Effect of Anthropometric Characteristics and Socio-Economic Status on Vertical Jumping Performances in Tunisian Athletic Children

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Abstract The purpose of this study was to examine the effect of socioeconomic factors on vertical jumping performance as well as on anthropometric parameters in athletic Tunisian children aged 7 to 13 in both sexes.
Four hundred and seven athletic Tunisian children (218 boys and 189 girls) ranging from 7 to 13 were randomly selected to participate in our study. They were asked to perform Squat jumps (SJ) and Countermovement jumps (CMJ) and to response to a questionnaire. Jump heights and leg power were simultaneously provided by the optojump device. Correlations and regression models were calculated in order to identify which factors influenced jumping performance variables. In our population of athletic Tunisian children, the socioeconomic status did not influence vertical jumping parameters whereas morphological factors were the main predictive factors of jumping. This research may help verifying the effectiveness of a specific training program and detecting highly talented athletes.

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1. Introduction

Assessment of aerobic metabolism during growth and maturation has been extensively studied in children. However, short-term maximal anaerobic power remains relatively poorly understood [48], particularly in trained children. This could be attributed to ethical considerations and/or the difficulties to recruit young trained subjects. Anaerobic metabolism, force, velocity and peak power are determinant factors in many physical activities and sports. Most of the studies on the anaerobic metabolism have been done on sedentary children using cycle ergometer [14,29,47]. Little attention has been paid to the vertical jump test which allows the estimation of the peak power of lower limbs [7]. The vertical jump test has emerged as a consistent test in adults as well as for children [47]. Some studies showed significant correlations between the force-velocity test and the vertical jump [8,47]. This field test is easy and could be realized in a great population. Several factors could affect the performance during the test. Some of these factors are related to the tested participants (e.g differences in gender, age, body composition, growth and maturity) [10,21], while others are predominantly related to lifestyle factors such as physical activity, environmental

conditions, sport selection and training [5]. Indeed, there are high correlations between jump performances and maximal anaerobic power [47]. Powerful athletes have high percentage of fast-twitch muscle fibres and high muscle performances. Specific anaerobic training, by using jumps and/or short sprints enhance ATP production by the anaerobic system (ATP-PC and anaerobic glycolysis). The mechanisms responsible for the reported improvements in anaerobic pathways are also related to improvements in aerobic fitness [4]. In addition, mechanisms responsible for jump performances enhancements are mainly related to muscle mechanical proprieties, such as contractile and elastic components [20], muscle type and architecture [15]. Repeated brief actions, such as sprints, or jumps depends essentially in both contractile and metabolic factors, such as energy supply (e.g. phosphocreatine utilisation and resynthesis), CPK enzymatic activity, calcium liberation, and improvements in H+ regulation [4].

An environmental factor, such as socioeconomic status (SES) is of great interest to those who study children's development. Indeed, some studies showed that low SES children have lower maximal anaerobic power than high SES children [6]. The authors suggested the role of negative energetic balance in the limitation of muscle power in such children.

Identification of factors influencing the development of muscle power may lead to specific strategies to select young athletes, distinguish between different performance levels, or provide normative data for various athletic or patient populations [10]. Factors which determine anaerobic performance include muscle quantity, muscle fibre type, musculoskeletal architecture, and neuromuscular activation [23,50].

During growth, a short-term performance, such as jumping, throwing and short sprinting depends essentially on the anaerobic mechanisms. In this context, the ability to produce short-term maximal anaerobic power is related in part to variation in age, sexes, body size, especially fat-free mass and muscle cross-sectional area [14,29]. For example, Buchanan & Vardaxis [10] showed that height and weight are important predictors of muscle strength in young players. However, it has suggested that development changes in muscle power cannot be explained merely by quantitative changes in growth [14]. Other factors such as altitude, socioeconomic status, and children's physical fitness levels may also influence short-term maximal anaerobic power among children [5,6].

Some studies have shown that short-term anaerobic power is significantly affected by socioeconomic and nutritional status. Blonc et al. [6] showed that socioeconomic status had significant effects on aerobic and anaerobic power in prepubertal Bolivian girls. Anaerobic power (Pmax, force-velocity test, wingate test) was reduced in low socioeconomic status (LSES) Bolivian girls at both high and low altitude. Bedu et al. [2] found also that LSES Bolivian boys have lower peak power values developed during anaerobic exercises. The authors suggested the weaker maximal power observed in LSES boys in comparison with high socioeconomic status (HSES), as a direct consequence of impaired structural and metabolic muscle function due to nutritional deprivation during childhood, especially muscle volume and enzymes activities responsible for both anaerobic glycolysis and oxidative metabolism. Moreover, Jiménez Pavón et al. [18] showed positive associations between socioeconomic status and lower body muscular strength (standing long jump, squat jump, counter movement jump and Abalakov jump) in European adolescents. The low socioeconomic status, as assessed by family affluence, influences physical fitness (upper body muscular strength) in European adolescents independently of total body fat and habitual physical activity. The family affluence scale was used as an index of socioeconomic status, which includes 4 questions answered by the child: do you have your own bedroom? How many cars are there in your family? How many PC are there in your home? Do you have internet access at home? By contrast, in elderly person, Rantanen et al. [33] demonstrated that the socioeconomic status was not associated with muscle force. Syddal et al. [40] showed also that lower social class was associated with falls in grip strength among older women only. They reported that negative social circumstances characterized essentially by material deprivation.

More recently, Trabelsi et al. [45] showed that lung function parameters in healthy Tunisian children were influenced by socioeconomic status. However, little attention has been paid to the relationship between socioeconomic status, anthropometric variables and vertical jumping parameters in Tunisian athletic children.

The majority of research studies have examined the relationships between leg power and anthropometric parameters [9,10]. To the best of our knowledge, there is no study on the effect of socioeconomic factors on vertical jumping performance as well as on anthropometric parameters in athletic Tunisian children. We hypothesized that socioeconomic factors influence age, height, weight, fat-free mass and vertical jumping performance among athletic Tunisian children. Therefore, we undertook to evaluate the effect of socioeconomic status on vertical jumping performance and anthropometric characteristics among athletic Tunisian children aged 7 to 13 in both sexes

2. Methods

2.1. Experimental Approach to the Problem

This study was designed to examine the effect of socioeconomic status on vertical jumping parameters and anthropometric variables in athletic Tunisian children. 407 subjects (218 boys and 189 girls) were asked to perform Squat jumps (SJ), Countermovement jumps (CMJ) and to response to a questionnaire. Jump height and leg power were simultaneously provided by the Optojump photocells. Non parametric analysis of variance and General Linear Model (GLM) were used to analyze the data set and to identify which factors significantly influence performance variables.

2.2. Subjects

Four hundred and seven athletic Tunisian children (218 boys and 189 girls) ranging in age from 7 to 13 were selected randomly to be the subject of our study.

The subjects were selected by a two- level cluster sampling: (a) four out of 15 clubs from central Tunisia were randomly chosen. The sample included a mix of school children, from rural and urban areas; (b) the sample involved also children practicing many sports such as gymnastics, soccer, handball, volleyball, basketball, swimming and tennis. All players passed medical examinations within 15 days prior to the tests. All subjects who participated in the study had no injury of their lower limbs.

A medical questionnaire, recommended for epidemiological research was used to assess subject characteristics such as medical and surgical histories. After answering the questionnaire, subjects were selected according to the exclusion criteria defined as follow: The history of neurological (n=2), muscular (n=13) or cardiac diseases (n = 6), and 8 children unable to perform vertical jump tests adequately. On the basis of these criteria, 29 children from 436 were excluded. Finally, 407 athletic children were included in subsequent analysis.

Prior to the study, the coach, the children and their parents/guardian had been fully informed of the aim of the research, the protocol and the procedure of the investigation before signing a written consent, which was in accordance with legal requirements and the Declaration of Helsinki, and was approved by the ministry of

education and by the Research Ethics Committee of Farhat Hached Hospital (Sousse).

The athletic children are enrolled in a training program developed by their clubs, which consists of training 3 times per week for the children aged 7 to10 and 4 times per week for the children aged 11 to 13. Each training session lasted about 2 hours. During the competition season they participated each week in the official national championship.

2.3. Questionnaire

A medical questionnaire, modified from Ferris [16] and translated into the Arabic language, was distributed by the interviewer and was answered by the child with parent's assistance. This questionnaire was tested with 100 children before the study. The modified questionnaire was used previously by Trabesli et al. [45] in 756 Tunisian children. It was adapted according to the Tunisian context, and contained the essential information to assess the economic status of children, using some items proposed by the National Institute of Statistics [32]. The socioeconomic score was objectively assessed according to parental occupation which is a better indicator of the current socioeconomic status than education which can not reflect changes in social status that occur after schooling ends [13]. For example, in Tunisia, many poor families cooked and heated their home with wood until now. The social classes were assessed according to the classification used by Arshad & Hide [1] as follows: Class 1, professionals (doctors, solicitors and directors); Class 2, farmers, managers, teachers, engineers, etc.; Class 3, skilled workers, such as nurses and technicians; Class 4, low-skilled workers as factory works; Class 5, (a), unskilled workers, such as labourer, and Class 5 (b), unemployed

We group class1, 2 and 3 as high socioeconomic status (HSES) and class 4 and 5 as low socioeconomic status (LSES) [32]

2.4. Test Procedures

All subjects completed two preliminary familiarization sessions to minimize any effects of learning and to be informed about pretest instructions. The experiment was conducted during spring season in Tunisia. Ambient temperature and relative humidity values were between 18-20ºC and 35-50% respectively. In addition, the tests were performed in the afternoon (2 pm-4pm) to rule out a possible effect of the circadian rhythm on the performance [3].

Individuals were asked to sleep normally and to wear the same sportswear and shoes for all the tests. They were also asked to avoid solid food for 2 hours before the test.

The test-retest intraclass correlation coefficients of the testing procedure variables used in this study were >0.91 and the coefficients of variation ranged from 0.9 to 7.3%.

2.4.1. Vertical jumping tests

Jumping performance was evaluated with the Optojump photocell system (Microgate SRL, Italy), which consists of two parallel bars placed approximately 1 m apart and parallel to each other. Optojump bars were connected to a portable computer and the propriety software (optojump software, version 3.01.0001) allowed jump height quantification.

All subjects performed the squat jump (SJ) and countermovement jump (CMJ) in their sports clubs under the supervision of the same investigator which are two of the most used jump modalities in sport practice and testing [37].

The children were given two practice jumps before the specific jump test was conducted. Three jumps were separated by a 2 minutes rest period to ensure sufficient recovery.

For all jumps, the athletes started with their hands on their hips to eliminate the influence of the arms swing impulse [6]. For the SJ test, they were instructed to sink and hold a knee position (approximately 120º Knee angle) for three seconds. On the count of three the child was instructed to jump as high as possible without performing any countermovement before the execution of the jump. A successful trial was one where there was no sinking or countermovement prior to the execution of the jump [22].

The CMJ assessment required the child to be in a standing position and, prior to jumping, counter-moved until the knee was flexed approximately to 90º.They were then instructed to sink as quickly as possible and then jump as high as possible. Verbal encouragements were constantly given to maintain high motivation in these groups. All subjects performed 3 consecutive experimental trials for each jump. The highest value for each jump was retained for analysis [22].

2.4.2. Anthropometry

Prior to jump data collection, Standing and sitting heights were measured with an appropriate stadiometer (Harpenden Portable Stadiometer, UK) to the nearest 0.1 cm. The difference between the standing height and the sitting height allowed us to determine the leg length. Body weight was obtained with a digital scale (Harpenden Balance Scale, UK) to the nearest 0.1 Kg. Body mass index (BMI) was calculated as weight divided by the square of the height. Waist size was measured around the smallest part of his or her waistline underwear with tape measure. Skinfolds thicknesses were estimated to the nearest 0.1 mm using a Harpenden Skinfold Caliper (Holtain Ltd, Crosswell, UK). We measured biceps, triceps, subscapular and supra iliac skinfold thickness. Each was measured in duplicate on the left side of the body and the mean value was used for calculation. The errors of measurement were less than 1mm and the reliability was greater than 95% [31].

We predicted the body density from the equation of Johnston et al. [19].The conversion of body density to percent fat (% fat) was accomplished using the age-gender conversion constants of Lohman [26].

Body fat weight was calculated as follows: fat weight= %fat × (weight / 100). For determining fat-free weight, it has been calculated by subtracting fat weight from total body weight [11].

2.5. Statistical Analyses

All values were expressed as arithmetic means ± standard deviation (SD). Data from boys and girls were analyzed separately. The normality of all anthropometric

and vertical jumping parameters was tested by Kolmogorov-Smirnov tests [38].

All means were compared using the Kruskal-Wallis nonparametric analysis of variance [24].

We used General Linear Model (GLM) and multiple regressions to reveal the global effect of anthropometric variables and socioeconomic status on jumping performance parameters.

Data were analyzed using the statistical software (SPSS version 17.0). Statistical significance was set at $p < 0.05$.

3. Results

3.1. Anthropometric characteristics

Frequency distributions in both genders according to socioeconomic status are shown in Figure 1. We classified class groups 1, 2 and 3 as high socioeconomic status (HSES) and class groups 4 and 5 as low socioeconomic status (LSES). The two Socioeconomic classes were homogeneous ($p < 0.05$). (Figure 1).
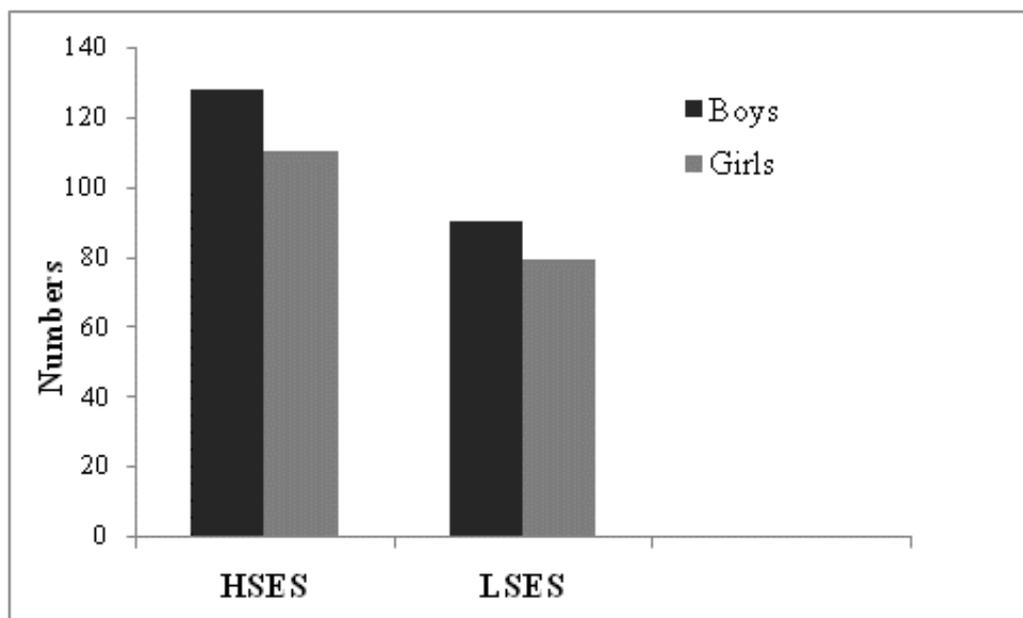

Figure 1. Frequencies distribution of athletic Tunisian children according to socioeconomic status and gender

The anthropometric characteristics of boys and girls of high (HSES) and low socioeconomic status (LSES) are presented in Table 1. Boys and girls of HSES and LSES were statistically ($p < 0.05$) different for all anthropometric variables except for body mass index and fat-free mass.

Non parametric comparison of means revealed significant effect of the socioeconomic status on body mass index and body fat only in boys. Significant differences ($p < 0.05$) were found in age, standing height, sitting height and leg length among the HSES and LSES girls.

Table 1. Mean and ± standard deviation of anthropometric variables of boys and girls of high (HSES) and low socioeconomic status (LSES)

Anthropometric characteristics	Boys		Girls	
	HSES	LSES	HSES	LSES
Number	128	90	110	79
Age (years)	10.1 ± 1.8 *	9.7 ± 1.9	9.6 ± 1.9	10.2 ± 1.8§
Standing height (m)	1.40 ± 0.09	1.39 ± 0.09 *	1.42 ± 0.14	1.47 ± 0.13§
Sitting height (m)	0.70 ± 0.04*	0.69 ± 0.04 *	0.71 ± 0.05	0.73 ± 0.05§
Leg length (m)	0.70 ± 0.06	0.69 ± 0.06 *	0.70 ± 0.09	0.73 ± 0.09§
Waist size (m)	0.62 ± 0.06	0.61 ± 0.06 *	0.63 ± 0.08	0.65 ± 0.08
Body mass (kg)	35.08 ± 7.21	33.46 ± 6.52 *	35.93 ± 9.02	37.67 ± 8.53
Body mass index (kg.m^{-2})	17.57 ± 1.59§	17.08 ± 1.45	17.50 ± 1.84	17.21 ± 2.16
Body fat (kg)	3.01 ± 1.81 §	2.38 ± 1.51 *	4.40 ± 2.29*	5.04 ± 2.55
Fat-free weight (kg)	32.01 ± 6.01	31.06 ± 5.50	31.58 ± 7.09	32.71 ± 6.65

Significant difference between boys and girls in the same socio economic status: *****$p < 0.05$
Significant difference between HSES and LSES in boys and girls : **§** $p < 0.05$
HSES = High Socio-economic status
LSES = Low socio-economic status

3.2. Vertical Jumping Performance: Effect of Sexes and Social Economic Status

Mean and standard deviation of vertical jumping performance in athletic Tunisian children by socioeconomic status and sex are shown in Table 2.

For the Countermovement Jump (CMJ), the HSES and LSES boys demonstrated significantly ($p < 0.05$) higher CMJ height and CMJ power than HSES and LSES girls.

There were no significant differences in vertical jumping parameters between HSES and LSES in both sexes.

Table 2. Mean and ± standard deviation of jumping performance in athletic Tunisian children by socio-economic status and sex

	Boys		Girls	
	HSES	LSES	HSES	LSES
Number	128	90	110	79
CMJ height (m)	0.17 ± 0.03*	0.17 ± 0.03	0.16 ± 0.03	0.16 ± 0.03
CMJ power (W.Kg^{-1})	13.9 ± 2.7*	14.2 ± 2.86*	13.1 ± 2.9	13.2 ± 2.6
SJ height (m)	0.16 ± 0.03	0.16 ± 0.03	0.16 ± 0.04	0.16 ± 0.03
SJ power (W.Kg^{-1})	13.2 ± 2.7	13.2 ± 2.6	13.5 ± 2.9	13.6 ± 2.6

Significant difference between boys and girls in the same socio economic status: ***$p < 0.05$.
CMJ = Counter-Movement Jump**HSES = High Socio-economic status
SJ = Squat Jump.**LSES = Low socio-economic status

3.3. Univariate Liaisons between Anthropometric Variables and Vertical Jumping Performance

Spearman correlations coefficients were calculated to check the influence of interaction between anthropometric and vertical jumping parameters. Spearman correlations of anthropometric variables and socioeconomic status with vertical jumping parameters in HSES and LSES athletic children are displayed in Table 3 and Table 4.

Anthropometric variables were correlated significantly with CMJ power, CMJ height, SJ power and SJ height in HSES and LSES children. HSES children presented statistically significant correlations coefficients with standing height (Figure 2), sitting height, leg length (Figure 3), waist size, body mass (Figure 4), fat-free mass (Figure 5). However, LSES children presented only statistically correlations with age, standing height, leg length and fat free mass. Similar results were observed with SJ power.

Table 3 .Spearman correlation coefficients (r) between vertical jumping parameters and anthropometric measures in HSES athletic Tunisian children (n=238)

	CMJ power (W.Kg-1)	CMJ height (m)	SJ power (W.Kg-1)	SJ height (m)
Age (years)	0.35**	0.48**	0.25**	0.39**
Standing height (cm)	0.30**	0.39**	0.24**	0.36**
Sitting height (s)	0.24**	0.30**	0.21**	0.28**
Leg length (cm)	0.28**	0.39**	0.22**	0.36**
Waist size	0.17**	0.24**	0.11*	0.23**
Body mass (Kg)	0.23**	0.36**	0.18**	0.33**
Body mass index (kg.m^{-2})	0.01	0.10*	0.003	0.11*
Body fat	-0.006	0.08	0.02	0.09*
Fat-free mass	0.28**	0.41**	0.22**	0.38**

* $p < 0.05$, ** $p < 0.01$.

Table 4. Spearman correlation coefficients (r) between vertical jumping parameters and anthropometric measures in LSES athletic Tunisian children (n=238)

	CMJ power (W.Kg^{-1})	CMJ height (m)	SJ power (W.Kg^{-1})	SJ height (m)
Age (years)	0.25**	0.45**	0.25**	0.31**
Standing height (cm)	0.16*	0.32**	0.19**	0.23**
Sitting height (s)	0.13	0.26**	0.22**	0.19**
Leg length (cm)	0.15*	0.32**	0.14	0.23**
Waist size	0.12	0.28**	0.11	0.23**
Body mass (Kg)	0.15	0.34**	0.14	0.20**
Body mass index (kg.m^{-2})	0.02	0.09	-0.06	-0.08**
Body fat	-0.09	0.08	0.02	0.021
Fat-free mass	0.21*	0.38**	0.18	0.24**

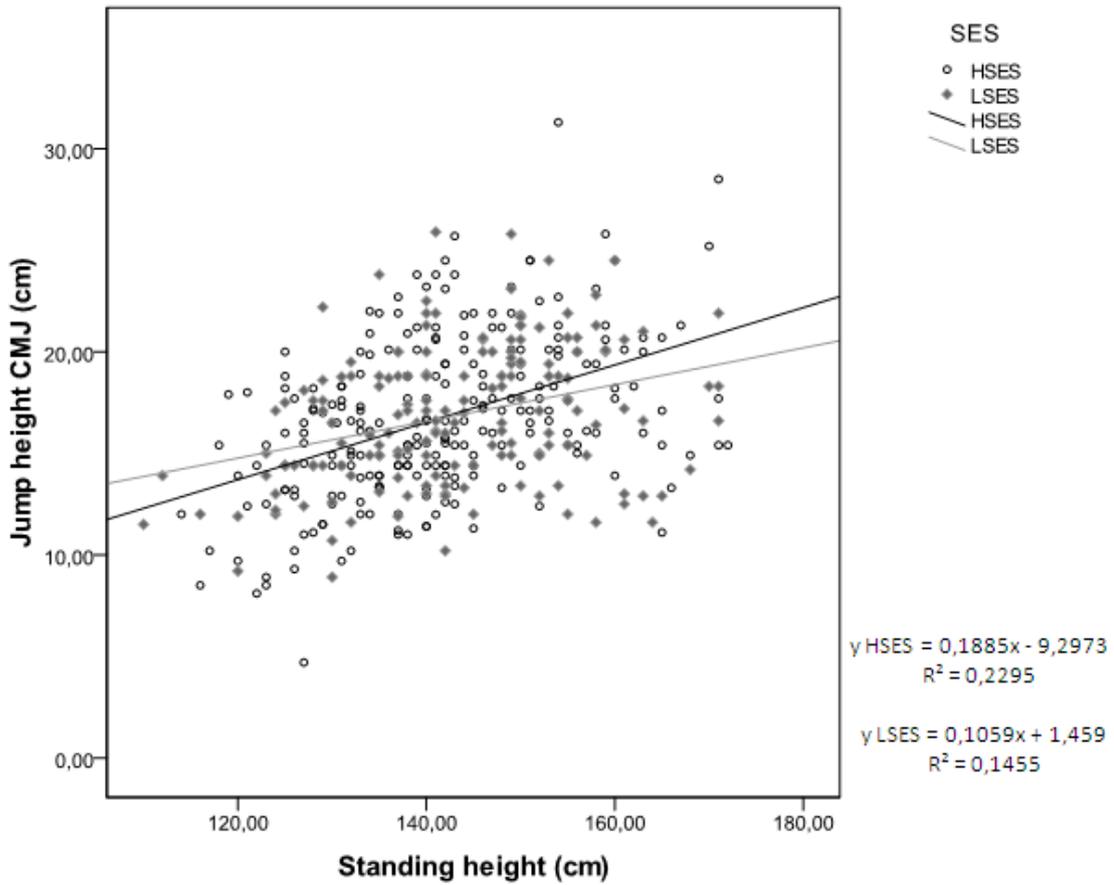* $p < 0.05$, ** $p < 0.01$.

Figure 2. Relationships between jump height and standing height in the children of high (HSES) and low (LSES) socioeconomic status during the countermovement jump (CMJ)
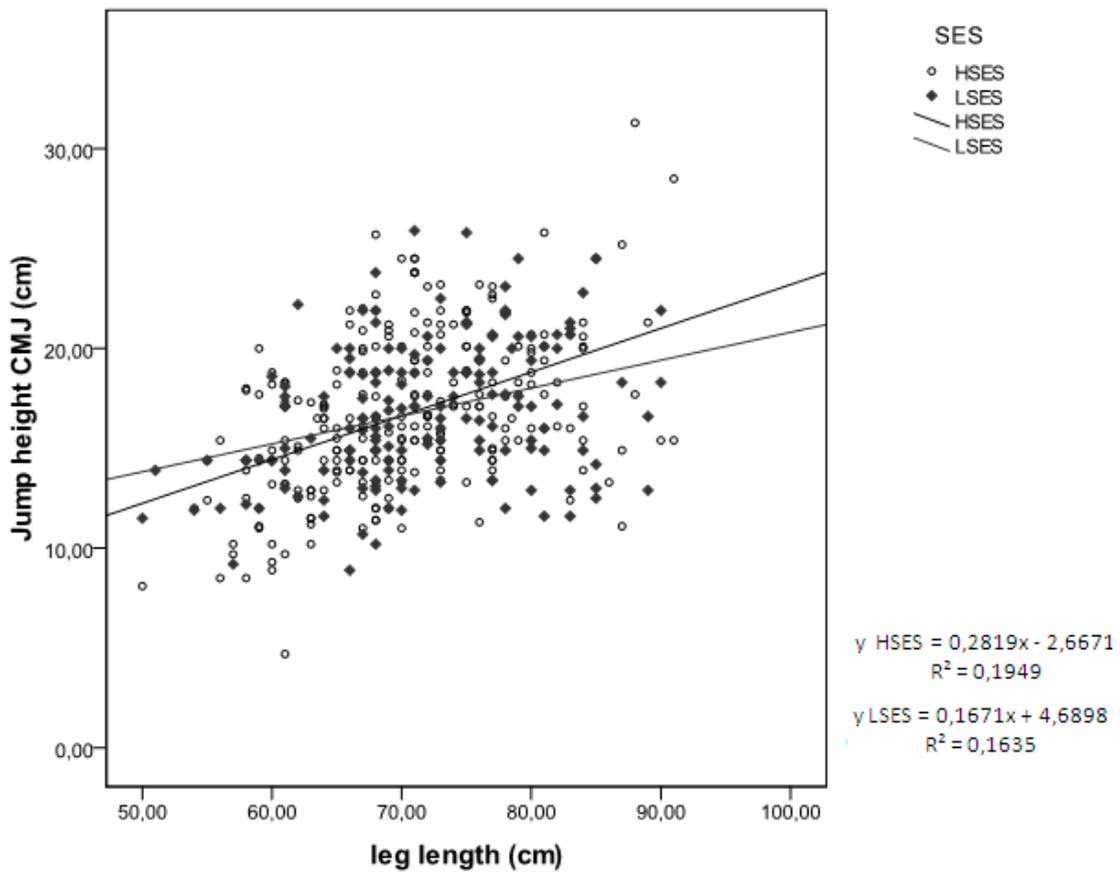

Figure 3. Relationships between jump height and leg length in the children of high (HSES) and low (LSES) socioeconomic status during the countermovement jump (CMJ)
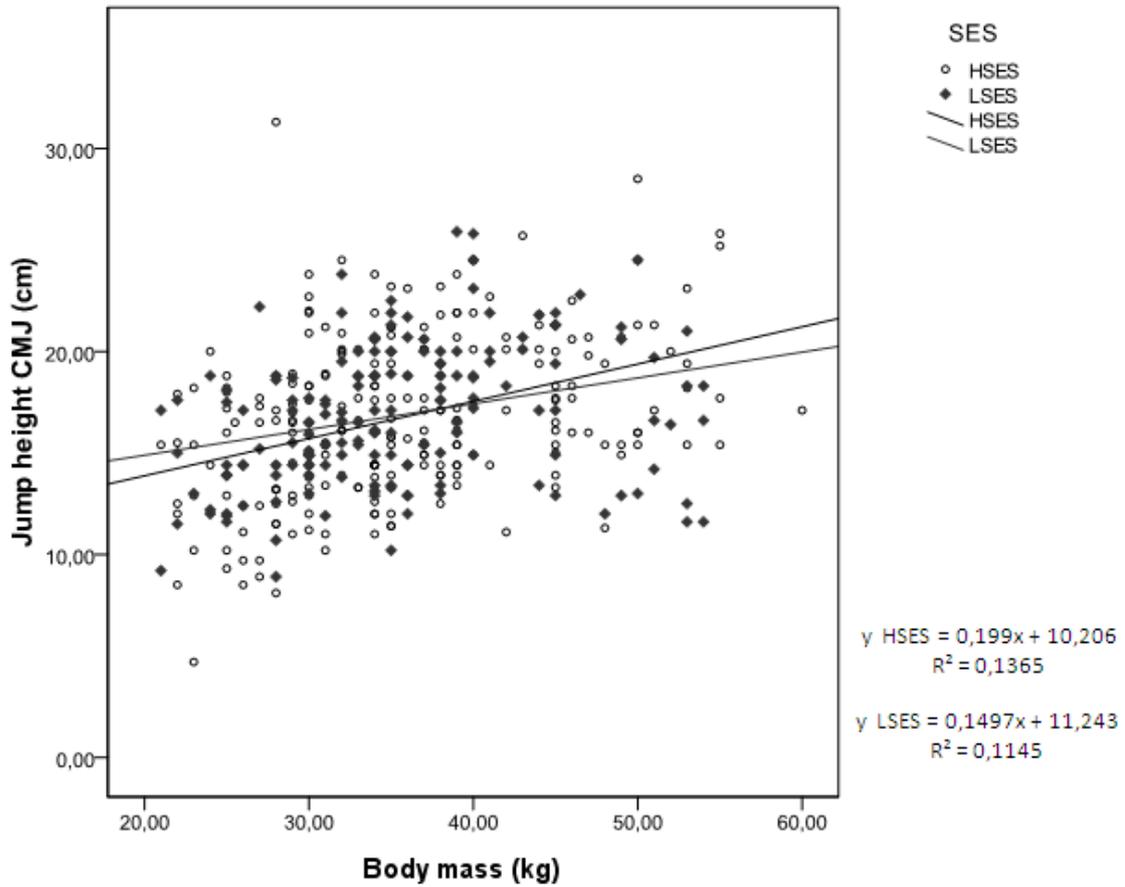
Figure 4. Relationships between jump height and weight in the children of high (HSES) and low (LSES) socioeconomic status during the countermovement jump (CMJ)
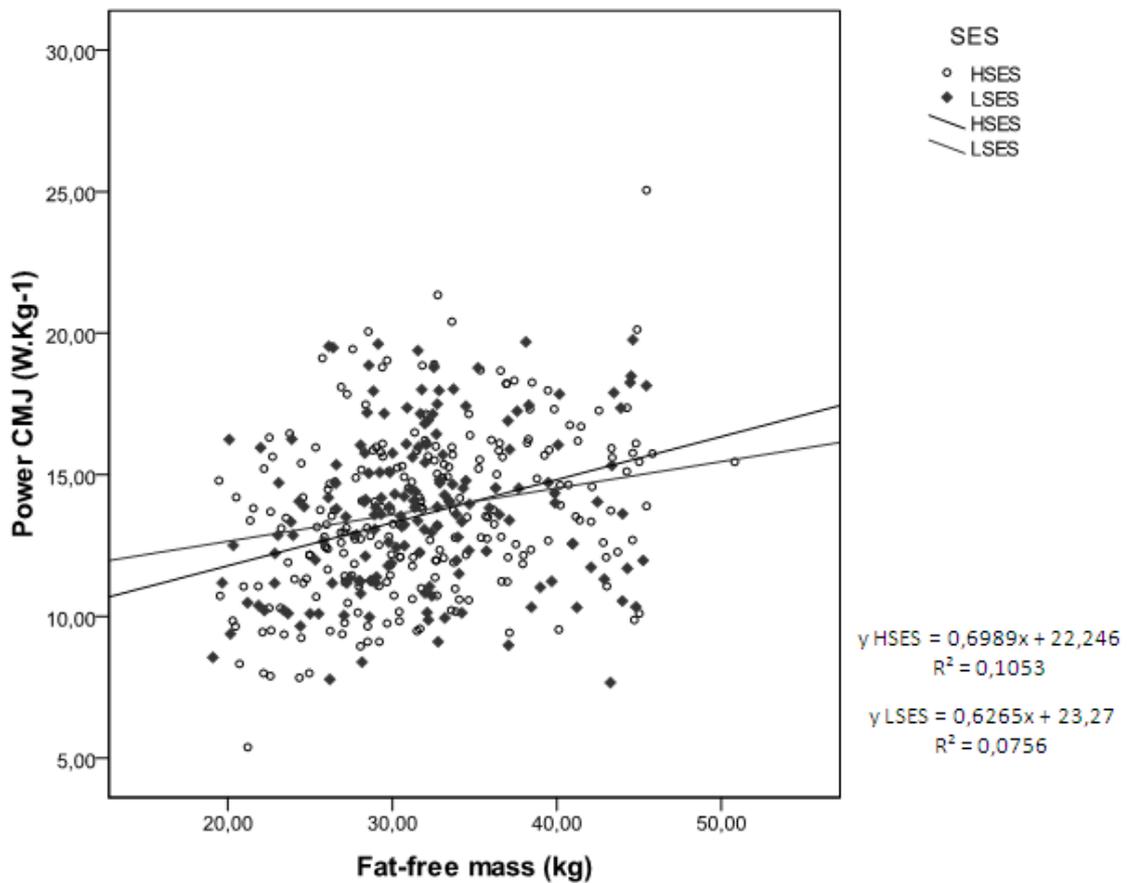

Figure 5. Relationships between power and fat-free mass in the children of high (HSES) and low (LSES) socioeconomic status during the countermovement jump (CMJ)

Only body fat was inversely correlated with CMJ power in HSES children (r= -0.006). Body mass index was also inversely correlated with SJ power (r = -0.06) and SJ height (r = -0.08, p < 0.01) in LSES children.

3.4. Relationships between Anthropometric Characteristics, Socioeconomic Status and Vertical Jumping Performance in Athletic Tunisian Children

Correlations between dependent vertical jumping performances and anthropometric parameters in HSES and LSES children were significant (Table 3 and Table 4).

Results of general linear model analyzing the multiple predictors (independent variables) of vertical jumping parameters were shown in Table 5. In this global way, waist size, sitting height, body mass index, leg length, body fat, socioeconomic status, had no significant correlations with vertical jumping parameters. However, for the other anthropometric parameters significant correlations were found for sex, age, height, body mass and fat-free mass for CMJ height, CMJ power, SJ height and SJ power ($P < 0.05$). The multiple linear regressions showed that age and sex were the major explanatory variables for jumping performances ($R^2 = 0.26$, $R^2 = 0.15$; $R^2 = 0.16$; $R^2 = 0.06$; $p < 0.05$ respectively), whereas the socioeconomic status and the others anthropometric measurements (Height, body mass, fat-free mass, waist size, sitting height, body mass index, leg length, body fat) were excluded from the predictive equations (data not shown).

Table 5. General linear model analyzing the multiple predictors (independent variables) of vertical jumping performance variables in athletic children. Tests of global effects

Predictors	Dependent variables			
	CMJ height	CMJ power	SJ height	SJ power
Sex	P=0.876	P=0.167	P=0.014	P=0.008
Age	P=0.000	P=0.001	P=0.000	P=0.018
Height	P=0.190	P=0.597	P=0.199	P=0.048
Body mass	P=0.195	P=0.014	P=0.865	P=0.006
Fat-free mass	P=0.101	P=0.005	P=0.320	P=0.005
Waist size	P=0.455	P=0.526	P=0.753	P=0.629
Sitting height	P=0.196	P=0.860	P=0.114	P=0.122
Body mass index	P=0.721	P=0.696	P=0.514	P=0.417
Leg length	P=0.247	P=0.758	P=0.160	P=0.094
Body fat	P=0.542	P=0.412	P=0.046	P=0.542
Socioeconomic status	P=0.876	P=0.970	P=0.898	P=0.614

4. Discussion

The main findings of the present study that the socioeconomic status did not influence vertical jumping parameters in our athletic Tunisian children.

The measurements of performance in vertical jump are objectively provided by the optojump system which is valid and reliable for jump height estimation [17].

The CMJ and SJ were chosen because they have been found to be the most reliable and valid field tests for assessing the explosive power output of the lower limbs in physically active subjects [27]. We only selected athletic children whose jumping performance was found to be reproducible.

The socioeconomic score was objectively assessed according to parental occupation which is a better indicator of the current socioeconomic status than education which can not reflect changes in social status that occur after schooling ends [13]. The association between vertical jumping performance and anthropometric parameters with each of the four classes were difficult to interpret because of the insufficient size of socioeconomic classes. Therefore we divided the whole sample into two categories the High (HSES) and low (LSES) socioeconomic status as suggested by Blonc et al. [6]

4.1. Anthropometric Characteristics

Anthropometric differences found between boys and girls from the same socioeconomic status may be explained by the growth and mature processes [34]. Our study included children aged between 7 and 13 years, and the onset of puberty corresponds classically to a biological age of ≈ 11 years in girls and 13 years in boys [42]. Under the influence of testosterone, which is a potent anabolic hormone, boys have a significant increase in lean body mass exceeds the total gain in weight because of the concomitant loss of adipose tissue [41]. Sex differences could occur previously in children [43,44].

Differences between HSES and LSES of girls in anthropometric parameters could be explained by the growth.

4.2. Vertical Jumping Performance

We found that boys jumped higher than girls in HSES and LSES. Hormonal secretion plays a key role. Indeed, testosterone, Growth Hormone (GH), Insulin-like Growth Factor I (IGF-I) and insulin influence muscle hypertrophy during growth and maturation. Testosterone concentration, starts increasing at puberty, this is associated with significant muscle hypertrophy in prepubertal trained

subjects [49]. Moreover, increasing levels of testosterone induce differentiation of muscles fibers in boys compared to girls, especially fast-twitch fibers [20].

We found no significant differences in vertical jumping performances between two HSES and LSES classes in athletic Tunisian children. However other studies reported by Doré et al. [14], Jiménez Pavón et al. [18], and Bedu et al.[2] revealed that power output were significantly affected by socioeconomic status. Others studies demonstrated that LSES children had significantly lower anaerobic performance than HSES children [14].We paid attention that these studies were interested in untrained subject.

Indeed, the low socioeconomic class (LSES) is a complex reality composed by several interrelated factors of which under nutrition is only one. Malnutrition could lead to a reduction in physical growth [39] and thereafter to the peak muscle power. In our study, the lack of differences in jump performances between HSES and LSES athletic children could be explained by an adequate daily dietary intake. Indeed, our children trained regularly in sport clubs, they could have free equilibrated meals. This could attenuate the effect of socioeconomic status on performance. Furthermore, they are well attended by pediatrician, who must alert for signs and symptoms of under nutrition and/or overtraining. So, sports clubs provided similarly adequate attention to their high (HSES) and low (LSES) athletic Tunisian children.

Moreover, Training programmes may contribute improving strength [35] which is another explanation for the lack of differences in vertical jumping performance between HSES and LSES children. In fact, each training programme affects muscle differently depending on recovery time and exercise intensity. However, in general, short periods of high muscle load with long recovery periods induce an adaptive response of anaerobic metabolism such as increases in phosphocreatine (PCr) kinase activity, while longer periods of effort have no effect on PCr metabolism, but induce a greater adaptative response in glycolytic metabolism [12,36].

Linossier et al. [25] revealed that sprint training caused a large increase in maximal power, mainly due to an increase in strength. However, the ability to develop strength in training seemed to be related more to intrinsic fibre properties (% fast twitch b fibre area and adenylate kinase activity). Indeed, increases in the proportion of type II muscle fibres with sprint training connected with the transformation of slow twitch fibre and fast twitch b fibres into fast twitch a fibres.

4.3. Relationship between Vertical Jumping Performance and Anthropometric Characteristics

In agreement with recent studies, we found correlations between power jump height and age in HSES and LSES athletic children [43,46]. Tsubaki et al. [46] found a high correlation between age and maximum power in physically active Japanese males and females under 20 years old. Taylor et al. [43] showed that Jump height and peak power increased progressively year by year for males between 10 and 15 years. Some investigators have suggested that sex- and age-related differences in anaerobic performance may be attributed to differences in

the ability to recruit and activate muscle during exercise [50]. Vandewalle et al. [47] reported correlations between body mass, vertical jump and peak power measured during force-velocity test. The authors suggested that athletes with high jump performances or peak power have high percentage of type II muscle fibres.

We also found that height, weight, leg length and lean body mass were correlated with leg power and jump height. This could be explained by the increase in muscle length during growth which contribute to power, since the power of a muscle is determined by its volume, as the product of the mean cross-sectional area and length [43]. This data is in agreement with study reported by Markovic & Jaric [28], who suggested that power calculated from the ground reaction force recorded during different types of maximum vertical jumps, was strongly related to body size.

In our study, we found high correlation between fat-free mass and leg power in trained children. This is an agreement with the study of Mercier et al. [30] who reported that lean body mass explained 88% of the total variance of maximal anaerobic power.

Jump weight measurements is a simple practical tool helping to identify talented children in explosive sports that require movement of body mass or the manipulation of an external mass [43].

4.4. Multiple Regression Equations of Jumping Performances Predicted in Healthy Tunisian Children

The general linear model and analysis of multiple regression equations allowed us to study the interrelation between the various liaisons with the vertical jumping performance globally and within each predictive factor. Using this statistical method we were able to determine that, in HSES and LSES Tunisian athletic children, the main factors affecting the vertical jumping performance were the sex, age, height, weight and fat-free mass ($P < 0.05$). The multiple stepwise regressions also indicated that sex and age were the major explanatory variables of jumping performances in HSES and LSES athletic Tunisian children.

In conclusion, using multivariate analysis in the whole population and by socioeconomic status, we have shown that morphologic parameters; sex, age, height, body mass and fat-free mass were the main factors affecting vertical jumping performance. These findings are important because identification of factors affecting vertical jumping performance may help to improve muscular performance by evaluating individual athletes, detecting talented young athletes and protecting trained children from possible injury.

Acknowledgments

Conflict of Interest

There is no conflict of interest regarding the information provided in this study.

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