.01	0.31
Real motor competence			
Total real motor competence (points)	**0.31**	**0.09**	**0.01***
Body control (points)	**0.27**	**0.07**	**0.02***
Object Control (points)	0.19	0.04	0.08

The results were obtained through a partial correlation adjusted for BMI and sex of the children.

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Discussion

The aim of this research is to compare and relate actual and perceived motor competence according to Peak Height Velocity (PHV) stages in Chilean fifth- and sixth-grade primary school students. The main results indicate that there are no significant differences in motor competence by PHV stage. However, a correlation was found between PHV and overall actual motor competence, as well as body control.

The lack of differences between PHV stages and Real Motor Competence (RMC) contrasts with other studies on similar Chilean groups, which report differences as age and maturation progress (Carcamo-Oyarzun et al., 2024). These results may be attributed to the specific population evaluated in this study, which indicates a generally low level of motor competence among children, highlighting a concern for physical education classes and student health in light of findings from previous studies (Pavez-Adasme et al., 2020; Carcamo-Oyarzun et al., 2024). Studies have shown an inverse relationship between motor competence and adolescent health, as individuals with lower motor competence tend to have higher levels of physical inactivity, which, in turn, increases adiposity and inflammatory markers (Werneck et al., 2020). Recent studies indicate that more than half of girls need to improve motor competence in body control and object control tasks, and one-third of boys need to strengthen these skills (Carcamo-Oyarzun et al., 2024).

Moreover, studies investigating physical activity levels and biological maturation did not find a relationship between these variables, reinforcing our study's results (Hermassi et al., 2024). This study did not perform a sex-differentiated analysis, which could have impacted the results, as girls typically reach maturation between ages 11 and 12, while boys reach it between 13 and 14 years (López-García et al., 2024).

Regarding Perceived Motor Competence (PMC), no significant differences were found between PHV stages. This aligns with the literature, where boys generally perceive themselves as more motor-competent in both body and object control tasks, although no significant difference exists compared to girls (Müller et al., 2022). Another factor that may explain these results is that a low RMC is often associated with low PMC, with correlations observed between PMC and RMC of r=0.48 in object control

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and r=0.40 in body control (Carcamo-Oyarzun et al., 2020). It is worth noting that, by the age of 10–13 years, children are typically capable of making accurate self-judgments, particularly regarding competence (Harter & Pike, 1984). Other studies have highlighted the relationship between body mass and motor competence, potentially due to self-esteem factors (Werneck et al., 2020), as girls mature earlier than boys, which can impact self-esteem, reduce motivation for physical activity, and ultimately result in lower motor competence (Schnaider et al., 2022).

However, most studies that find a relationship between these variables are based on athlete populations (Fernandez-Fernandez, et al., 2023), possibly due to specific sports movements, such as lateral movements or technical skills unique to sports like ball control in soccer players (Hermassi et al., 2024), basketball players (Arede et al., 2021), and gymnasts (Moeskops et al., 2020). For body control, these studies show that post-PHV individuals perform better than those who are pre-PHV, primarily due to increased age and improvements in sports technique (Živković et al., 2022).

Longitudinal research (Dos Santos et al., 2019) has also examined motor skill improvement based on somatic maturation, with findings indicating peak performance 18 months pre-PHV in forward and backward movements, as well as single-leg jumps, while lateral jumps peak 12 months post-PHV.

On the other hand, studies have shown that there is no linear correlation between movement quality and somatic maturation, as a stagnation in sensorimotor function, often called “adolescent awkwardness” (Fernandez-Fernandez, et al., 2023), may occur due to temporary stiffness in lower and upper limb joints, impacting body control (Ford et al., 2010).

Another finding of this study was the correlation between PHV, overall motor competence, and body control. These results align with research indicating that post-PHV individuals exhibit better motor competence (Arede et al., 2021; Bezuglov et al., 2023), likely due to increased average testosterone concentration, which rises from 0.07 nmol/L to 17.9 nmol/L (Bezuglov et al., 2023). This hormonal increase raises muscle strength levels (Xu et al., 2021), which could enhance performance in tasks involving jumping and lateral movements.

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Moreover, as individuals develop, neural circuits within the central nervous system (CNS) – including the motor cortex, basal ganglia, cerebellum, and thalamus – become increasingly robust, enhancing motor and postural control (Roth & Ding, 2024), which enables more precise movement execution (Rocha et al., 2023).

Finally, object control movements, such as throwing balls or dribbling, are more closely related to motor learning and neuronal plasticity. These skills involve motor correction loops engaging the motor cortex, sensorimotor area, and supplementary area and are developed through interaction with the environment rather than spontaneously (Carcamo-Oyarzun et al., 2024). However, similar studies have found that older children tend to have better object control than younger children, resulting in improved performance (Müller et al., 2022).

The findings of this study highlight the importance of sports practice and physical education classes, which are crucial for acquiring motor experiences that enable individuals to navigate their environments (Carcamo-Oyarzun et al., 2024), especially regarding object control.

Limitations

While these results are significant, some limitations of this study must be considered. For instance, an a priori sample size calculation was not conducted. Additionally, the sample was not balanced; 46 children were in the pre-PHV periods, while 19 and 15 schoolchildren were in the during and post-PHV stages, respectively. The level of physical activity, which could have influenced motor competence in schoolchildren, was also not considered. Finally, the sample was selected for convenience based on the proximity of the data collection site, so the findings may not be generalizable to the entire population.

Conclusion

When assessing actual and perceived motor competence among children in pre-PHV, during-PHV, and post-PHV periods, no significant differences were found in body control or object control tests. However, there was a correlation between PHV and overall actual motor competence, as well as body control, but not in the object control test.

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These findings could be applied to physical education classes to guide the evaluation criteria used by teachers when assessing motor skills. Differences in student performance are expected based on their maturation stage pre-PHV, during-PHV, and post-PHV particularly in activities involving jumps, rotations, and complex body movements. Furthermore, PHV could serve as an indicator for initiating students into sports that require high levels of body control, such as gymnastics, swimming, and athletics, supporting an adapted approach in the early stages of sports practice.

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