



Jump strength in secondary students using the hyppy tool. A comparative study.

Estudio comparativo de la potencia de salto vertical de alumnos de secundaria a través de la herramienta hyppy

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Resumen

Introducción: El estudio de parámetros de salto puede proporcionar información con una correlación directa sobre la salud física de los individuos. Así a través de la medida de éste podemos obtener datos significativos sobre los alumnos del IES Plaza de la Cruz en Pamplona. **Objetivos:** El objetivo de este trabajo consiste en obtener la altura de una batería de saltos mediante una muestra de jóvenes estudiantes del IES Plaza de la Cruz relacionándolos con otras variables estudiadas, como edad media y su desviación típica. Se plantea una nueva herramienta para medir la longitud de salto de estudiantes de instituto mediante la realización de un test de salto (BDJ, VUCJ, VUDJ), calcular la altura de los saltos y para describir las características de una muestra de jóvenes del IES Plaza de la Cruz de ambos sexos. **Métodos** La muestra estuvo compuesta por 73 estudiantes pertenecientes a los cursos de 1º de la ESO y 1º de Bachillerato. Se utilizó la herramienta HYPPY que está formada por un sensor inercial y una app que analiza automáticamente el salto, desarrollado por la empresa Movalsys S.A. **Resultados y discusión:** Se recogen las pruebas diferenciando entre la edad, el sexo y si los sujetos hacen o no deporte habitualmente y se encuentran diferencias significativas con respecto al salto entre la población de 1º de la ESO y 1º de Bachillerato, ciertas diferencias respecto al género y ninguna con respecto a la cantidad de deporte. **Conclusiones:** En el momento clave de la adolescencia los cuatro años que distan entre de 1º de la ESO y 1º de Bachillerato suponen un gran aumento de la altura y masa muscular lo que explica perfectamente la diferencia en potencia de salto. Por otra parte las claras diferencias entre sexos en población adulta, que no se observan en la población infantil también empiezan a notarse, **Palabras clave:** Herramienta HYPPY, Movalsys, salto vertical, análisis estadístico, diferencias significativas, sensor inercial.

Abstract

Introduction: The study of jump parameters can provide information with a direct correlation on the physical health of individuals. Thus, through its measurement we can obtain significant data about the students of the IES Plaza de la Cruz in Pamplona. **Aim:** The aim of this work is to obtain the height of a battery of jumps using a sample of young students from the IES Plaza de la Cruz, relating them to other variables studied, such as average age and its standard deviation. A new tool is proposed to measure the jump length of high school students by performing a jump test (BDJ, VUCJ, VUDJ), calculate the height of the jumps and to describe the characteristics of a sample of young people from the IES Plaza de la Cruz. **Methods:** The sample was made up of 73 students belonging to the 1st year of ESO and 1st year of Baccalaureate. The HYPPY tool was used, which is made up of an inertial sensor and an app that automatically analyzes the jump, developed by the company Movalsys S.A. **Results & discussion:** The evidence is collected differentiating between age, sex and whether or not the subjects do sports regularly and significant differences are found with respect to the jump between the population of 1st year of ESO and 1st year of Baccalaureate, certain differences with respect to gender and none with regarding the amount of sport. **Conclusions:** At the key moment of adolescence, the four years between 1st year of ESO and 1st year of Baccalaureate represent a great increase in height and muscle mass, which perfectly explains the difference in jumping power. On the other hand, the clear differences between sexes in the adult population, which are not observed in the child population, are also beginning to be noticed. **Keywords:** HYPPY tool, Movalsys, vertical jump, statistical analysis, significant differences, inertial sensor.

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Estudo comparativo da potência de salto vertical de alunos do ensino secundário utilizando o instrumento hyppy

Resumo

Introdução: O estudo dos parâmetros de salto pode fornecer informações com uma correlação direta sobre a saúde física dos indivíduos. Assim, através da sua medição podemos obter dados significativos sobre os alunos do IES Plaza de la Cruz em Pamplona. **Objetivos:** O objetivo deste trabalho é obter a altura de uma bateria de saltos utilizando uma amostra de jovens estudantes da IES Plaza de la Cruz, relacionando-os com outras variáveis estudadas, como a média de idade e seu desvio padrão. Propõe-se um novo instrumento para medir o comprimento de salto de estudantes do ensino médio através da realização de um teste de salto (BDJ, VUCJ, VUDJ), calcular a altura dos saltos e descrever as características de uma amostra de jovens da IES Plaza de la Cruz. **Métodos:** A amostra foi constituída por 73 alunos pertencentes ao 1º ano do ESO e 1º ano do Bacharelato. Foi utilizada a ferramenta HYPPY, que é composta por um sensor inercial e uma app que analisa automaticamente o salto, desenvolvida pela empresa Movalsys S.A. **Resultados e discussão:** As evidências são recolhidas diferenciando entre idade, sexo e se os sujeitos fazem ou não desporto regularmente e são encontradas diferenças significativas em relação ao salto entre a população do 1º ano do ESO e do 1º ano do Bacharelato, algumas diferenças em relação ao género e nenhuma em relação à quantidade de desporto. **Conclusões:** No momento chave da adolescência, os quatro anos entre o 1º ano do ESO e o 1º ano do Bacharelato representam um grande aumento da altura e da massa muscular, o que explica perfeitamente a diferença na potência de salto. Por outro lado, as diferenças claras entre sexos na população adulta, que não se observam na população infantil, começam também a ser notadas.

Palavras-chave: Ferramenta HYPPY, Movalsys, salto vertical, análise estatística, diferenças significativas.

Reference:

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I. Introduction / Introducción

The study of jump parameters can provide information with a direct correlation on the physical health of individuals, in addition to preventing injuries, improving performance or determining different specific and particular aspects in relation to each of the people under study (Setuain et al, 2016). The study is directly related to sustainable development goal 3; health and well-being. Near-body inertial sensors are an easy-to-use, portable and objective tool. These devices provide data on the acceleration and angular velocity of a given movement. Furthermore, advances in signal-analysis techniques supply parameters that can be easily interpreted, thus, to improve movement, both in terms of sports performance and quality of life. One of these relevant parameters, closely related to average health is the jump height (Millor et al 2013, Setuain et al. 2016, Sáez de Asteasu et al., 2019).

Numerous studies which relate the power and height of a jump with different variables (age, sex, BMI, sport performed, etc.) both in primary school (Bogataj et al., 2020) and professional athletes (Laffaye et al., 2014; Setuain et al., 2015) and in the elderly population (Millor et al., 2013) are known to date. However, no such research had been conducted in the adolescent population, as far as our knowledge. Although correlations between jumping and other variables may change widely between childhood and adulthood, it is interesting to replicate the jumping study with teenagers. Thus, the jumping data can be obtained through the Inertial Sensor HYPPY tool and related to different variables previously collected in a questionnaire, as a mean to afford a comparative analysis study through statistical descriptions of the sample (Gómez et al., 2020). In this paper we study the correlation between five different jump tests (Barbalho, 2021) and a set of variables such as age and gender in teenagers. Measured with an inertial sensor coupled to a mobile application. The jump tests are: Bilateral Drop Jump (BDJ); Vertical Unilateral Countermovement Jump (VUCJ); Vertical Unilateral Vertical Unilateral Drop Jump (VUDJ).

A sample of seventy-three students from the high school IES Plaza de la Cruz (7th and 11th Grade) that statistically represents the population of both years. Vertical jump height is widely used to quantify lower limb power. Prior to the development of inertial sensors, force plates (FP) were the common tool used to analyze countermovement jumps (CMJ) in children with and without disabilities (Hasani et al., 2014), the elderly (Caserotti et al., 2001), and athletes (Chelly et al., 2010). Nowadays, inertial motion sensor systems present new and outstanding advantages in terms of portability and size for jumping studies.



Due to the fact that the average subject cannot maintain a squat position without affecting performance, the jumping method best suited to measure vertical movement is the countermovement jump (CMJ). Various studies have used performance factors (PFs) to analyze CMJ in children (Hasani et al., 2014), the elderly (Caserotti et al., 2001), and athletes (Chelly et al., 2010). PFs accurately determine the vertical acceleration of the center of mass (CoM), but they are expensive and difficult to transport. Instead, contact mats are often used for field testing (e.g., Optojump and Ergojump) (Rogan et al., 2015). In these cases, time-of-flight (FT) is used to estimate vertical displacement, assuming that take-off and landing postures are identical. This assumption may lead to errors, especially in children and populations with low sports training (Nielsen et al., 2019).

Inertial measurement units (IMUs) have become a popular tool due to their ability to analyze different types of motion (Li & Hisiao-Wecker, 2013; Hundza et al., 2013; Bonnet et al., 2013), as well as their small size, ease of use, and affordability (Nielsen, 2019). Previous studies with inertial sensors have been conducted on both the elderly (Millor et al., 2013) and athletes (Setuain et al., 2016).

I.1.Aims / Objetivos:

The main objective of this study is to carry out a study of strength and overall physical capacity of 7th and 11th Grade students at the high school IES Plaza de la Cruz.

To carry on these aims, we establish the following hypotheses:

H1- The analysis of the measured parameters would show significant differences between both sexes. Bearing in mind that boys have 30% more strength (López, 2015) and that, in general, they are faster and more resistant to fatigue than girls, it is to be expected that there will be notable differences in the parameters analyzed (Ben Mansour et al, 2021).

H2- 11th Grade students would have greater jumping power than 7th graders, because the former have more developed musculature.

II. Methods / Material y métodos

Experimental design

A descriptive, cross-sectional, prospective study is proposed to assess the relationship between jump strength and different variables in teenage students from 7th and 11th Grade. To carry out the practical phase of this research we worked with 73 students, chosen randomly from among students of the IES Plaza de la Cruz. In total there were 36 students from 7th grade and 37 from 11th grade, divided

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into two samples. Prior to the data collection, the participants will fill up a questionnaire and be given precise instructions on how to conduct the experiment.

The experimentation was carried out in the gymnasium of the IES Plaza De La Cruz secondary school, each test took an average time of seven minutes per student, previously measured in the test stage.

Therefore, in each session (which lasted approximately one hour), seven jumping tests were carried out with seven different participants. Each specific test was overseen by the same investigator.

Instrumentation

For the development of the jumping tests the high school gymnasium was the chosen location. Two different jumping platforms were built there according to the literature (Barbalho, 2021).

HYPPY sensor and Belt were placed into each participant prior to the test, and a mobile phone with the pertaining app was used to record and measure the jumping test.

Methods

The comparative study carried out with the HYPPY tool consists of five jump tests. During the tests, the students of both 7th and 11th grade of the IES Plaza de la Cruz must execute the jumps following a strict order:

The first jump (BDJ) consists of the person standing on a 50 cm high platform, dropping down with both feet together and, once on the ground, jumping upwards. In the second jump (VUDJ) the person stands on a 20 cm high platform, drops on one foot and, when he/she reaches the ground, jumps vertically upwards. Finally, the test ends when the third jump (VUCT) has been performed in which the person is on the ground and must jump upwards on one leg. Each jump is repeated twice with a 10-second rest interval between them. In the case of VUDJ and VUCT, it is performed with both legs and twice each jump. The rest time varies depending on whether the person is able to give their best performance in the next jump or not, in that case they would rest for as long as necessary. The person who performs the jump should jump as high as possible, without previously specifying how, using different strategies such as bending or not bending the knees in the jump.

III. Results / Resultados

Descriptive statistics of the quantitative variables

The statistical variability in relation to age, weight, height and time in hours spent weekly in sport is as follows:

Table 1.

Distribution of the variables collected in the sample of students at IES Plaza de la Cruz.

	N	Minimum	Maximum	Mean	Std. deviation	Variance
AGE (years)	73	12,00	18,00	14,821	2,0299	4,121
WEIGHT (kg)	73	39,00	87,00	58,219	10,942	119,729
HEIGHT (cm)	73	146,00	185,00	166,575	3,664	13,430
TIME (hours)	73	,00	13,50	3,712	3,664	13,430
BMI	73	14,02	31,20	20,916	3,050	9,304

The data corresponding to the variables age, weight, height and time spent in sport per week in hours were collected on a form prior to the jumping tests and can be found in a questionnaire in annex 2.

Descriptive statistics of the qualitative variables

Table 2.

Participants grade.

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
7 th Grade	36	49,3	49,3	49,3
11 th Grade	37	50,7	50,7	100,0
TOTAL	73	100,0	100,0	

Table 3.

Participants' self-assigned gender.

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Boys	37	50,7	50,7	50,7
Girls	36	49,3	49,3	100,0
TOTAL	73	100,0	100,0	

Table 4.

Sport practice according to participants.

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
No	27	37,0	37,0	37,0
Yes	46	63,0	63,0	100,0
TOTAL	73	100,0	100,0	

Descriptive statistics of the jumping tests

Regarding to the data measured in the jumping tests (VUDJ_L, VUDJ_R, VUCJ_L, VUCJ_R, BDJ) with the HYPPY tool on the sample described above, the following descriptive statistics are found:

Table 5.

Descriptive statistics of the variables corresponding to the five types of jumping.

	N	Range	Mín.	Máx.	Mean	Std. Dev.	Variance
VUDJ_L	73	23,00	4,00	27,00	15,096	5,329	28,393
VUDJ_R	73	24,00	7,00	31,00	15,219	5,742	32,979
VUCJ_L	73	24,00	4,00	28,00	14,671	5,523	30,502
VUCJ_R	73	27,00	4,00	31,00	14,233	5,248	27,542

BDJ	73	42,00	5,00	47,00	25,192	8,123	65,990
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In order to assess the relationship between the different types of jumping and the variables extracted from the questionnaire, a comparative analysis of dichotomous variables, i.e. variables with only two values, is carried out. To this end, ANOVA analysis (Analysis of Variance) or comparison of variances is considered to determine whether there are significant differences in the jumping data in two groups of interest: Year 7th or year 11th Grade; male or female sex; practicing sports or not.

Statistical relationship between grades and the different types of jumping.

Table 7.

Comparison between the battery of jumps and the grade.

	Grade	N	Mean	Std. Dev.	Mean error
VUDJ_L	11 th	37	16,622	4,798	,789
	7 th	36	13,528	5,454	,909
VUDJ_R	11 th	37	17,108	5,896	,969
	7 th	36	13,278	4,943	,824
VUCJ_L	11 th	37	16,784	5,078	,835
	7 th	36	12,500	5,163	,860
VUCJ_R	11 th	37	16,054	4,714	,775
	7 th	36	12,361	5,167	,861
BDJ	11 th	37	27,811	7,992	1,314
	7 th	36	22,500	7,439	1,239

To establish whether the differences between the groups are statistically significant, we performed the t- student test.

In this way, it can be affirmed that, in general, students do jump differently depending on the age and, looking at the error bars, students in 7th grade jump less than those in 11th. In fact, the only test in

which no significant differences are found in VUDJ_L, as in most cases the right dominant leg is worked more frequently with unilateral exercises.

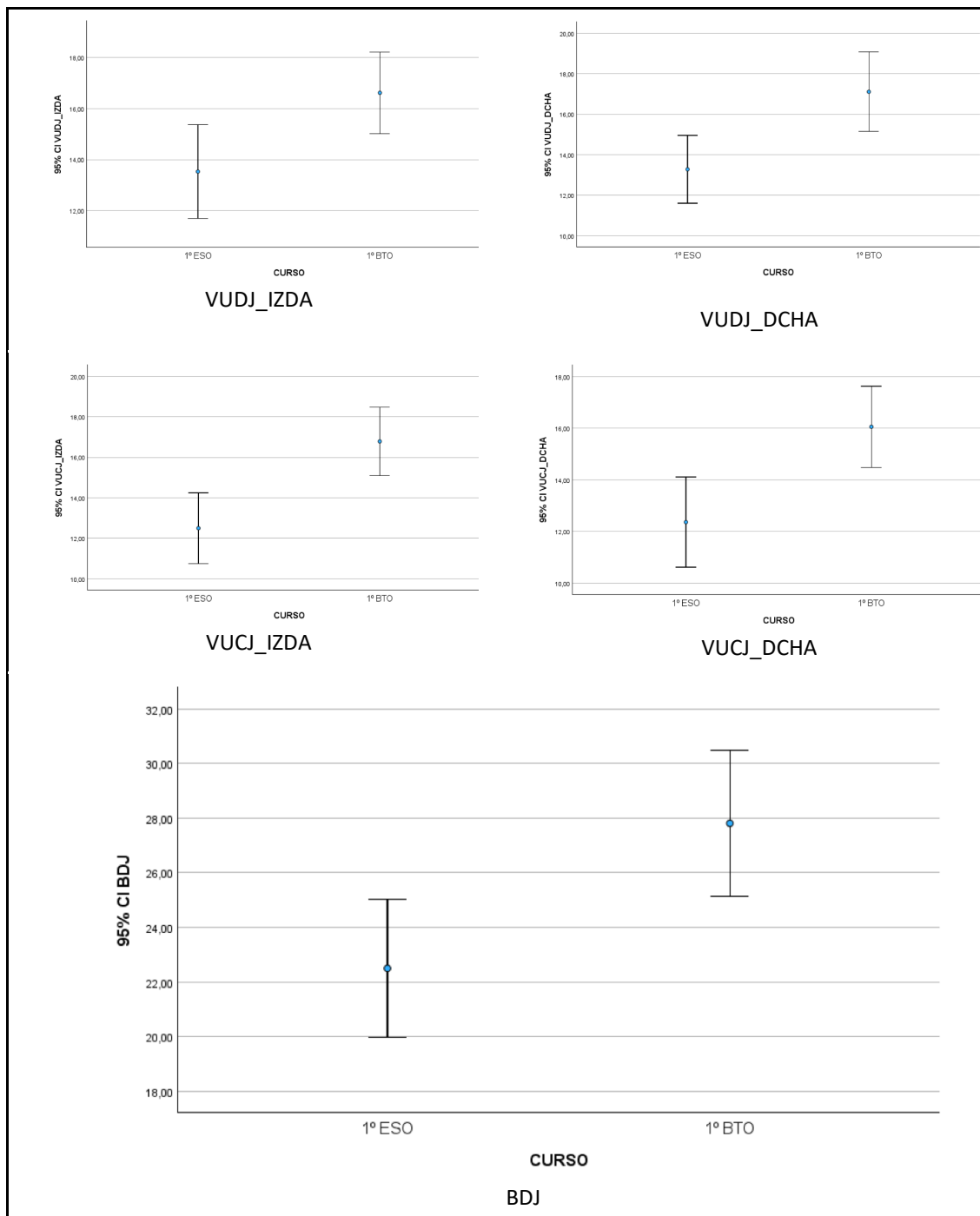


Figure 1. Student grade vs jumping.



Statistical relationship between gender (male/female) and the different types of jumping

As the variable sex is dichotomous, the normality test does not take place. We apply directly the study of the statistical relationship between gender and jump height with the ANOVA test.

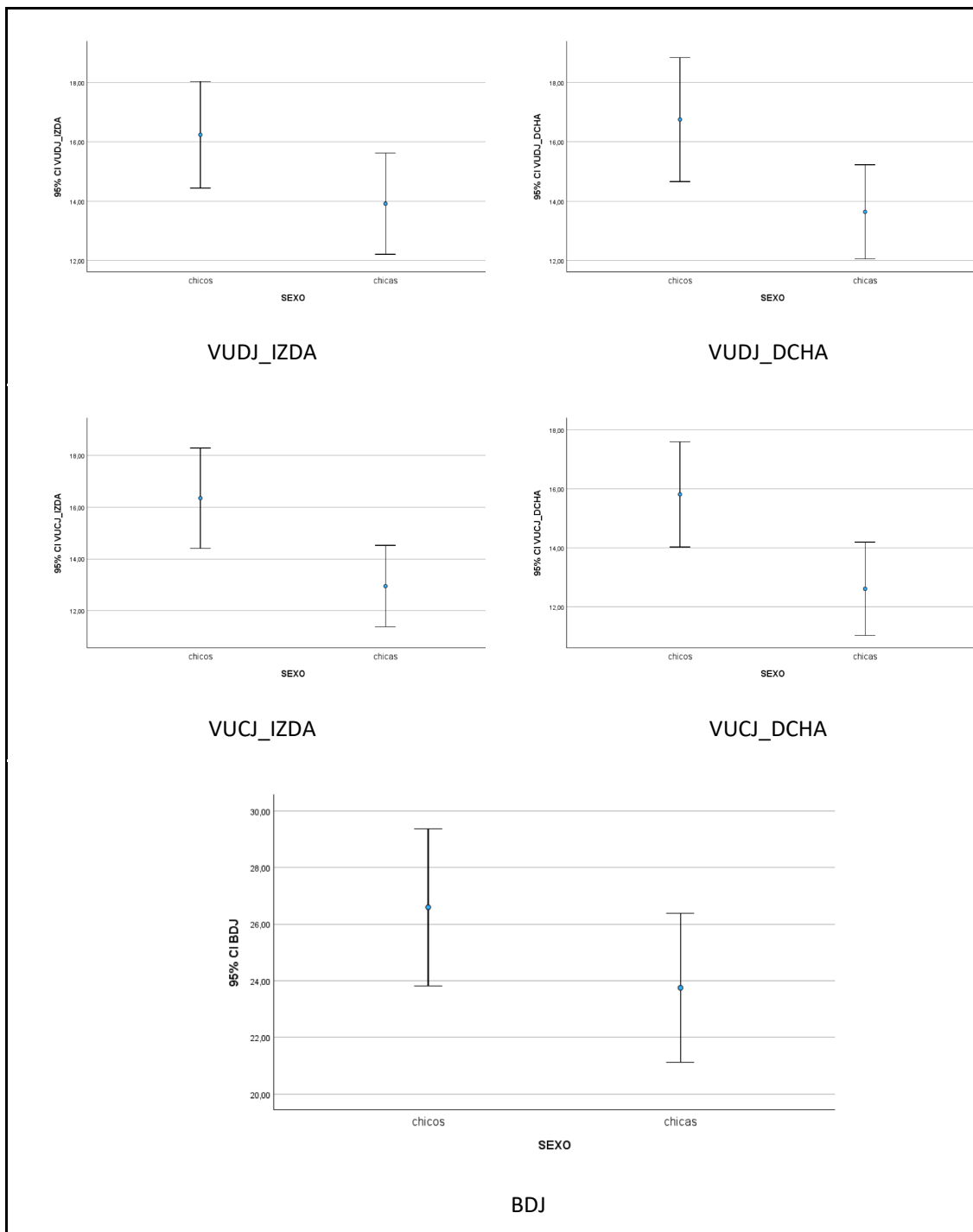
Table 8.

ANOVA table on the battery of jumps vs sex.

		Sum of squares	fd	Mean squared	F	Sig.
VUDJ_L	Between groups	98,768	1	98,768	3,604	,062
	Within groups	1945,561	71	27,402		
	Total	2044,329	72			
VUDJ_R	Between groups	177,377	1	177,377	5,732	,019
	Within groups	2197,116	71	30,945		
	Total	2374,493	72			
VUCJ_L	Between groups	211,788	1	211,788	7,578	,007
	Within groups	1984,321	71	27,948		
	Total	2196,110	72			
VUCJ_R	Between groups	186,810	1	186,810	7,384	,008
	Within groups	1796,231	71	25,299		
	Total	186,810	72			
BDJ	Between groups	147,656	1	147,646	2,277	,136
	Within groups	4603,669	71	64,840		
	Total	4751,315	72			

Here we can see that in the countermovement test, there are significant differences, while in the rest of the variables, there are not. This statistical table corroborates the hypothesis that boys would jump more than girls. Significant differences are found, since the constitution of both genders is totally different, and they generally do not have the same leg strength. It is possible to find 'outliers' within both genders, as it may be that a girl has more ability to jump higher than the rest of her group and is on a par with the male gender. Such occurrences are not so common and that is why differences are found between all types of jumping. This is especially noticeable in the VUCJ jump with both legs.

Figure 2. Participant gender vs jumping test.



Statistical relationship between sport practice and different jump types

Table 9.

ANOVA table on jumping battery vs. sport (yes or no)

		Sum of squares	fd	Mean squared	F	Sig.
VUDJ_L	Between groups	96,832	1	96,832	3,530	,064
	Within groups	1947,497	71	27,430		
	Total	2044,329	72			
VUDJ_R	Between groups	89,022	1	89,022	2,766	,101
	Within groups	2285,471	71	32,190		
	Total	2374,493	72			
VUCJ_L	Between groups	,045	1	,045	,001	,970
	Within groups	2196,064	71	30,930		
	Total	2196,110	72			
VUCJ_R	Between groups	15,593	1	15,593	,563	,456
	Within groups	1967,448	71	27,711		
	Total	1983,041	72			
BDJ	Between groups	99,663	1	99,663	1,521	,222
	Within groups	4651,652	71	65,516		
	Total	4751,315	72			

*fd= degrees of freedom, sig.= significance or p-value for a null hypothesis, F= is a value in the F-distribution.

In this case, no differences can be seen, although in the future, an additional analysis could be carried out on only those people who play sports in which the lower limbs are the main ones (football, skating, etc.).



IV. Discussion / Discusión

Regarding the students' age, the jump of 11th graders is significantly higher than the 7th graders' jump. Therefore, the significant increase in the height and musculature of the individuals from twelve/thirteen to sixteen/seventeen years of age justifies this evolution in jumping power (García-Pinillos et. al., 2014).

Analyzing sex/gender vs jump tests, it can be noticed that greater differences are presented in counter-movement jumps, which may be due to the fact that they are the most muscular demanding and even more so when the leg used is the right leg, which is generally the most developed.

Furthermore, a small difference appears between the genders as the average jumps corresponding to the male gender is always higher. These analyses corroborate another of the hypotheses initially put forward, which stated that boys would jump higher than girls (H1). Therefore, a change is observed with respect to the study carried out in primary school in which there were no significant differences between the jumps of both sexes (Bogataj et al, 2020) which on the other hand are also found to be prevalent in the male population in young athletes (20-25 years) (Laffaye et al., 2014). Thus, it can be stated that teenage is the period in which the difference between the jumping power of men and women is established.

Comparing the variables of sport practice and jumping battery, no significant differences were observed, although there was a tendency to jump higher in those subjects who practice sport. To the best of our knowledge, scientific studies correlating sport practice and jump height or power are oriented towards finding those sports practices that improve a particular jump performance (Laffaye et al, 2014). However, in this study we have not considered the type of sport performed by the subjects in the sample for the statistical analysis, which could be of interest in the future.

V. Conclusions / Conclusiones

Considering the initial hypotheses and the results shown by the statistical analyses, both hypotheses H1 and H2 can be confirmed. There were significant differences in all jumping tests so the first hypothesis (H1), that boys will jump more than girls, is true. It may be that boys jumped more because they have a different build, but it is worth noting that there were outliers in the female graph that were at or above the male average (Ben Mansour et al, 2021).



Finally, the second hypothesis (H2) argues that 7th grade students will not jump as high as 11th grade students. According to the tests conducted and the statistical analyses of this study, the latter hypothesis is confirmed. It is true that some students in the lower year, with a height and weight of 1.62 ± 0.09 m and 51.58 ± 6.37 kg, jumped higher than the average of the 11th grade, showing outliers in the comparative graphs. This result is probably due to the fact that the older students, with a height and weight of 1.71 ± 0.09 m and 64.68 ± 10.64 kg, have developed their lower body musculature more and, in addition, the vast majority are taller, which gives them more height for jumping.

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VII. Conflict of interests / Conflicto de intereses

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

VIII. References / Referencias

- Barbalho, M., Kleiner, A. F. R., Callegari, B., de Lima, R. C., da Silva Souza, G., de Athayde Costa E Silva, A., & Coswig, V. S. (2021). Assessing Interlimb Jump Asymmetry in Young Soccer Players: The My Jump 2 App. *International journal of sports physiology and performance*, 16(1), 19–27. <https://doi.org/10.1123/ijsp.2019-0981>
- Ben Mansour, G., Kacem, A., Ishak, M., Grélot, L., & Ftaiti, F. (2021). The effect of body composition on strength and power in male and female students. *BMC sports science, medicine & rehabilitation*, 13(1), 150. <https://doi.org/10.1186/s13102-021-00376-z>
- Bogataj, Š., Pajek, M., Hadžić, V., Andrašić, S., Padulo, J., & Trajković, N. (2020). Validity, Reliability, and Usefulness of My Jump 2 App for Measuring Vertical Jump in Primary School Children. *International journal of environmental research and public health*, 17(10), 3708. <https://doi.org/10.3390/ijerph17103708>



- Bonnet, V., Mazzà, C., Fraisse, P., & Cappozzo, A. (2013). Real-time estimate of body kinematics during a planar squat task using a single inertial measurement unit. *IEEE transactions on bio-medical engineering*, 60(7), 1920–1926. <https://doi.org/10.1109/TBME.2013.2245131>
- Caserotti, P., Aagaard, P., Simonsen, E. B., & Puggaard, L. (2001). Contraction-specific differences in maximal muscle power during stretch-shortening cycle movements in elderly males and females. *European journal of applied physiology*, 84(3), 206–212. <https://doi.org/10.1007/s004210170006>
- Chelly, M. S., Ghenem, M. A., Abid, K., Hermassi, S., Tabka, Z., & Shephard, R. J. (2010). Effects of in-season short-term plyometric training program on leg power, jump-and sprint performance of soccer players. *The Journal of Strength & Conditioning Research*, 24(10), 2670-2676.
- García-Pinillos, F., Ruiz-Ariza, A., Navarro-Martínez, A. V., & Latorre-Román, P. A. (2014). Análisis del rendimiento en salto vertical, agilidad, velocidad y velocidad de golpeo en jóvenes futbolistas: influencia de la edad. *Apunts. Medicina De L'esport*, 49(183), 67-73.
- Hundza, S. R., Hook, W. R., Harris, C. R., Mahajan, S. V., Leslie, P. A., Spani, C. A., & Livingston, N. J. (2013). Accurate and reliable gait cycle detection in Parkinson's disease. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 22(1), 127-137.
- Laffaye, G., Wagner, P. P., & Tombleson, T. I. (2014). Countermovement jump height: Gender and sport-specific differences in the force-time variables. *The Journal of Strength & Conditioning Research*, 28(4), 1096-1105.
- Millor, N., Lecumberri, P., Gómez, M., Martínez-Ramírez, A., & Izquierdo, M. (2013). An evaluation of the 30-s chair stand test in older adults: frailty detection based on kinematic parameters from a single inertial unit. *Journal of neuroengineering and rehabilitation. Journal of neuroengineering and rehabilitation*, 10.
- Nielsen, E. T., Jørgensen, P. B., Mechlenburg, I., & Sørensen, H. (2019). Validation of an inertial measurement unit to determine countermovement jump height. *Asia-Pacific journal of sports medicine, arthroscopy, rehabilitation and technology*.
- Rogan, S., Radlinger, L., Imhasly, C., Kneubuehler, A., & Hilfiker, R. (2015). Validity study of a jump mat compared to the reference standard force plate. *Asian journal of sports medicine*, 6(4).
- Setuain, I., Izquierdo, M., & Millor, N. (2014). Jumping performance and biomechanical differences among elite female handball players with or without previous ACL reconstruction: An ISU based study. *Trauma Fund MAPFRE*

Millor, N., Sancho-Sanz, I., Córdova, M. & Garro, C. (2025). Jump strength in secondary students using the hyppy tool. A comparative study. *ESHPA - Education, Sport, Health and Physical Activity*, 9(3), 266-281. <https://doi.org/10.5281/zenodo.15608031>

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- Setuain, I., Millor, N., González-Izal, M., Gorostiaga, E. M., Gómez, M., Alfaro-Adrián, J., Maffiuletti, N. A., & Izquierdo, M. (2015). Biomechanical jumping differences among elite female handball players with and without previous anterior cruciate ligament reconstruction: a novel inertial sensor unit study. *Sports biomechanics*, 14(3), 323–339.
<https://doi.org/10.1080/14763141.2015.1060253>
- Setuain, I., Izquierdo, M., Gonzales-Izal, M., Martínez-Ramírez, A., Gómez, M., Alfaro-Adrián, J., & Izquierdo, M. (2016). Vertical jumping biomechanical evaluation through the use of an inertial sensor-based technology. *Journal of sports sciences*, 34(9).