Analysis of Body Composition and Physical Fitness in a Population of Students With Down Syndrome: a Trend Study (10 Years) in two Different Periods and Subject Groups

Análisis de la Composición Corporal y Condición Física en una Población de Estudiantes con Síndrome de Down: un Estudio de Tendencia (10 años) en dos Periodos y Grupo de Sujetos Distintos

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Short title:
Body Composition and Physical Fitness in Down Syndrome

How to cite this article:
Pino, M., & Benavides-Roca, L. (2024). Analysis of body composition and physical fitness in a population of students with Down syndrome: a trend study (10 years) in two different periods and subject groups. *Cultura, Ciencia y Deporte, 19*(62), 2175. https://doi.org/10.12800/ccd.v19i62.2175

Received: 11 February 2024 / **Accepted:** 08 September 2024

Abstract

The aim of this study was to analyze the body composition and physical fitness of a population of students with Down syndrome at two time points (in 2009 and 2019) and different subject groups. It is a trend study that examines the relationship between body composition, physical fitness, and age in a population divided into two groups based on a 10-year interval between evaluations. The results indicate a positive correlation of hip circumference in both groups of women, albeit weaker in 2019 compared to 2009. Men show weaker relationships in 2019 compared to 2009. Physical fitness in women exhibits a somewhat unpredictable trend, with maximum VO2 showing a negative relationship only in 2019, unlike dynamometry, where the positive relationship is observed only in the 2009 group. Men show that flexibility and abdominal capacity have positive relationships in the 2009 group, contrasting with maximum VO2 where the negative relationship is present in 2019. In conclusion, body composition exhibits somewhat unpredictable behavior over time, while physical fitness shows a more homogeneous trend.

***Keywords*:** Physical capacity, anthropometry, special population and genotype.

Resumen

El objetivo del estudio fue analizar la composición corporal y la condición física de una población de estudiantes con Síndrome de Down en dos momentos (año 2009 y 2019) y grupos de sujetos distintos. Es una investigación de tendencia, que relaciona la composición corporal, condición física y edad en una población dividida en dos grupos diferenciados por 10 años de cuando habían sido evaluados. Los resultados hacen referencia a la correlación positiva del perímetro de cadera en ambos grupos de mujeres, se ve menor relación en el año 2019 con respecto al 2009. Los hombres muestran relaciones menores en el 2019 en contraste con el 2009. La condición física en las mujeres tiene una tendencia poco predecible, el VO2 máximo tiene una relación negativa solo en el año 2019, a diferencia de la dinamometría, donde la relación positiva se observa únicamente en el grupo de 2009. Los hombres muestran que la flexibilidad y la capacidad abdominal tienen relaciones positivas en el grupo 2009. Caso contrario con el VO2 máximo donde la relación negativa está presente en el 2019. En conclusión la composición corporal exhibe un comportamiento poco predecible a lo largo del tiempo, en cambio la condición física tiene una tendencia homogénea.

Palabras clave: Capacidad física, antropometría, población especial y genotipo.

Introduction

Down syndrome (DS) is one of the most prevalent genetic anomalies worldwide, with an estimated incidence of approximately 1 in 1000 live births (Rodriguez et al., 2019). DS occurs when an individual has an extra copy of chromosome 21, resulting in both genotypic and phenotypic traits. Genotypically, individuals with DS typically have trisomy 21, meaning they possess three copies of chromosome 21 rather than the usual two. Phenotypically, DS manifests in observable characteristics shaped by both genetic expression and environmental interactions (Jojoa-Acosta et al., 2021).

DS is associated with distinct phenotypic features, such as hypotonia, joint hypermobility, ocular alterations, and gastrointestinal disorders (Pino et al., 2021), Alterations in some higher executive functions, such as attention and memory, have also been observed (Vega-Díaz & González-García, 2020). These conditions, combined with lifestyle factors, make overweight and obesity prevalent within this population (De la Piedra et al., 2017). Additionally, DS individuals often exhibit sedentary lifestyles and low physical fitness levels (Martínez-Espinoza et al., 2020).

These factors contribute to slower motor development and significantly affect the overall health of people with DS, influencing both their physical fitness and body composition (Bergamo et al., 2021). Body composition and physical fitness are shaped by the lifestyle and pathology characteristics of individuals with DS (Herrera-Quintana et al., 2022). While certain traits are common, not all individuals with DS exhibit the same features. Alongside genetic predispositions, individual factors—such as abilities, family environment, education, and social interaction—play crucial roles in shaping each person's lifestyle (Filgueira et al., 2019).

As trends within the DS population continue to evolve due to technological advancements, economic development, and cultural shifts, common lifestyle patterns and functional characteristics emerge. Notably, body composition and physical fitness are influenced by both the individual's lifestyle and the pathology's unique traits (Herrera-Quintana et al., 2022). One notable trend is the increased life expectancy and quality of life among individuals with DS, primarily due to enhanced understanding of the syndrome and improvements in health, social, and educational assistance programs (Arenas Angulo et al., 2018).

Similarly, Chile has seen a rise in the number of people with disabilities, including those with DS, enrolled in schools over the past two decades, leading to improvements in motor skills and greater social inclusion (Valle-Ramírez et al., 2022). Recommendations for adapted physical activities have also had a positive impact on the quality of life and functionality of this population, regardless of age (Gámez-Calvo et al., 2022).

Thus, while individuals with DS may display specific baseline traits that affect their quality of life, it is essential to recognize the changes and trends brought about by modern societal demands, particularly in terms of physical fitness and body composition. These factors significantly influence well-being and provide increased opportunities for participation throughout the lifespan.

Given this context, the primary objective of this research was to analyze the body composition and physical fitness of students with DS in the commune of Talca, Maule region, Chile, at two points in time (2009 and 2019), across different subject groups.

Methodology

Design

This study follows a longitudinal trend design, analyzing changes over a 10-year period in anthropometric and physical condition variables among a population with Down syndrome (DS) attending schools in Talca, Maule region, Chile. The analysis compares two distinct samples, as the measurements were conducted on different groups of subjects at two separate time points (2009 and 2019).

Participants

The study assessed individuals with DS aged 11 to 26, enrolled in special schools in Talca, Maule region, Chile. Data collection occurred across two time periods, with different subjects representing the target population. In 2009, 53 subjects participated, of which 24 were women and 29 were men. In 2019, 55 subjects were evaluated, of which 24 were women and 31 were men. An exclusion criterion ensured that the age difference between the two samples did not significantly affect the results to avoid bias related to biological maturation trends. For participants under 18, informed consent was obtained from parents or guardians. For those over 18 with sufficient cognitive ability to understand the research procedures, both assent and consent from a guardian or parent were required. The study adhered to the Declaration of Helsinki and received approval from the Ethics Committee of Universidad Santo Tomás (Code no. ID-116).

Procedure and Instruments

The assessments in 2009 and 2019 took place in the participants' educational establishments (controlled settings) between September and October, over a period of three consecutive weeks. Both evaluations were conducted by the same research team from Universidad Santo Tomás, Chile. The following organization of tests was applied:

Table 1
Distribution of application of the test

Test	Factor	Weeks of application
Wells and Dillons	Measuring Trunk Flexion	1-2-3
Abdominal in 60 seg	Abdominal Muscle strength	2-3
Test of Rockport ou 1 mile (1609 mts)	Aerobic Capacity	1-2-3
Body Mass Index (BMI)	Health index	1
Waist Hip Index (WHI)	Regionalisation of body fat and risk of metabolic conditions.	1
Anthropometry/skinfold measurement	Sum of skinfolds	1
Manual Dynamometry	Measuring Muscle Strength	2-3

Regarding the physical condition variables, flexibility was evaluated by means of the Wells and Dillon or Seat and Reach test, in which the seated subject must flex the trunk as far as possible over the flexibility box (Baseline®, Sit&Reach box). This test has a generally high reliability with values around *0.89 - 0.99* (Ayala et al., 2012).

To evaluate the resistance of the abdominal musculature, the abdominal crunches per minute test was used, where the participants were placed in a supine position, with their knees bent and feet resting on the floor. Starting from this initial position, as many trunk flexions as possible were performed with a straight back, where a monitor stabilizes the participant's knees (Terblanche & Boer, 2013).

Manual muscle strength was measured by means of the static hand-grip strength test, which is highly reliable (between *0.88 - 0.92*). In the measurement, the subjects had to stand with their back straight and arms extended along the body, instructing the subject to squeeze as hard as possible for 3-5 seconds, separating the arm with an approximate angle of 30º with respect to the side of the body and without flexing the elbow. A digital dynamometer (Baseline®, model 12-086) was used. Two attempts were made with the right hand and two with the left hand, recording the highest value for each hand (Bofill & San Molina, 2009).

To measure VO2 max, the participant was asked to walk the distance of one mile (1609,34 m) at his or her personal pace, monitoring the time and heart rate with a heart rate monitor once the test was completed. To favor the functional response of the subjects during the test, taking into account the low level of physical activity and cognitive or behavioral difficulties typical of DS, the application considered the following complementary aspects of the protocol proposed by Bofill-Ródenas and San Molina (2009), to be accompanied by a monitor, which was maintained during all evaluations, having the task of motivating the recording of time and heart rate variables. The test was performed in three moments, during three consecutive weeks (one opportunity per week) in order to have the most specific data to the subject and to seek the highest reliability of the test for the person with DS.

The determination of VO2 max is made from the following equation:

VO2 max = 132.6 - (0.17 x body weight) - (0.39 x Age) + (6.31 x Sex [0=Female and 1=Men]) - (3.27 x Time) - (0.156 x Heart Rate).

For the measurement of anthropometric variables, the standardized protocol proposed by the International Society for the Advancement of Kineanthropometry (ISAK) was used. The sum of skinfolds was made by measuring the triceps, subscapular, supraspinatus, abdominal, front thigh and calf skinfolds (6 skinfolds). All measurements were performed three times on the right side of the body, considering the average value.

Body mass (kg) was estimated with the participant dressed in light clothing and barefoot on a calibrated digital scale (Tanita, model SC 240-MA). Height (cm) was measured with the participant barefoot using a portable stadiometer (Seca, model 213). Body mass index (BMI) was considered using the formula: [kg/m²]. Waist circumference (WCi) and hip circumference (HCa) were assessed with a tape measure (Seca) with an accuracy of 1 mm. The waist-hip index (WHI) was considered using the formula: [PCi / PCa].

Analysis

Statistical analysis was performed in the SPSS Statistics 22 program. The data were subjected to the Kolmogorov-Smirnov test to determine normality. Descriptive statistics of mean and standard deviation were calculated. To analyze the behavior of the groups, Pearson's correlation test was used between the variables of age, physical condition and body composition, where indices up to .390 were considered as a weak correlation, between .400 to .690 as a moderate correlation, from .700

to .890 as a strong correlation, while ≥ .900 was considered a very strong correlation (Schober et al., 2018). The significance value was p ≤ 0.05.

Results

Table 2 shows the values of the variables evaluated, according to each group.

Table 2
Characterizations of the subjects

	ANTHROPOMETRIC VARIABLES							PHYSICAL CONDITION VARIABLES				
	Age	**Weight (kg)**	**Size (cm)**	**Waist (cm)**	**Hips (cm)**	**Whi**	**Folds**	**Flex. (cm)**	**Abd (rep)**	**VO2 Max**	**Dyn Right**	**Dyn Left**
2009	14.9 ± 2.58	49 ± 15.36	141.8 ± 10.34	74.7 ± 11.72	85.5 ± 11.68	0.9 ± 0.05	85.5 ± 27.56	21.9 ± 4.93	21.1 ± 7.64	29.3 ± 5.60	19.3 ± 4.75	18.1 ± 4.50
Men	14.9 ± 2.72	53.1 ± 17.17	144.9 ± 11.32	77.5 ± 12.38	87.4 ± 12.53	0.9 ± 0.05	91.0 ± 30.76	21 ± 4.71	21.3 ± 7.41	30 ± 5.73	20.5 ± 4.91	19.2 ± 4.87
woman	14.8 ± 2.32	43.5 ±10.48	137.7 ± 7.21	71.1 ± 10.05	83.2 ±10.08	0.9 ± 0.05	78.4 ± 20.58	20.9 ± 5.35	20.7 ± 8.01	28.4 ± 5.30	17.9 ± 4.17	16.6 ± 3.57
2019	16.6 ± 4.27	58.9 ± 10.7	150.6 ±10.5	82.8 ± 10.20	93.5 ± 10.52	0.9 ± 0.06	86.6 ± 18.61	27.2 ± 9.10	14.2 ± 7.15	27 ± 11.76	19.4 ± 8.60	21.2 ± 8.18
Men	17.3 ± 3.90	63.9 ± 9.10	153 ± 9.91	86.7 ± 9.30	97 ± 10.4	0.9 ± 0.06	89.6 ± 14.93	28.2 ± 7.45	15.1 ± 7.52	26.5 ± 11.63	22.5 ± 8.99	23.5 ± 8.10
woman	15.9 ± 4.13	52.4 ± 9.01	147.5 ± 10.67	77.6 ± 9.27	89 ± 9.32	0.9 ± 0.06	82.8 ± 22.27	25.9 ± 10.77	13.1 ± 6.77	27.7 ± 12.12	15.3 ± 6.08	18.2 ± 7.38

Table 3 shows the correlations of the physical condition and age of both groups independent of sex, it is observed that the trend is homogeneous since in both groups there are no changes in significance, except in the VO2 max, which has in the year 2019 a significant negative relationship of moderate type.

Table 3
Correlations of physical fitness and age

	Flex. (cm)	**Abd. (rep)**	**VO2 Max**	**Dyn Right**	**Dyn Left**
Age 2019	*.110*	*.235*	*- .444[c]*	*.490*	*.415*
Age 2009	*- .375*	*- .294*	*- .250*	*.357*	*.270*

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

Table 4 describes the relationships of body composition and age in the population with DS. It shows a trend that is not very predictable, as there are changes between both groups. Specifically, the weight and height variables have a lower value in the 2019 group with respect to 2009. Regarding the other variables, there are significant relationships in 2009, but not in 2019.

Table 4
Correlations of body composition and age

	Weight (kg)	**Size (cm)**	**BMI**	**P. Waist**	**P. Hip**	**Whi**	**Folds**
Age 2019	.54[c]	.521[c]	.301	.345	.290	.152	.310
Age 2009	.801[a]	.634[b]	.718[b]	.790[b]	.870[a]	.051	.673[b]

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

Table 5 shows the correlations according to the sex of the groups. In women, a not very predictable trend is observed, since the VO2 max and dynamometry variables change their significance. As for men, the trend is similar, due to the fact that the relationships of flexibility and abdominal capacity are not present in 2019, while the opposite is true for VO2 max.

Table 5
Gender correlations between physical fitness and age

	Flex.	Abd.	VO2 Max	Dyn Right	Dyn Left
Woman 2009	- .288	- .169	- .264	.597[b]	.553[c]
Woman 2019	- .000	.010	- .476[c]	- .036	.080
Men 2009	- .355[c]	- .411[c]	- .230	.191	.060
Men 2019	.080	.155	- .398[c]	.070	- .009

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

Specifically, in women, dynamometry measurements showed moderate correlations in 2009, but not in 2019. Likewise, VO2 max presented only moderate correlations in 2019. As for men, VO2 max showed a moderate relationship only in 2019, while flexibility and number of sit-ups presented moderate correlations in the 2009 group, but not in 2019.

Table 6 shows the correlations according to the sex of the groups. In women, a not very predictable trend is observed, as the variables of VO2 max and dynamometry change their significance. As for men, the trend is similar, due to the fact that the relationships of flexibility, abdominal capacity are not present in 2019, while in VO2 max the opposite occurs.

Specifically, in women, dynamometry measurements showed moderate correlations in 2009, but not in 2019. Likewise, VO2 max presented only moderate correlations in 2019. As for men, VO2 max showed a moderate relationship only in 2019, while flexibility and number of sit-ups presented moderate correlations in the 2009 group, but not in 2019.

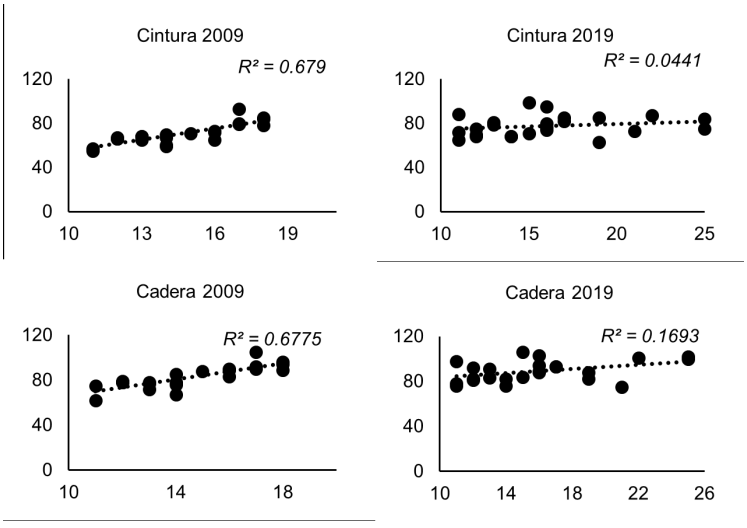
Also, table 6 also shows the correlations of body composition variables and age according to sex. In women, a more homogeneous trend is shown, where only the height and waist circumference variables have a relationship in 2009 and not so in 2019. As for the parameters of weight, BMI, hip circumference and folds, a decrease in the value of the relationships is observed. In the case of men, the trend is low, since only waist and hip perimeters show correlations in both groups, and these tend to decrease as time goes by.

Table 6
Sex correlations between body composition and age

	Weight (kg)	Size (cm)	BMI	P. Waist	P. Hip	Whi	Folds
Woman 2009	.827[a]	.643[c]	.675[c]	.824[a]	.823[a]	.115	.681[c]
Woman 2019	.745[b]	.281	.555[c]	.209	.411[c]	- .238	.525[c]
Men 2009	.731[b]	.634[c]	.633[c]	.687[b]	.764[b]	- .125	.460[c]
Men 2019	.320	.164	.173	.410[c]	.461[c]	- .090	.330

Note: a: very high significant correlations, b: high correlations, c: moderate correlations.

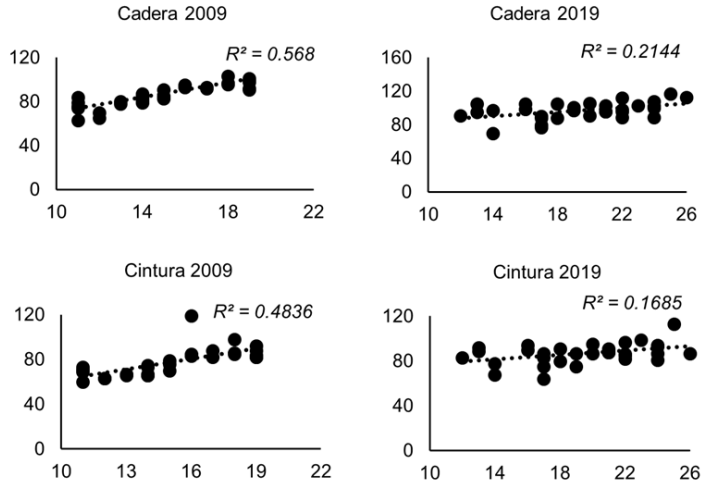
Graph 1
Relationships of waist and hip circumferences to age in women with DS



Graph 1 shows the waist and hip circumference variables that show positive correlations in both groups of women. When contrasting the values between the groups, a lower relationship is seen in the year 2019 with respect to 2009.

Graph 2 shows the relationship of waist and hip circumference variables with age in both groups of men. It is observed that the relationship values are lower in the 2019 group in contrast to 2009.

Graph 2
Relationships of waist and hip circumference to age in men with DS



Discussion

The objective of this study was to analyze the body composition and physical condition of students with DS from Talca, Maule Region, Chile, at two distinct time points (2009 and 2019).

The key findings indicate contrasting trends between body composition and physical condition. Body composition exhibited an unpredictable pattern, with significant changes in certain parameters, while physical condition followed a more consistent trend, with minimal significant changes in most capacities.

This pattern aligns with typical DS characteristics, where, as individuals age, they tend to develop an unhealthy anthropometric profile characterized by weight gain (Nixon, 2018). Gómez-Campos et al. (2021) also noted that overweight and obesity are prevalent across childhood, adolescence, and adulthood, contributing to metabolic and cardiac diseases (Ferreira et al., 2021).

The body composition variables were higher in the 2009 group compared to 2019, suggesting a decreased impact of anthropometric variables over time. This is relevant given the slower maturational development and higher prevalence of increased adiposity in individuals with DS (Ghiglione & Lopez, 2022). These findings suggest a positive trend in the health of this population.

In women, a decrease in anthropometric values related to obesity was observed, a noteworthy finding given the propensity for weight gain with age in individuals with DS (Pirett et al., 2023). Males, too, showed a shift from high to moderate correlations in certain parameters, with a reduced impact of these variables in 2019 compared to 2009. This is significant given the longitudinal evidence showing an increase in fat mass over time in individuals with intellectual disabilities (Lahtinen et al., 2007).

Waist and hip circumference exhibited significant correlations in both time periods, with lower values in the 2019 group. This reduction indicates a shift towards a healthier profile (Lip-Licham & Velasquez, 2023), potentially influenced by advances in nutrition, physical activity, and medical care that have improved life expectancy in individuals with DS (Gatica-Mandiola et al., 2018). The decrease in weight, waist, and hip measurements, as well as BMI, correlates with improved health outcomes (Gómez-Campos et al., 2022). In terms of physical fitness, most variables showed stable behavior across both groups and time periods. However, VO2 max showed significant temporal changes, with an inverse relationship between age and oxygen consumption in 2019 (r= - .04). This reflects a decline in aerobic capacity, consistent with previous findings that highlight reduced aerobic performance in individuals with DS as they age (Silva et al., 2017).

Manual dynamometry remained stable between the two groups, though sex was an influential factor in the relationship between age and strength. In women, significant relationships were observed in 2009 but not in 2019, indicating a decline

in strength over time. Since strength is a predictor of health and functionality in individuals with DS (Legerlotz, 2018), this trend may have negative implications for the population's development.

Flexibility and abdominal strength showed sex-specific variations, with men in 2009 exhibiting a negative correlation with age, a trend not seen in 2019. This finding suggests that, over time, these variables have less impact on the population, which is significant given the role these capacities play in enhancing independence and functionality in adults with DS (Cabeza-Ruiz & Gómez, 2022; Oppewal et al., 2014).

Ultimately, the observed behaviors in physical fitness and body composition are likely attributable to evolving contexts over the 10-year period between the groups.

Limitations

The age differences between the groups (2009: 14.9 ± 2.6; 2019: 16.6 ± 4) may have influenced the analysis of results and trends. Given that individuals with DS experience earlier growth spurts (at 11 years for boys and 9.5 years for girls) (Sarmiento & Gómez, 2022; Zamel et al., 2015), care was taken to minimize significant age discrepancies between the groups.

Conclusion

This study reveals distinct trends in body composition and physical fitness among individuals with DS across the evaluated periods. Physical fitness generally displayed more consistency between the two periods, with fewer changes, whereas body composition demonstrated a less predictable pattern, fluctuating over time. These findings suggest that physical fitness is less susceptible to external factors such as age or sex compared to body composition. This should be considered in designing interventions aimed at improving the physical condition and health of individuals with DS. The study also highlights that waist and hip circumference relationships with age primarily decrease in the 2019 group.

Ethics Committee Statement

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of university Santo Tomas (Código n.° ID-116).

Conflict of Interest Statement

The entities and authors of this article were not involved in the design of the study, the analysis of the data, or the interpretation of the results.

Funding

This research did not receive funding because it is part of a regional project and the university institution.

Authors' Contribution

Conceptualization Pino, M. & Benavides, L.; Methodology Pino, M. & Benavides, L.; Software Benavides, L; Validation Pino, M. & Benavides, L; Formal Analysis Benavides, L.; Investigation Pino, M.; Resources Pino, M.; Data Curation Pino, M.; Writing – Original Draft Pino, M. & Benavides, L.; Writing – Review & Editing Pino, M. & Benavides, L.; Visualization Pino, M; Supervision Pino, M; Project Administration Benavides, L.; Funding Acquisition Pino, M. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data available on request from the author of the correspondence **(**benavides.roca@gmail.com**)**.

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