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Original

A STANDING LONG JUMP STUDY IN PRE ADOLESCENTS AGED 9-13

ESTUDIO DEL SALTO DE LONGITUD SIN CARRERA EN PRE ADOLESCENTES DE 9 A 13 AÑOS DE EDAD

Espinosa Sánchez, M.[1]

[1]*Investigación en Biomecánica Deportiva,*

Instituto de Investigaciones Antropológicas,

Universidad Nacional Autónoma de México

Matilde Espinosa-Sánchez
Ave. Universidad 3000, IIA, Circuito Exterior S/N
Ciudad Universitaria, Del. Coyoacán, México, D.F. 04510
email: matilde@unam.mx
tel. (52) 55 56224800 ext. 45729

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editor@journalshr.com

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ABSTRACT

The aims of this study were to identify the kinematics characteristics of the standing long jump performance in two groups, 43 girls and 38 boys; and determine whether, between the two groups, there are significant differences in the anthropometric characteristics and in the kinematic values of the jump.

The children had been selected according to chronological age ranges before the theoretical occurrence of maximum growth. A videogrammetric method was used, and the recorded sagittal projection of jumps was the source for measuring the parabolic behavior of the body center of mass and its location. The normal distribution of the variables and the equality between the two groups was tested (p<0.05). A Z-score analysis was done, grouping the children according to height-for-age charts recommended by WHO.

In average, boys are 1.45 years older, 8.71 kg heavier, 0.1 m taller and jump 0.15 m longer than girls. Almost the 70% of all the participants (28 girls and 27 boys) are within the range considered as average stature, according to standards, and their jump parameters almost correspond to the mean values in descriptive statistics. The Mann-Whitney U non-parametric Test indicated that between girls and boys, only three jump parameters relative the takeoff posture, are equal.

Keywords: Growth Process; Movement pattern maturation; Movement Kinematics.

RESUMEN

Los objetivos de este estudio fueron identificar las características de la cinemática de la ejecución del salto largo sin carrera en dos grupos, 43 niñas y 38 niños; e indagar si entre los dos grupos existen diferencias significativas en las características antropométricas y en los valores cinemáticos del salto.

Los niños habían sido seleccionados de acuerdo a los rangos de edad cronológica antes de, teóricamente, el periodo de máximo crecimiento. Se utilizó un método videogramétrico y la proyección sagital registrada de los saltos fue la fuente para medir el comportamiento parabólico del centro de masa del cuerpo y su ubicación. La distribución normal de las variables y la igualdad entre los dos grupos fue probada (p<0,05). Se realizó un análisis de puntuación Z, agrupando a niñas y niños de acuerdo a la estatura para la edad, recomendada por la OMS.

En promedio, los varones son 1,45 años mayores, 8,71 kg más pesados, 0,1 m más altos y saltan 0,15 m más, que las niñas. Casi el 70% de todos los participantes (28 niñas y 27 niños) están dentro del rango que se considera como la estatura promedio, de acuerdo con los estándares, y los parámetros del salto aproximadamente corresponden a los valores medios de la estadística descriptiva. La prueba no paramétrica de Mann-Whitney indicó que, entre las niñas y los niños, sólo tres parámetros del salto, con respecto la postura de despegue, son iguales.

Palabras clave: Proceso de crecimiento; Maduración de patrones de movimiento; Cinemática del movimiento.

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INTRODUCTION

The performance of voluntary movement is an indicator of quality (Magill, 2001), because of the precision, accuracy and economy involved (Malina et al., 2004). The quantitative description is focused on the result of the performance with regard to the goal of the movement, such as the distance in a long jump. The qualitative description, by contrast, refers to specific processes of movement. These are the temporal sequences of a given set of spatial movements which are executed regularly by the body segments, known as movement patterns (Burton & Miller, 1998). The fundamental movements can be assessed in terms of process, this is the technique employed in the task execution; and the resulting product of the application of mechanical principles of movement. Motor performance is normally improved throughout childhood years by a gradual increase in motor efficiency through growth and maturation combined with an increases in body size and strength, or/and instruction and practice of movements (Parízkova & Merhavtova, 1973). Motivation and environment are relevant factors that influence motor performance; these interact with social, cultural, economic and genetic factors (Barabas, 1996).

Growth and development

Growth and development of individuals is the change in size and function, respectively, which appears in physical structure and performance. Motor development relates to the maturing process, which is considered the highest stage of development of the neuromuscular mechanism which permits progressive performance in motor skills involving the fastest and most effective synchronization of the body segments (Barabas, 1996). There are individual differences in maturation rates during the pre-adolescence period. The taller and heavier children tend to be early maturing individuals while the shorter and lighter children tend to be late maturing individuals. However, height is a linear measurement but the totally of the body components do not grow with the same pattern; for example, weight measurement includes both lean body mass and body fat, and its proportionality and distribution depend on age, gender, environmental and genetic factors. Normal growth is an indicator of health, deviation from the normal pattern indicates a pathological process. Assessing growth status is possible by means of reference data that indicate the size attained by girls and boys at a given age: the distances curve charts (Tanner et al., 1966; NCHS, 1982). The World Health Organization (WHO) recommends the use of growth reference (or "growth chart"), mainly based on *Z*-scores of anthropometric measures, to assess children's nutritional status and growth (Wang & Chen, 2012). The *Z*-score transformation is especially useful when trying to compare the relative standings of different measures (e.g., height vs. BMI, or the measures of boys vs. girls) from distributions with different means and/or different SDs (Frisancho, 2008; Wang & Chen, 2012).

Within any given age group, the growth rates vary considerably and it is possible that differences in the performance of the group may arise simply as a result of varying sizes of body parts rather than its function (Floria & Harrison, 2013). The period up to 8 years of age appears to be transitional in which the children develop strength and motor performance, during this period most children develop a variety of fundamental movement patterns (or basic skills). The development of basic skills in children is a gradual process. There are descriptions of the development of a particular skill with developmental sequences of successive steps, based on qualitative changes in the critical features of the skill (Haywood & Getchell, 2009).

During the middle childhood and pre-adolescence period there is a linear improvement in movement from the age of 5 to 12-13 years, before the biological maturation growth spurt (Barabas, 1996). The motor performance of girls reaches a peak and may decline during adolescence, but the strength and motor performance of boys generally increase through this period, making clear that differences associated with sex occur after the growth spurt and are influenced by body size (Tanner, 1966). Therefore, any assessment of factors related to performance in children has to control the large variations in anthropometry that happen during childhood (Floria & Harrison, 2013). The differences between girls and boys are relatively small but widen during adolescence (Malina et al., 2004).

The occurrence of maximum growth (peak velocity), sexual maturation and adolescence initiation happens at different age periods for women and men of different populations, as has been established

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according to the criteria and research reported by several authors (Tanner, 1966; Hagg & Taranger, 1982; Faulhaber, 1989; Barabas, 1996; Stang & Story, 2009), although growth and development follow definite patterns. On average, the peak velocity of growth comes at age 12 in girls and at age 14 in boys. Recent references or standards, released by the World Health Organization (WHO Reference, 2007) used the LMS (lambda, mu, and sigma) estimation procedure (Cole & Green, 1992; Kuczmarski et al. 2002) to accommodate the distributions of different anthropometric measurements. The LMS method was conducted in order to correct the skewness of distribution in each month, and convert the percentile into a *Z*-score (Wang & Chen, 2012). The absolute value of Z-scores represents the distance between the raw score and the population mean in units of standard deviation. The released a set of growth standards are for children and adolescents aged 5–19 years (de Onis et al. 2007) which provide the sex-age-specific LMS parameters that could be used to calculate the *Z*-score that corresponds to each child's measured value, with the following equation: $\text{Z-score} = ((\text{child's measured value} / M)^{L} - 1) / SL$; when $L \neq 0$. According to Frisancho (2008), the growth status is defined with reference to gender-specific standards of height: short (z<-1.650), below average (-1.645<z<-1.040), average (-1.036<z<+1.030), above average (+1.036<z<+1.640), and tall (z>+1.645).

Jumping

Jumping is a skill generally acquired during the fundamental movement period, which usually occurs reaching the seventh year (Barabas, 1996; Burton & Miller, 1998; Malina et al., 2004; Floria and Harrison, 2013). Studies have observed a progressive increase in jumping performance from childhood to adolescence (Grosser & Starischka, 1989; Malina et al., 2004; Sokolowski & Chrzanowsk, 2012), and published developmental sequences may help to identify the stages that children are able to make in the transition from inefficient to proficient movement patterns (Seefeldt et al., 1972). That is, the long jump in individuals may first appear as vertical jump (initial stages), but as the movement pattern matures (intermediate stages), the horizontal distance covered by the jump increases (Floria & Harrison, 2013). The stages sequences are often associated with changes in anthropometric characteristics (dimensions, proportions, and body composition) as children become taller and heavier.

The efficient execution is usually the result of muscular force application; for proper performance, the factors of strength, balance and coordination go into action. Ideally the jump starts with arms motion, followed by hip extension, knee extension and ankle extension. Jumping represents a complex movement involving several joints, resulting an external mechanical power of the feet when pushing the ground, which is an indicator of the power capacity for example, of the knee extensors (O'Brien et al., 2009).

The Standing Long Jump (SLJ), also called the Broad Jump is a common test to measure the explosive strength and power of the lower limb (EUROFIT, 1983; Grosser y Starischka, 1989; Cvejić et al., 2013; Malina et al., 2004). The SLJ was also once an event at the Olympic Games and is an event in Sports Hall competitions in the UK; it is included in the EUROFIT battery used to evaluate children in Europe (Grosser & Starischka, 1989). Advantages in test include that the jump is simple, quick to perform and requires minimal equipment. The test result is the jump distance which only requires a measure tape. It is evaluated by the horizontal distance from the takeoff line to the mark made by the heel on landing, or the nearest point of contact to the takeoff line at landing. The distance depends on the displacement of the center of mass (COM) of the individual's body when traveling in the air as with any projectile, and is determined by the following factors: the magnitude of the velocity vector of the COM at the time of the start of flight (takeoff initial velocity vector), the angle of the initial velocity vector at the start of the jump (takeoff angle), the value of acceleration due to gravity in the region where the jump takes place, and the air resistance at the time of the jump execution (Hay & Reid, 1988). The person's feet should take off at the same time so that a full extension of the ankles, knees and hips (called triple extension) must be achieved in order to use all the energy of each joint (ASEP, 2008).

In the SLJ Movement System, two main phases are distinguished: (a) Preparation (arms swing and flexion of hips, knees and ankles) and (b) Action (takeoff, flight, landing and standing recovery) (Hay

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& Reid, 1988; Malina et al., 2004). At the preparation phase the swing of the arms shifts the COM to the edge of the supporting base (the takeoff distance). Ashby & Heegaard (2002) reported increases of 8 cm in the horizontal displacement of the COM before the takeoff (body forward lean or body inclination), and Wen-Lan et al. (2003) showed an average increase of 7.5 cm in the horizontal displacement. The individual position at the takeoff is highly unstable, it is characterized by a large forward lean of the body: the extended legs are into a powerful thrusting stance and the individual adopts a position that requires minimal force to thrust toward the greatest distance in the intended direction (Wakai & Linthorne, 2005). The quick forward swing of the arms adds to the thrust of the legs. It has been shown that the movement of the arms contributes significantly to the distance of the SLJ, supplying also balance and control (Ashby & Heegaard, 2002). Selecting the optimum angle of takeoff and the technical use of the arms are two of the most important factors that define performance jump (Wen-Lan et al., 2003).

It is possible that when a SLJ is not executed according to the proven technique, the real potential of the individual is not revealed. In childhood period, the average SLJ performance increases linearly with age in both sexes until age 12 the girls and 13 the boys (Malina et al., 2004; Barabas, 1996). Physical size and maturity are factors in a child's progress in skill development. Each child has her/his unique rate of improvement with chronological age, although, there are children who spend more time than others in a given stage of performance of a skill (Haywood & Getchell, 2009).

The average distances reported in some SLJ studies for pre adolescents of different populations include 1.4 m among American girls and boys between the ages of 11 and 13 (Wilkerson and Satern, 1986). German girls aged 10 jumped a distance of 163.1 cm, German boys aged 12 jumped a distance of 177 cm (Groesser and Starischka, 1989). In the 7 to 12 years old range, girls jumped a distance between 1.2 and 1.6 m, and boys 9 to 14 years old jumped a distance between 1.4 and 1.9 m (Haubenstricker and Seefeldt, in Malina et al., 2004). Chinese girls aged 10 jumped a distance of 1.29 m and Chinese boys aged 12 jumped a distance of 1.55 m (Chung et al., 2013).

Objectives

Objectives of this study were to find the kinematic parameter values of the Standing Long Jump performance, and the differences between girls and boys.

METHODS

Participants

This is a cross-sectional study. Data collection was carried out in 1997 in a private elementary school (Escuela Teceltican) considered to be of medium socioeconomic status. The parents of 81 children (43 girls and 38 boys) were informed about the project and were asked to sign consent authorizing the participation of their children in the experiment (Manzini, 2000;_Andanda, 2005). The date of birth and other information about children's health was requested. Girls were selected from the 4th and 5th grades (around 10 years old), and boys were selected from the 5th and 6th grades (around 11 years old).

Experimental procedures

During sessions of data collection, the children were asked to be barefoot, to dress swimsuit or shorts, the boys shirtless and the girls wearing a top. Each participant's *stature*, *sitting height* and body mass (*weight*) were measured. After warming up and practicing for a while, the sagittal projection of each of the participants executing the SLJ was recorded using a standard video camera (Sony camcorder CCD-TR81 NTSC, 60 Hz) fixed on a tripod at a distance of 10 m with the focal axis perpendicular to the ideal jumping course. The data for each jump were obtained using a videogrammetric method, that is, the videos were the sources for the calculations of parabolic behavior of the COM and its location (Hay & Reid, 1988; Wakai &, Linthorne,_2005), according to the proposed model of Chandler et al. (Enoka, 1988). From the images, the information about body posture was extracted in order to calculate the body COM location and to identify the instants of the feet takeoff and touchdown. A known scale was also required and recorded as reference. The wind speed at the time of execution was not considered.

The Standing Long Jump technique

The children jumped following a specific technique. According to various descriptions and with the intention of establishing a standard, the sequence of movements executed during the SLJ are: The participant stands upright, comfortably, with her/his

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feet slightly apart, and symmetrically behind the line marked on the ground to takeoff. From this position the individual flexes hips, knees and ankles to provide a forward drive while swinging arms back, helping with reverse rotation at the shoulders. The individual swings both arms forward aggressively, jumping forward as far as possible, extending the joints of the hip, knee and ankle quickly, landing gently with both feet without falling backwards, flexing the joints of the hip, knee and ankle to prevent the torso collapsing forward, swinging the arms with an opposite movement (see Figure 1) (EUROFIT, 1983; Hay and Reid, 1988; Malina & Bouchard, 1991; Wakai & Linthorne, 2005).

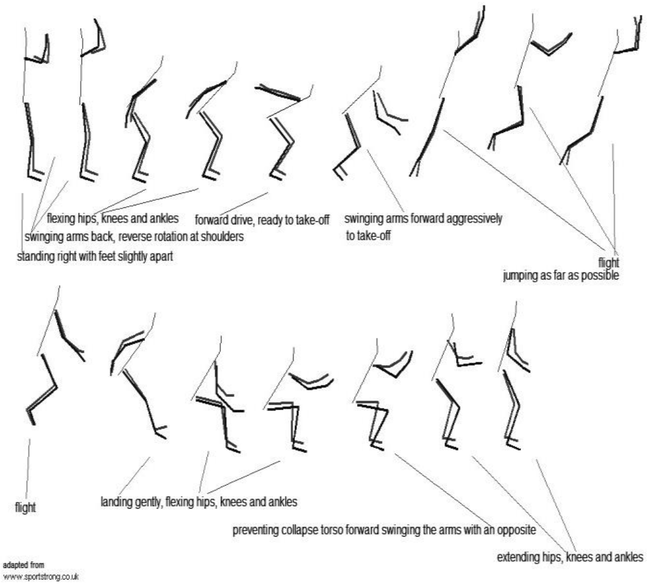

Figure 1. The technique of the Standing Long Jump.

Variables

The sample variables include: *gender*, chronological *age* [years], stature (*St*) [m], body mass (*weight*) [kg] and sitting height (*SH*) [m]. Additionally, the Quetelet's index or body mass index (BMI = kg/m^2), and the Sitting Height Ratio or Cormic Index (*SHR* = *SH**100/*St*) were calculated.

The kinematic variables that determine the SLJ are those which were determined at the time of takeoff (see Figure 2): horizontal distance from the distal end of the feet to the COM projection at the frontal lean (d_x) [m], COM height or takeoff height (h_{to}) [m], angle of forward lean (*alpha*) [degree], horizontal component (v_x) [m/s] and vertical component (v_y) [m/s] velocity of the COM, initial velocity vector (v_o) [m/s], initial velocity vector angle or takeoff angle (*theta*) [degree]. The jump distance (Hay & Reid, 1988) is largely dependent on the biomechanical characteristics (that is, the kinematic values) at the time of takeoff. COM takeoff velocity and angle, and the technique executed to jump (body posture sequence: COM location). There are two right triangles in Figure 2, on one of them, *alpha* angle, distances d_x and h_{to}, and on the other, initial velocity vector v_o, components v_x and v_y, and takeoff angle *theta*.

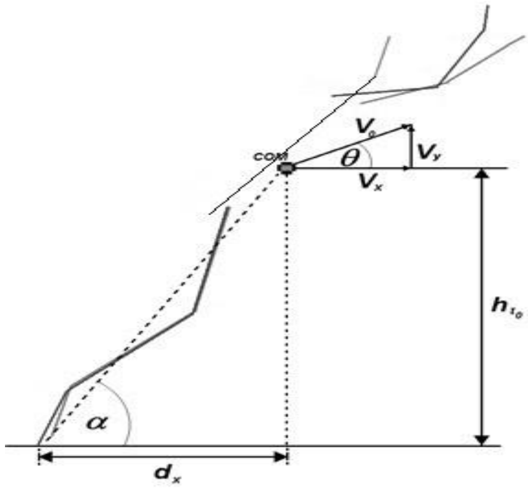

Figure 2. Standing Long Jump variables: angle of forward lean (α=*alpha*) at takeoff, takeoff distance (*dx*), takeoff angle (θ=*theta*) and takeoff height (*hto*) of the boby center of mass (COM), initial velocity at takeoff (*vo*), horizontal velocity (*vx*), vertical velocity (*vy*), and jump distance (*d*). Adapted from Wakai, M. and Linthorne, NP (2005).

Statistical analysis

Different statistical tests were applied in order to determine whether there is enough evidence to affirm that the two groups, girls and boys, executed SLJ with a similar variability. The SPSS 19 software for Windows and Microsoft Office Excel 2007 were used to process the data and the criterion for significance was set to $p<0.05$.

The Assessment of children's growth status

Each participant's growth assessment was determined by computing the Z-scores, extracting LMS values in the tables Height-for-age (WHO Reference, 2007) by the age in years and month. These WHO curves fit well the patterns child growth, and provide an appropriate reference for the group of

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5-19 years old (de Onis et al., 2007). The procedure was done in order to bring together participants from the sample by growth assessment.

RESULTS

The descriptive statistics of the anthropometrical variables are shown at Table 1. In average boys are 1.5 years older, 0.1 m taller and 8.71 kg heavier, the *age* range for both groups includes more than 3 years.

Table 1. Basic descriptive statistics of the anthropometric variables of the sample. **p*<0.05

	ALL	GIRLS	BOYS
N	81	43	38
age, mean	10.72	10.04	11.49
(years ± SD)	1.25	1.04	0.98
Skewness	-0.10	-0.23	0.09
Kurtosis	-0.42	-0.78	-1.19
Max	13.17	11.75	13.17
Min	7.83	7.83	9.92
Range	5.34	3.92	3.25
CV	11.61	10.41	8.51
weight, mean	37.18	33.09	41.80
(kg ± SD)	10.27	6.70	11.65
Skewness	1.61	0.38	1.52
Kurtosis	4.39	-0.62	3.06
Max	82.50	47.80	82.50
Min	23.85	23.85	24.00
Range	58.65	23.95	58.50
CV	27.62	20.25	27.86
St, mean	1.42	1.37	1.47
(m ± SD)	0.10	0.08	0.10
Skewness	0.29	0.34	0.10
Kurtosis	-0.31	-0.21	-0.21
Max	1.71	1.57	1.71
Min	1.23	1.23	1.28
Range	0.48	0.34	0.43
CV	7.19	6.18	6.52
SH, mean	0.74	0.71	0.76
(m ± SD)	0.05	0.04	0.05
Skewness	0.24	0.36	0.46
Kurtosis	0.65	0.16	1.02
Max	0.90	0.81	0.90
Min	0.60	0.64	0.67
Range	0.30	0.17	0.23
CV	6.78	5.56	5.97

The *St* differences within the groups are large, nevertheless the difference between the two groups is 9 cm. In spite of this, there are differences in *weight* within the group of boys, a range of 58.5 kg. The boys are on average also taller in *SH*, but there are no large differences in relation to *SHR* between girls and boys. *BMI* values are also bigger for boys. Skewness and Kurtosis show that the data are approximately normally distributed. There is high variability in the data and a significant deviation (CV > 20%) in *weight*.

The descriptive statistics of the SLJ variables are shown at Table 2. The boys jump a longer distance (*d*) on average, but not much more than girls do. For this, the average values of the other variables are also larger in boys than in girls, with the exception of the angle of forward lean (*alpha*). For these variables the Skewness and Kurtosis results show a small degree of asymmetry and a relative peak or flatness compared with the normal distribution. Significant deviation (CV > 20%) are shown in horizontal (v_x) and vertical (v_y) components of velocity, and in takeoff angle (*theta*).

Table *2. Basic descriptive statistics of the Standing Long Jump kinematic parameters of the sample. *p<0.05*

	ALL	*GIRLS*	*BOYS*
N	*81*	*43*	*38*
alpha, mean	*62.85*	*64.13*	*61.40*
(degrees ± SD)	*4.53*	*4.07*	*4.63*
Skewness	*0.06*	*0.25*	*0.16*
Kurtosis	*-0.30*	*-0.44*	*-0.31*
Max	*72.50*	*72.30*	*72.50*
Min	*53.22*	*56.56*	*53.22*
Range	*19.28*	*15.74*	*19.28*
CV	*7.21*	*6.35*	*7.54*
d_x, mean	*0.44*	*0.41*	*0.48*
(m ± SD)	*0.08*	*0.07*	*0.07*
Skewness	*0.14*	*-0.12*	*0.47*
Kurtosis	*0.24*	*-0.71*	*0.61*
Max	*0.67*	*0.54*	*0.67*
Min	*0.28*	*0.28*	*0.35*
Range	*0.39*	*0.27*	*0.32*
CV	*16.96*	*16.54*	*14.55*
h_{to}, mean	*0.86*	*0.85*	*0.88*
(m ± SD)	*0.08*	*0.06*	*0.10*
Skewness	*0.83*	*0.47*	*0.67*
Kurtosis	*1.47*	*0.13*	*0.78*
Max	*1.14*	*1.01*	*1.14*
Min	*0.69*	*0.74*	*0.69*
Range	*0.45*	*0.27*	*0.45*
CV	*9.28*	*7.22*	*10.98*
theta, mean	*30.24*	*29.87*	*30.66*
(degrees ± SD)	*10.65*	*10.88*	*10.53*
Skewness	*-0.11*	*-0.08*	*-0.16*
Kurtosis	*0.50*	*0.67*	*0.53*
Max	*58.00*	*56.30*	*58.00*
Min	*0.00*	*0.00*	*8.70*
Range	*58.00*	*56.30*	*49.30*
CV	*35.24*	*36.41*	*34.35*
v_x, mean	*2.00*	*1.89*	*2.11*
(m/s ± SD)	*0.42*	*0.39*	*0.43*
Skewness	*-0.15*	*-0.60*	*0.09*

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Kurtosis	*0.21*		*-0.10*		*-0.02*	
Max		*2.87*		*2.43*		*2.87*
Min		*0.88*		*0.88*		*1.11*
Range		*1.99*		*1.55*		*1.76*
CV		*21.15*		*20.84*		*20.22*
v_y, mean	*1.17*			*1.10*		*1.25*
(m/s ± SD)		*0.42*		*0.41*		*0.43*
Skewness	*-0.33*		*-0.30*		*-0.47*	
Kurtosis	*-0.31*		*0.37*		*-0.73*	
Max		*1.99*		*1.77*		*1.99*
Min		*0.00*		*0.00*		*0.44*
Range		*1.99*		*1.77*		*1.55*
CV		*36.09*		*37.22*		*34.23*
v_o, mean		*2.35*		*2.22*		*2.49*
(m/s ± SD)		*0.42*		*0.40*		*0.41*
Skewness	*-0.20*		*-0.64*		*0.18*	
Kurtosis	*0.46*		*0.39*		*-0.25*	
Max		*3.38*		*3.01*		*3.38*
Min		*1.13*		*1.13*		*1.68*
Range		*2.25*		*1.88*		*1.70*
CV		*18.06*		*18.17*		*16.26*
***d*,** mean		*1.22*		*1.15*		*1.30*
(m ± SD)	*0.22*		*0.20*		*0.21*	
Skewness	*0.31*		*-0.32*		*0.86*	
Kurtosis	*1.29*		*-0.02*		*1.56*	
Max		*1.98*		*1.51*		*1.98*
Min		*0.67*		*0.67*		*0.94*
Range		*1.31*		*0.84*		*1.04*
CV		*17.78*		*17.18*		*16.38*

Because of the descriptive statistics results, it is possible to say that the data are not homogeneous. The Shapiro-Wilk contrast test was used in order to verify if dependent variables are normally distributed.

Weight, v_y and in girls v_x, are not approximately normally distributed (Table 3).

Table 3. *Statistical Tests for Normality, Homogeneity and for comparing two population means*

	Age	*weight*	*St*	*SH*	*alpha*	d_x	h_{to}	*theta*	v_x	v_y	v_o	*d*
Normality, Shapiro-Wilk *p<0.05												
Girls												
Statistic	*0.964*	*0,944*	*0,969*	*0,966*	*0,967*	*0,972*	*0.973*	*0.984*	*0,933*	*0.940*	*0.963*	*0,980*
p-value	*0.188*	*0.035*	*0,282*	*0.238*	*0.257*	*0.366*	*0.410*	*0.817*	*0.015*	*0.027*	*0.185*	*0.661*
Boys												
Statistic	*0.958*	*0.877*	*0.983*	*0.952*	*0.986*	*0.972*	*0.966*	*0.960*	*0.948*	*0.925*	*0.983*	*0,956*
p-value	*0.157*	*0.001*	*0.816*	*0.103*	*0.905*	*0.434*	*0.296*	*0.186*	*0.076*	*0.014*	*0.827*	*0,143*
Levene Test of Homogeneity of Variances. *p<0.05												
Statistic	*0.399*	*6.454*	*1.100*	*0.362*	*0.546*	*0.058*	*4.914*	*0.072*	*0.103*	*0.980*	*0.000*	*0.040*
p-value	*0.530*	*0.013*	*0.297*	*0.549*	*0.462*	*0.810*	*0.030*	*0.789*	*0.749*	*0.325*	*0.992*	*0.843*
Mann-Whitney Test Statistics. *p<0.05 Grouping Variable: sex MR = Mean Ranke												
G MR	*27.91*	*32.22*	*30.81*	*31.02*	*47,190*	*32.31*	*38.28*	*39.49*	*36.14*	*36.80*	*34.72*	*33.81*
B MR	*55.82*	*50.93*	*52.53*	*52.29*	*34.00*	*50.83*	*44.08*	*42.71*	*46.50*	*45.75*	*48.11*	*49.13*
U	*254.0*	*443.5*	*379.0*	*388.0*	*551.0*	*443.5*	*700.0*	*752.0*	*608.0*	*636.5*	*547.0*	*508.0*
Z	*-5.332*	*-3.539*	*-4.145*	*-4.062*	*-2.518*	*-3.539*	*-1.109*	*-0.616*	*-2.008*	*-1.736*	*-2.558*	*-2.926*
A Sig (2-t)	*0.000*	*0.000*	*0.000*	*0.000*	*0.012*	*0.000*	*0.267*	*0.538*	*0.045*	*0.083*	*0.011*	*0.003*

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The Levene Test of Homogeneity of Variances was carried out in order to test the condition that the variances of both groups of the sample are equal. For *weight* and h_{to} the variances are significantly different (Table 3). Considering variables that are not normally distributed, the Mann-Whitney U Test have been applied in order to assess whether the two independent groups are significantly different from each other. The results at Table 3 show that there is a statistical significance attained for the anthropometric variables and the jump variables, with the exception of h_{to}, *theta* and v_y. The mean rank values (Girls MR and Boys MR) indicate that for all variables, except for the forward lean angle (*alpha*) in girls are less than in boys. The difference in the sum of ranks is large enough to be statistically significant at 0.05 levels.

The associations in between the variables of both groups were explored. To know whether there was a linear relation among the variables, the Pearson product-moment Correlation Coefficient *r* ($p<0.05$) was obtained. A strong ($0.8<|r|$) positive relationship between *St* and *SH*, *weight* and *BMI*, v_x and v_o, v_y and *theta*, and a strong inverse relationship between d_x and *alpha*. A moderate ($0.5<|r|< 0.8$) positive relationships between *age* and *St*, *age* and *SH*, *St* and *weight*, *weight* and *SH*, d_x and v_x, and finally, a moderate inverse relationship between v_x and *alpha*, *d* and *alpha*. In girls only: *age* and *weight*, v_y and v_o, *age* and *d*, d_x and *d*. In boys only: *age*, *weight*, *St*, *SH*, *alpha* and h_{to}, *alpha* and *theta*, and a moderate inverse relationship between d_x, v_x and *theta*. A weak ($0.3<|r|<0.5$) positive relationships between *d* and v_x, *d* and v_o, and a weak inverse relationship between v_o and h_{to}, *alpha* and v_o were found. In girls only: *age*, *weight*, *BMI* and d_x, *St*, *SH*, *alpha* and h_{to}, *alpha* and *theta*, and a weak inverse relationship between d_x, v_x and *theta*. In boys only: *weight and age*, *St*, *SH*, h_{to} and *BMI*, d_x, v_y and v_o, *age*, *St*, *SH*, *weight* and *alpha*, *d* and d_x, and a weak inverse relationship between *St* and *SHR*, h_{to} and v_x, *BMI* and v_y, v_y and d_x, *weight*, *BMI*, h_{to} and *d*.

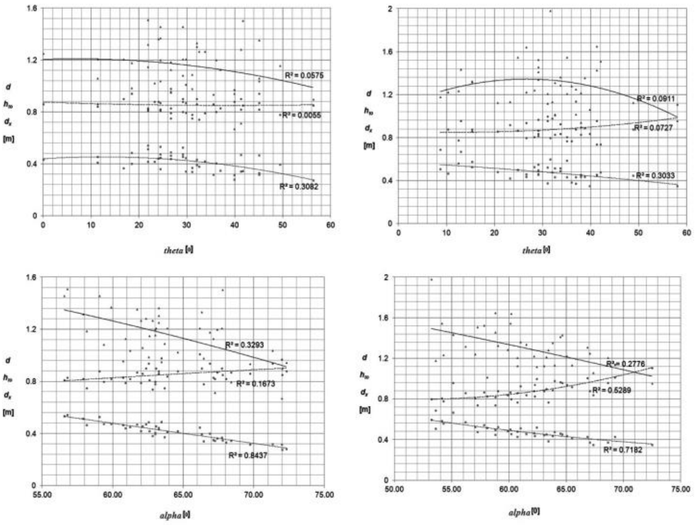

Figure 3. Relation of jump ·distance (*d*), ·takeoff height (*hto*), ·takeoff distance (*dx*) with takeoff angle (*theta*) and forward lean angle (*alpha*), with polynomial tendency R^2 The graphs on the left correspond to girls on the right to boys.

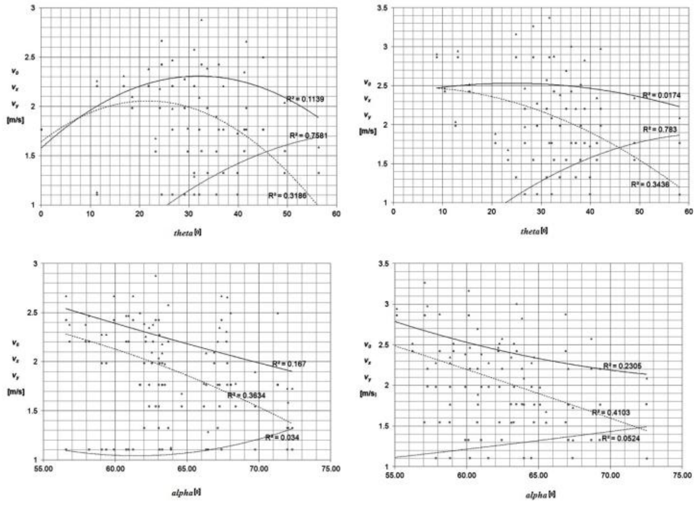

Figure 4. Relation of initial · vector velocity (*vo*), ·horizontal component of initial velocity (*vx*) and · vertical component of initial velocity (*vy*), with takeoff angle (*theta*) and forward lean angle (*alpha*), and with polynominal tendency R^2. The graphs on the left correspond to girls and on the right to boys.

Regression analysis lines can be employed as a way to visually represent the relationship between independent and dependent variables on a graph. In scatter graphs for variables, and in order to predict the data trend, a line of a best fit and a R^2 (Coefficient of Determination) value, are considered. The jump variables scatter graphs are shown in Figures 3 and 4. For the forward lean angle (*alpha*), the distances *d* and d_x decreased while the angle increases. But height h_{to}, increased as the angle increased mainly in boys. Variations of velocities (v_o, v_x, v_y) in relation to takeoff angle (*theta*) were more pronounced. In girls v_o and v_x have a top at 30 and 20 degrees

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respectively. There was a top about 25 degrees for v_o in boys, the velocities values decreased while the *theta* angle increased. But v_y for both groups, increased from 23 degrees in girls and from 25 degrees in boys. The relation between both angles, *theta* and *alpha*, show in Figure 5, increased together. The girls increase performance (*d*) as they grow. The boys, however, show a stable performance in this age range.

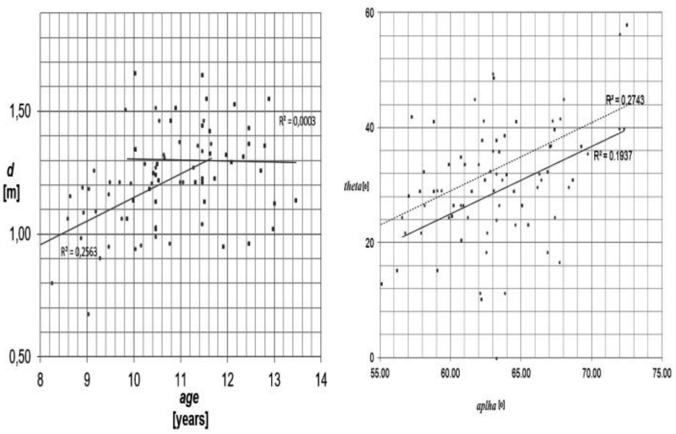

Figure 5. Distance jumps *d* according to the *age* of • girls and • boys with polynomial tendency R^2. Takeoff angle (*theta*) and forward lean angle (*alpha*) relation with polynomial tendency R^2.

Table 4 summarized the growth assessment of the participants grouped according to the calculated Z-Score using the height-for-age Table MLS parameters, of girls and boys (WHO Reference, 2007). There is the mean and the standard deviation of the anthropometric and SLJ variables of girls and boys grouped in the corresponding Z-Score group. It is included the number of participants in the corresponding Z-Score. The biggest number of participants (65% of group of girls (28) and 71% of group of boys (27)) is within the Z-score range corresponding to the average level, according to sex-specific standards of height-for-age value (Frisancho, 2008). There are in the sample 5 children (9.3% of girls and 2.6% of boys) considered short; 8 children (11.6% girls and 7.89% boys) considered below average; 5 children (4.65% girls and 7.89% boys) considered above average; and 8 children (9.3% girls and 10.52% boys) considered tall. The values in the table show that children with greater weight are also the highest; for both groups, the values of the *stature* and h_{to} increase together; tall girls have the highest value in *alpha* angle and the lower *d*; but girls below the average have the highest *d* and the lowest *alpha*; the short boy is the one with the highest *theta*, v_o, v_x and *d* values, but with the lower *alpha* value. In average, the Z-scores shown in Table 4, indicate that for the average level, the values are very similar to the mean values of the sample.

Table 4. Distribution of children in the sample. according criteria of statue (Frisancho, 2008) on the calculated Z-score (z). The values are based on height-for-age (WHO. 2007).
Short: z < -1.650. Below average (BA): -1.645<z<-1.650. Average: -1.036<z<+1.030. Above average (AA): +1.036<z<+1.640. Tall: z>+1.645.

ALL	**Short**	**BA**	**Average**	**AA**	**Tall**
N	5	8	55	5	8
age	10.47	10.53	10.82	9.97	10.87
(years ± SD)	0.76	1.06	1.32	0.96	1.34
weight	28.64	32.13	36.01	46.93	49.50
*(kg ± SD)*4.24	7.99	8.39	9.27	14.33	
stature	1.28	1.33	1.42	1.45	1.57
(m ± SD) 0.03	0.06	0.08	0.06	0.09	
sit height 0.66	0.70	0.74	0.76	0.81	
(m ± SD) 0.04	0.03	0.04	0.02	0.05	
alpha	62.65	61.53	62.71	63.50	64.88
(degree ± SD)	6.02	4.33	4.55	3.26	4.72
d_x	0.41	0.45	0.44	0.44	0.45
(m ± SD) 0.09	0.08	0.07	0.03	0.10	
h_{to}	0.80	0.83	0.86	0.89	0.95
(m ± SD) 0.06	0.06	0.08	0.06	0.09	
theta	34.42	28.91	31.15	23.58	26.81
(degree ± SD)	7.93	10.38	11.47	4.34	7.81
v_x	2.12	2.13	1.97	1.81	2.07
(m/s ± SD)	0.46	0.39	0.44	0.18	0.42
v_y	1.46	1.16	1.20	0.79	1.02
(m/s ± SD)	0.46	0.39	0.44	0.20	0.27
v_o	2.60	2.46	2.35	1.99	2.33
(m/s ± SD)	0.55	0.34	0.43	0.22	0.38
d	1.25	1.21	1.23	1.15	1.17
(m ± SD) 0.21	0.16	0.24	0.05	0.22	
GIRLS	**Short**	**BA**	**Average**	**AA**	**Tall**
N / %	4/9.3	5/11.6	28/65.1	2/4.7	4/9.3
age	10.36	10.43	10.01	9.04	9.94
(years ± SD)	0.83	1.25	1.07	0.06	1.08
weight	27.46	34.02	32.18	38.60	41.24
*(kg ± SD)*3.83	9.35	5.55	10.18	5.02	
stature	1.28	1.33	1.37	1.40	1.51
(m ± SD) 0.03	0.07	0.07	0.09	0.08	
sit height 0.66	0.70	0.71	0.73	0.78	
(m ± SD) 0.04	0.04	0.03	0.02	0.04	
alpha	64.00	61.56	64.50	63.11	65.38
(degree ± SD)	6.01	4.45	3.90	5.31	2.92
d_x	0.40	0.44	0.41	0.44	0.41
(m ± SD) 0.10	0.07	0.07	0.05	0.07	
h_{to}	0.81	0.82	0.86	0.87	0.89
(m ± SD) 0.06	0.07	0.06	0.10	0.04	
theta	32.53	28.74	30.66	23.75	26.13
(degree ± SD)	7.75	10.46	12.17	7.57	6.05

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v_x	2.10	2.17	1.80	1.99	1.94
(m/s ± SD)	0.52	0.24	0.40	0.00	0.38
v_y	1.33	1.20	1.08	0.89	0.94
(m/s ± SD)	0.41	0.40	0.44	0.32	0.22
v_o	2.50	2.51	2.14	2.19	2.16
(m/s ± SD)	0.58	0.13	0.40	0.13	0.37
d	1.18	1.26	1.14	1.13	1.07
(m ± SD) 0.17	0.15	0.21	0.07	0.23	
BOYS	**Short**	**BA**	**Average**	**AA**	**Tall**
N / %	1/2.6	3/7.9	27/71.0	3/7.9	4/10.5
age	10.92	10.70	11.66	10.58	11.79
(years ± SD)		0.89	0.98	0.63	0.84
weight	33.35	28.98	39.98	52.48	57.76
(kg ± SD)	4.98	9.05	2.13	16.50	
stature	1.31	1.33	1.47	1.49	1.63
(m ± SD)	0.04	0.07	0.02	0.06	
sit height 0.70	0.70	0.76	0.77	0.83	
(m ± SD)	0.02	0.04	0.04	0.05	
alpha	57.24	61.49	60.84	63.76	64.37
(degree ± SD)		5.09	4.48	2.63	6.53
d_x	0.48	0.47	0.48	0.45	0.49
(m ± SD)	0.10	0.06	0.03	0.13	
h_{to}	0.74	0.85	0.86	0.91	1.01
(m ± SD)	0.03	0.09	0.04	0.09	
theta	42.00	29.20	31.66	23.47	27.50
(degree ± SD)		12.58	10.91	3.01	10.22
v_x	2.21	2.06	2.14	1.70	2.21
(m/s ± SD)		0.64	0.42	0.13	0.48
v_y	1.99	1.11	1.31	0.73	1.11
(m/s ± SD)		0.45	0.41	0.13	0.32
v_o	2.98	2.38	2.56	1.85	2.51
(m/s ± SD)		0.59	0.36	0.15	0.34
d	1.51	1.14	1.33	1.16	1.27
(m ± SD)	0.17	0.22	0.05	0.20	

DISCUSSION

Participants in the study were selected according to chronological age, and the sample was supposed to be homogeneous, girls about 10 ± 1 (<12) years and boys about 11 ± 1 (<14) years of age, this is, the study included girls and boys within the age range before the occurrence of maximum growth (peak velocity). However, as can be seen in Table 1, the sample is more dispersed than expected in relation to the chronological age and also includes younger and older individuals.

Although the correlation between *age* and *St*, is for both girls (r=0.580) and boys (r=0.719) moderate, boys are taller and girls are shorter for these age range, but this is a normal relation between the stature of women and men.

When comparing mean values of the sample with the American and Mexican reported values (even though data collection are two decades apart), it can be said that in this study, the girls were a little heavier and shorter than average American girls (NCHS, 1982), but higher than average Mexican girls (Faulhaber, 1989), and close to the 50th percentile values for the two references. Boys, however, were heavier and taller, and their values were close to the 60th percentile for both references. These findings could be a result of positive secular trend in growth and maturation.

When comparing jump distances (*d*) that the individuals of the sample jumped, on average both groups had poor performance in relation to reported values (Wilkerson & Satern, 1986; Grosser & Starischka, 1989; Malina et al., 2004; Chung et al., 2013). This sample shows that the performance is better in boys than in girls. On average, the boys are larger and jump more distance, even though they do not improve their performance as they grow within the age range, as girls do. The two groups do not increase their performance linearly, as reported Malina et al. (2004). The individuals are slightly inclined to the front, specifically girls are not inclined as much (forward lean angle *alpha*) as boys, and it is even reasonable to say that on average, the girls don't jump to the front but a bit up instead.

The correlation coefficients show that *age* related to distance (*d*) of the jump is only moderate in girls. There is a weak or no relation between gender and *age* in the jump variables. This indicates that for the SLJ performance, *age* and *gender* are not determinant factors. The variables that may determine the SLJ distance are, however, the angle of forward lean (*alpha)*, and with this, the takeoff distance (d_x). The horizontal component (v_x) and the initial velocity (v_o) are also influential. Coefficients show that the forward lean angle affects the horizontal velocity and thereby the jump distance. The relation between the initial velocity vector and the vertical velocity component indicates that some children jump slightly up instead forward; that is, some children have not matured in performing the jump.

The statistical results of the Mann-Whitney U test indicate that only the values takeoff height (h_{to}), takeoff angle (*theta*) and vertical velocity (v_y) of the two groups are equal.

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The scatter graphs indicate that the points representing the values are not close to the tendency lines, but widely scattered. The relation, expressed with the Coefficient of Determination, (girls R^2=0.2743, boys R^2=0.193) between *alpha* and *theta* is not as strong as Wakai and Linthorne (2005) reported in their study (R^2=0.99), that is, for this sample the two angles do not counted together in the jump profit. The results show also that the average of takeoff angle, in both groups (girls *theta* =29.87^o, boys *theta*=30.66^o), are almost within the range of preferred takeoff angle (about 33^o) of the sample analyzed by Wakai and Linthorne (2005). There are differences between this sample and the pre-adolescent's performance of the Wilkerson and Satern (1986) study, in average there are moderate relations r=0.67 between v_o and d, and r=-0.64 between d and *theta* but for this sample there is a weak and non-relation respectively, for both girls (r=0.396 and r=-0.224) and boys (r=0.427 and r=-0.116).

The values of Z-scores show that within the range corresponding to the average height, where most individuals in the sample are located, both anthropometric and kinematic parameter values, are near the mean values of the groups of girls and boys.

There is possibility of differences in the physical activities of participants, boys are older and had more time for games and practice opportunities. Cultural and social reasons can affect performance in women, including the fact that they do not play as much as boys.

CONCLUSIONS

The differences between the groups of girls and boys are statistically significant; however, only 3 of them (takeoff height (h_{to}), takeoff angle (*theta*) and vertical velocity (v_y)) are statistically equal between the two groups. Although the Z-score analysis shows that in this sample about 65% of girls and 70% of boys have been regarded as with an average height for their age; shorter, lighter, and larger, heavier children have been an important factor in the applied statistical analysis to indicate that the differences between the anthropometric variables of boys and girls are statistically significant.

The information obtained from this analysis showed that, although the similarities, it is possible to conclude that, in this sample, the jump performance similarity between the two groups could not be determined.

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