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Socio-demographic differences in Colombian children's muscular fitness. Does scaling for differences in body size present a challenge to conventional thinking?

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Running Head: Colombian children's muscular fitness

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Abstract

Objectives: In low- to middle-income countries, children from less-deprived areas (from families of higher socio-economic status [SES]) have superior muscular fitness than those from low-SES groups. They are also taller and heavier, factors associated with muscular fitness. The purpose of this study was to identifying any socio-demographic differences in Colombian children's muscular fitness and examining how these conclusions can be modified by scaling for differences in body size.

Methods: A total 38,098 youths (46% girls), of 9th grade students (aged 14 to 15 years) participated using a cross-sectional design. We recorded socio-economic status and family incomes, stature and mass. Standing broad jump and handgrip strength were used to assess muscular fitness. A multiplicative allometric model was adopted to adjust for body-size differences.

Results: Children from the mid- to high-SES groups jumped significantly higher than the children from lowest SES group, although no SES group difference in grip strength was observed. After adjusting for body size, children from higher SES and with higher family incomes had significantly lower handgrip strength, and their superior jump height performances remained but were greatly reduced. Only children from the highest SES now jumped significantly higher that the lowest SES group.

Conclusions: The superior jump performance and no difference in handgrip strength of Colombian children from higher SES may simply reflect their superior physiques. When body size is accounted for, these differences are reduced or even reversed suggesting that children from higher SES groups should not be complacent regarding their apparent superior muscular fitness.

Keywords: Allometric; multiplicative allometric model; socio-economic status; Low-middle income countries.

Introduction

Musculoskeletal strength and power (muscular fitness) are recognised as important indicators of metabolic health status in youth (Steene-Johannessen, et al., 2009; Artero, et al., 2011; Grontved, et al., 2015; Ramirez-Velez, et al., 2016). While associations between cardiorespiratory fitness and cardiovascular risk factors have been evaluated in youth from both high- and low-middle income countries, studies examining interactions between muscular strength and health related risk factors have been conducted exclusively in high income countries, and largely in Caucasian cohorts. There is a need to also assess these associations in low-middle income countries, where there is a larger and more rapidly increasing burden of non-communicable disease (Cohen et al., 2014).

The benefits of good muscular fitness are particularly evident in populations with excess adiposity or high body mass (Steene-Johannessen, et al., 2009; Artero, et al., 2011; Cohen et al., 2014; Cohen et al., 2016).

Exposure to social deprivation produces childhood health inequalities that may persist into adult life (Shishehbor, et al., 2008). We conceptualise socio-economic status as a combined measure of an individual's or family's economic and social position in relation to others, based on income, education, and occupation. Children from less-deprived areas (or from families of higher socio-economic status [SES]) have better aerobic and muscular fitness than those in low-SES groups (Jimenez-Pavon, et al., 2010; Jin and Jones-Smith, 2015). Children in higher SES groups are also taller and have greater lean body mass than those of lower SES (Sandercock, et al., 2017; Monyeki, et al., 2005).

In developed nations, SES is positively associated with indices of childhood physical fitness (Jimenez-Pavon, et al., 2010; Jin and Jones-Smith, 2015). A more complex, curvilinear association appears to exist in low- to middle-income countries

(LMICs) (Petroski et al., 2012; Petroski et al., 2012). Research has indicated that, in low-middle income countries, family SES is inversely associated with physical fitness (Garber, Sajuria, and Lobelo, 2014). SES disparity is considered the most fundamental cause of health disparities and physical fitness is a predictor of adult health and disease (Leong, et al., 2015). The PURE study of over 140,000 adults across low, middle, and high-income countries, reported that the lowest income countries had the lowest mean value for handgrip strength while highest income countries had the highest mean values (Leong et al., 2015).

The superior fitness of children from high-SES backgrounds has been attributed to differences in habitual physical activity between SES groups (Jimenez-Pavon et al., 2010; Vandendriessche et al., 2012; Esmaeilzadeh et al., 2013). Differences in muscular fitness could also be the product of SES-related differences in body dimensions (Sandercock, et al., 2017; Monyeki, et al., 2005).

Understanding how best to scale measures such as muscular fitness is important for researchers and policy makers in public health, education and the exercise sciences (Nevill et al., 1992). Appropriate scaling helps ensure valid inferences can be made when investigating physiological differences in populations that also differ in terms of body size (Silva et al., 2016).

In LMICs, high SES children are taller and heavier than those with lower SES (Sandercock, et al., 2017; Monyeki, et al., 2005). Where SES differences in fitness are reported, there are often also differences in body size between the SES groups (Monyeki et al., 2005). Such body size differences may confound any analysis of how fitness may differ as a consequence of SES. Few studies adjust for the potential confounding effects of body mass (Cohen et al., 2014; Otero et al., 2017), none adjust for both stature and mass unless expressed as BMI in an attempt to adjust for adiposity. In LMICs however,

BMI is more strongly and positively associated with lean body mass than adiposity (Sandercock, et al., 2017; Monyeki, et al., 2005). It may therefore be important to account for both stature and body mass independently when attempting to understand how body size may influence muscular fitness in children from LMICs.

There is growing evidence that muscular fitness can aid prevention and treatment metabolic disease independent of adiposity (Thivel et al., 2016). Allometric models provide valuable insight into the most appropriate body dimensions associated with children's physical performance and shape characteristics (Silva et al., 2016).

Allometric scaling may provide a more culturally specific method to understand the relative contribution of anthropometric and socio-demographic influences on the muscular fitness of children (Dos Santos et al., 2016). There is strong evidence that body size varies according to socio-economic status in Colombian children (Sandercock et al., 2017) but associations between SES and of muscular fitness are less well-described (Cohen et al., 2014; Zhang et al., 2017). To date, there are no data on the scaling of muscular fitness in Colombian children. This study sought to address this issue by identifying any socio-demographic differences in Colombian children's muscular fitness and examining how these conclusions might be influenced by appropriately scaling for differences in body size.

Materials and Methods

Study design and participants

The sample consisted of children drawn from the combined 'Curriculum 40 x 40' and 'Prueba Ser' surveys administered by Bogota's District Secretary of Education in November 2015. These were cross-sectional surveys of 9th grade students (aged 14 to 15 years) recruited from public and private schools in all 20 'localidades' (municipalities) within the District Capital of Bogota (Cundinamarca Department, Andean Region of Colombia).

The Study was approved by the Review Committee for Research in Human Subjects at the University of Rosario (Code N° CEI-ABN026-000262). The nature and purpose of the study were given to potential participants and their parents or guardians explaining that data would be available to the Colombian Health Authorities in accordance with the Law of Data Protection (Resolution 8430/93). Further details regarding the sample and study design can be obtained here: http://www.educacionbogota.edu.co/archivos/Temas%20estrategicos/Documentos/Resultados _PruebasSER-Bienestar_Fisico_Ciudadania_y_Convivencia.pdf .

Anthropometric variables

Data on the variables were collected at the same time in the morning (between 7:00 a.m. and 10:00 a.m.) following an overnight fast in accordance with the ISAK (International Society for the Advancement of Kinanthropometry) guidelines (Stewart et al., 2011). Mass was measured to the nearest 0.10 kg with the participant lightly dressed using a portable electronic weight scale (Tanita® BC544, Tokyo, Japan) with a low technical error of measurement (TEM= 0.510). Stature was measured to the nearest 0.1 cm in bare or stocking feet with the adolescent standing upright against a portable stadiometer (Seca® 274, Hamburg, Germany; TEM = 0.019).

Social economic status and family income

SES was determined using the System of Identifying Potential Beneficiaries of Social Programs (SISBEN, 1-6 on a scale defined by the Colombian authorities) (The World Bank, 2005). SISBEN is a composite score based on sociodemographic characteristics (family composition, employment status, level of educational); living conditions (dwelling type, construction materials) and access to public utilities (sewerage, electricity, potable water,

refuse collection). Note that the term 'dwelling' refers to where the children lived rather than where they went to school and the term 'family composition' refers to as a person or group of persons that live in a house or part of it and share food or food budget. Level of education is classified based on the median level of education attained by residents in each given geographical area. Households are ranked or split into 6 strata with SISBEN with 1-very low, 2-low, and 3-medium-low are the most vulnerable and targeted in social programs. SISBEN level 4-medium, 5-medium high, and 6-high strata are considered the least vulnerable sectors of society. SISBEN 4-6 are regarded as wealthy, and for the purposes of the present study we conceptualised SES as 4 categories 'Very Low', 'Low' and 'Medium', corresponding to SISBEN categories 1-3, and 'High' corresponding to SISBEN categories 4-6. Parental income data was used to create the variable. Parental income data was used to create the variable 'Family Income' according to the classification used by the District Secretary of Education and SISBEN at the time of enrolling the child in school in Jan 2014. This variable was grouped into three categories as 1 (low, ≤$ 205 USD per month), 2 (middle, >$205 < $410 USD per month), and 3 (high > $ 410 USD per month). 'Family income' reflected the average monthly income of all members of the household (i.e., both parents). The average monthly income for Colombia is $380 USD.

Muscular fitness measurement

Musculoskeletal fitness was assessed using two tests. The Standing broad jump (Jump) was used assess lower body muscular fitness. Participants were instructed to jump as far as possible using a two footed take-off and landing technique. They were encouraged to flex then extend their knees, ankles, and hips and to swing their arms to maximise performance. Test performance was assessed by measuring the distance between participants' toes at take off to the heel at landing. Participants were required to

execute two jumps using the correct technique with performance recorded as the greatest distance achieved in either jump. The reproducibility of our data reached R=0.78.

Handgrip strength was assessed as an indicator of upper-body muscular fitness using an adjustable analogue handgrip dynamometer (Takei Scientific Instruments Co., Ltd, Niigata, Japan). Researchers provided standardized verbal instructions describing the correct execution of the test before providing a visual demonstration of the technique. Dynamometers were adjusted to account for differences in hand size. Handgrip strength was measured with the subject in a standing position with the shoulder adducted and neutrally rotated and arms parallel but not in contact with the body. The participants were asked to squeeze the handle for a maximum of 3–5 seconds. No verbal encouragement was given during the test. Participants performed two trials with each hand. The values used in the present study represent the highest value obtained with either hand. This procedure was employed as asymmetry in hand grip strength as a function of hand dominance is rare in children of the ages taking part in the present study (Butterfield, et al., 2009). The reproducibility of our data was R = 0.96.

Statistical methods

An appropriate method of analyzing hierarchical data (children nested within schools) is to adopt a multilevel modelling approach using the Statistical Software MLwiN version 2.36. Multilevel modelling is an extension of ordinary multiple regression where the data have a hierarchical or clustered structure. A hierarchy consists of units or measurements grouped at different levels. In the current study, the multilevel regression analyses were performed to identify those factors (differences in SES, family income, rural versus urban etc.) associated with the development of hand-grip strength and jump performance respectively, both before and after adjusting for differences in body size (stature and

mass). The two levels of hierarchical or nested observational units used in the analyses were, (i) the children at level 1 (within schools), and (ii) between the schools at level 2.

Human strength and work capacity increases proportionally with body size (Nevill et al., 1985; Bustamente Valdivia et al., 2015). Adapting a multiplicative, allometric model structure that has been used to describe a variety of human performance indices, such as hand grip strength (Nevill and Holder, 2000), strength and aerobic power (Nevill et al., 1985), physical performance (Bustamente Valdivia et al., 2015), the proposed model for the grip strength and jump performances of the Colombian 9th grade children (aged 14 to 15 years) measurements (Y) is given as follows:

$$Y = \text{stature}^{k_1} . \text{mass}^{k_2} . \exp(b_0 + b_1 . \text{age}). \tag{1}$$

The model (Eq. 1) can be linearized with a log transformation using natural logs (Ln). A linear regression analysis on Ln(Y), can then be used to estimate the unknown parameters of the log transformed model (Eq. 2).

$$\text{Ln(Y)} = k_1 . \text{Ln(stature)} + k_2 . \text{Ln(mass)} + b_0 + b_1 . \text{age} \tag{2}$$

Further categorical or group differences within the population (e.g. different in SES, family income, rural versus urban etc.) can easily be explored by allowing some of the parameters in the log transformed model (Eq. 2) to vary for each group (by introducing fixed indicator factors).

The proportional model (Eq.1) also assumes that the residual errors of Y are heteroscedastic (proportional), that is, the error variance will increase with larger measurement means and conversely decrease with smaller means. Thus, by fitting the parameters using log-linear regression (Eq.2), it is assumed that the residual error variance of the log transformed handgrip strength and jump performance measurements remains constant throughout the range of observations.

Results

In our sample of 38,098 youths (46% girls and 54% boys), girls were 5% shorter, weighed 3% less, achieved handgrip strength scores 23% lower, and jumped 26% lower compared to boys (see Table 1a and 1b). Importantly boys and girls from the higher SES groups were both taller and heavier than children from the lower SES groups.

Table 1 here

Handgrip results

Compared to our baseline group (boys from the very lowest SES, with the lowest family income, and from an urban background), there were little or no significant differences in handgrip strength (log transformed) between all other groups other than girls having approximately 25% lower handgrip (Δb_0=-0.25 SE=0.0019) after adjusting for age. Hand grip strength increased significantly at approximately 7% per year (b_1=0.071, SE=.002) (Table 2, Model i).

However, after adjusting for both body size (mass and stature) and decimal age, we found that children from higher SES and with higher family incomes had significantly lower handgrip strength (Table 2, Model ii). Also, children living in rural locations had significantly higher handgrip strength 4% (Δb_0=0.0386, SE=.0133) than children living in urban locations. After adjusting for both body size and age, girls had approximately 17% lower handgrip strength and the children's handgrip strength increased at a lower, but still significant rate of approximately 4% per year (body size explaining both these (sex and age) reductions in hand grip performances observed in model I earlier). This indicates that

handgrip strength increases at a rate of 4% per year having already controlled for body size.

Note that the contributions of log-transformed mass and stature were both positive and highly significant (see Table 2, Model ii).

Table 2 Here

Jump results

Compared to our baseline group (boys from the very lowest SES, with the lowest family income, and from an urban background), children from the mid- to high-SES groups jumped significantly higher than children from lower SES groups. Girls also jumped approximately 31% lower (Δb_0=-0.31 SE=0.0016) than boys after adjusting for age alone. No difference in mean jump heights were observed between family-income groups nor urban vs rural locations. Jump height also increased significantly at approximately 2.5% per year (b_1=0.0246, SE=.0017) (Table 3, Model i).

After adjusting for both body size (mass and stature) as well as decimal age, we found that the differences observed in model ii remained but were greatly reduced. Only children from the highest SES group jumped significantly higher that the baseline SES group. As observed in model i, no difference in mean jump heights were observed between family-income groups nor urban *vs* rural locations. After adjusting for body size, girls jumped approximately 26% lower (Δb_0=-0.259 SE=0.0019) than boys having also adjusted for age. Jump height increased significantly at a slightly reduced rate of approximately 2.2% per year (b_1=0.0216, SE=.0017) (Table 3, Model ii). Once again, body size can explain both these (sex and age) reductions in jump height performance observed in Table 3, Model i described earlier).

Note that the contributions of log-transformed mass and stature now had opposite signs and were both highly significant (see Table 3, Model ii).

Table 3 here

Discussion

This study presents novel data, using an allometric scaling model, to better understand differences in muscular fitness in Colombian children from different socio-demographic backgrounds. This is the first study to present such data in Colombian children and as such extends the body of knowledge relating to pediatric health and fitness related to socio-economic status. The current study suggests that, if body is not accounted for, there are no differences in handgrip strength between SES or family income groups nor between children from urban or rural areas. Stature and body mass were, however, greater in urban dwelling children and those from higher SES groups. Handgrip strength increased as a function both of stature and body mass. In order to obtain a more accurate interpretation of socio-demographic differences, body size must be accounted for. After adjusting for differences in body size, we found urban children, those with high SES, and higher family income had lower handgrip strength. It would appear that children from higher SES groups underperform at the handgrip strength test proportional to their (larger) body dimensions. This finding is at odds with studies in HICs (Jimenez-Pavon, et al., 2010; Jin and Jones-Smith, 2015) and LMICs (Petroski, et al., 2011; Petroski, et al., 2012) which reports better handgrip in middle or high SES children.

The body-mass and stature exponents reported (Table 2) are 0.38 (SE=0.006) and 1.33 (SE=0.02) respectively, both a little greater than a linear ($L=M^{0.33}$) dimension of body size (see Astrand and Rodahl, 1986). Taken together the product approximates L^2, which

can be interpreted as the cross sectional or surface area of the children's body size dimension. No study of SES has adjusted children's handgrip both for the body mass and for stature; despite clear evidence that both measures vary according to SES.

Our results illustrate the importance of appropriate scaling using the allometric approach in order to avoid making erroneous conclusions as to the association between fitness and socio-demographic factors that are actually explained by differences in body dimensions.

Regarding handgrip scores, our results agree with another recent study (Otero, et al., 2017) which found Colombian youth with poor handgrip strength were more likely to be from higher SES groups. The authors reported lower BMI (z-scores) in children with the poorest handgrip strength but found no meaningful between-group differences in adiposity (skinfold thickness) (Otero, et al., 2017).

The variation in children's stature associated with SES results in difficulty interpreting the between-group differences in BMI (Sandercock, et al., 2017; Monyeki, et al., 2005; Silva, et al., 2016). The model used to predict handgrip included positive exponents for both body mass and stature; as shown previously in studies of South American (Silva, et al., 2017), European (Nevill, et al., 2009; Tambalis, et al., 2011) and African (Dos Santos, et al., 2016) youth. The importance of appropriate scaling when comparing cohorts of different body size is also highlighted a recent cross-cultural comparison showing higher absolute handgrip values in youth from Portugal compared with Mozambique (Dos Santos, et al., 2016). However, once concurrent differences in body size were accounted for, the direction of handgrip differences was reversed.

Greater stature is advantageous to horizontal jumping performance (Dos Santos, et al., 2016) but, in contrast to handgrip strength, in the current study we found the exponent

for body mass was negative. This resulted in the performance difference for jumping between high and low SES children being reduced once data were adjusted for body size.

Participants in the highest SES group jumped 5.3% further than those from the lowest group. Adjusting for body size attenuated the SES-related differences in jump performance but high SES children still jumped 3.8% further than the lowest group. Positive associations of SES with muscular fitness have been reported in HICs and LMIC youth.

Regardless of whether we adjusted for body size, there were no significant differences in jump performance by family income or rural versus urban dwelling. These findings conflict with studies in LMICs which report better muscular fitness in urban, rather than rural-welling youth (Tambalis, et al., 2011; Pena Reyes, et al., 2017; Ujevic, et al., 2013; Andrade, et al., 2014; Garber, et al., 2014) but only one study of Greek youth has scaled for body size (Tambalis, et al., 2011).

However, probably one of the most illuminating findings obtained from the jump height [model (ii)] was identified with the body-mass and stature exponents given in Table 3. These were -0.18 (SE=0.006) and 1.05 (SE=0.02) respectively. Note that they have opposite signs. After taking ant-logs, these opposite signs indicate that the association between jump height and body size is a "height-to-weight" ratio, given by stature/(mass)$^{0.18}$. This empirically derived ratio is not dissimilar to the reciprocal Ponderal index, RPI= stature/(mass)$^{0.333}$, well known for being a strong indicator of athletic performance (Watts, et al., 2012).

Scaling is an important consideration when working with physical fitness or performance data in pediatric populations as it can reveal differences between groups with different body dimensions (Dos Santos, et al., 2016) that otherwise would not have been identified. Body mass and stature are both important determinants of handgrip strength

and horizontal jump performance; two of the most frequently used field based measures of muscular fitness. However, research fails to adequately consider the impact of stature and body mass on performance of these tests. While prior research has adjusted (as covariates) for variables such as BMI or skinfolds (Jimenez-Pavon, et al., 2010), stature is an important predictor of handgrip strength and many studies only correct for body mass when examining handgrip data. Scaling handgrip for body mass at a 1:1 ratio results in a negative association between mass and the resultant variable and may penalise heavier individuals unfairly. As a consequence it is important for scientists, epidemiologists and public health practitioners to consider both body mass and stature when examining differences in muscular fitness between groups.

The present study illustrates this point elegantly in the context of SES differences in muscular fitness in Colombian children. As high SES children have a physical advantage over their low SES peers, they should theoretically perform better than low SES children. When adjusting for body size, high SES children demonstrate considerably lower muscular strength; while variations in jump performance persisted, differences between high and low SES groups became less pronounced. We acknowledge that these results are specific to Colombian children.

The results of the current study provide evidence supporting the utility of scaling as a means to better understand the impact of SES on children's muscular fitness in LMICs. Our findings suggest the superior muscular fitness of high SES children is attributable to superior physique demonstrated in the high SES group rather than being a result of socio-economic status per se.

Conflict of Interest: None

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Table 1a. Characteristics of boys by socio-economic status, family income and dwelling.

Boys		N	Stature (cm)	SD	Mass (kg)	SD	DAge (y)	SD	HG (kg)	SD	Jump (cm)	SD
Overall		17677	164.8	7.2	54.9	9.5	15.10	0.46	32.2	6.4	167.3	25.1
SES	Very Low	2172	163.6	7.1	54.2	9.6	15.10	0.45	32.0	6.5	165.5	25.2
	Low	8901	164.5	7.2	54.6	9.5	15.11	0.46	32.2	6.4	166.7	24.8
	Mid	6252	165.6	7.1	55.6	9.6	15.09	0.46	32.3	6.4	168.4	25.4
	High	352	167.6	7.1	57.2	9.4	15.18	0.45	31.6	6.1	173.0	24.7
Family income	Low	602	164.8	7.4	54.7	9.6	15.14	0.46	32.6	6.3	168.9	25.0
	Middle	10340	164.7	7.2	54.7	9.5	15.11	0.46	32.2	6.5	167.4	25.1
	High	6735	165.1	7.1	55.3	9.6	15.09	0.46	32.2	6.4	166.9	25.1
Dwelling	Urban	17389	164.9	7.2	55.0	9.5	15.10	0.46	32.2	6.4	167.4	25.1
	Rural	288	163.5	7.6	53.1	9.5	15.12	0.48	32.8	6.6	161.9	27.2

Key: SES = socio-economic status; Dage = decimal age; HG = handgrip strength; Jump = Standing broad jump height.

Table 1b. Characteristics of girls by socio-economic status, family income and dwelling.

Girls		N	Stature (cm)	SD	Mass (kg)	SD	DAge (y)	SD	HG (kg)	SD	Jump (cm)	SD
Overall		20421	156.4	5.7	53.2	8.5	15.05	0.46	24.7	4.2	122.9	19.9
SES	Very Low	2687	155.7	5.8	52.9	8.6	15.06	0.46	24.8	4.2	120.6	19.4
	Low	9931	156.2	5.7	53.0	8.4	15.05	0.46	24.7	4.2	122.1	19.4
	Mid	7325	156.7	5.6	53.5	8.5	15.04	0.46	24.7	4.2	124.5	20.5
	High	478	158.2	6.2	54.2	8.1	15.10	0.43	24.3	4.0	127.6	21.8
Family income	Low	975	156.1	6.0	53.4	8.9	15.11	0.45	25.2	4.3	123.9	20.0
	Middle	13050	156.3	5.7	53.0	8.4	15.05	0.46	24.7	4.2	122.6	19.6
	High	6396	156.7	5.7	53.5	8.5	15.04	0.46	24.7	4.2	123.2	20.6
Dwelling	Urban	20057	156.4	5.7	53.2	8.5	15.05	0.46	24.7	4.2	122.9	19.9
	Rural	364	156.2	5.9	52.1	7.6	15.07	0.46	25.6	4.5	122.7	20.1

Key: SES = socio-economic status; DAage = decimal age; HG = handgrip strength; Jump = Standing broad jump height.

Table 2. The multilevel regression analysis of log-transformed (using natural logs Ln) hand-grip strength of 9th grade Colombian boys and girls, (i) after adjusting for only decimal age (Dage) and (ii) after adjusting for body size (mass and stature) and decimal age

Fixed Explanatory Factors	Model (i)		Fixed Explanatory Factors	Model (ii)	
	Estimate	SE		Estimate	SE
Constant (b_0)	2.3780	0.0316	Constant (b_0)	0.6214	0.0313
FI Mid (Δb_0)	-0.0103	0.0048	FI Mid (Δb_0)	-0.0078	0.0040
FI High (Δb_0)	-0.0068	0.0049	FI High (Δb_0)	-0.0090	0.0041
RURAL (Δb_0)	0.0250	0.0133	RURAL (Δb_0)	0.0386	0.0133
SES Low (Δb_0)	0.0049	0.0061	SES Low (Δb_0)	-0.0009	0.0061
SES Mid (Δb_0)	0.0058	0.0062	SES Mid (Δb_0)	-0.0135	0.0063
SES High (Δb_0)	-0.0086	0.0114	SES High (Δb_0)	-0.0439	0.0112
Girls (Δb_0)	-0.2536	0.0019	Girls (Δb_0)	-0.1747	0.0019
Dage	0.0713	0.0020	Dage	0.0420	0.0017
			Ln(Mass)	0.3869	0.0058
			Ln(Stature)	1.3310	0.0231
Variance of Random Factors	**Constant (a)**	**SE**		**Constant (a)**	**SE**
Level 2 (Schools)	0.0012	0.0001	Level 2 (Schools)	0.0014	0.0001
Level 1 (Individuals)	0.0324	0.0002	Level 1 (Individuals)	0.0225	0.0002

Values are means ±SE. Hand grip strength is recorded in kg and entered as [Ln (kg)]. Age was measures as decimal age (Dage) in years. Boys from the very lowest SES, with the lowest family income (FI) and from an urban background were used as the constant baseline measure in equation 2 (b_0, and other groups were compared with it, indicated by (Δb_0).

Table 3. The multilevel regression analysis of log-transformed (using natural logs Ln)

jump height of 9th grade Colombian boys and girls, (i) after adjusting for only decimal age

and (ii) after adjusting for body size (mass and stature) and decimal age (Dage)

Fixed Explanatory Factors	Model (i)		Fixed Explanatory variables	Model (ii)	
	Estimate	SE		Estimate	SE
Constant (b_0)	4.7200	0.0270	Constant (b_0)	4.9860	0.0308
FI Mid (Δb_0)	0.0003	0.0040	FI Mid (Δb_0)	-0.0009	0.0039
FI High (Δb_0)	0.0025	0.0041	FI High (Δb_0)	0.0014	0.0040
RURAL (Δb_0)	-0.0153	0.0174	RURAL (Δb_0)	-0.0166	0.0172
SES Low (Δb_0)	0.0103	0.0082	SES Low (Δb_0)	0.0058	0.0081
SES Mid (Δb_0)	0.0202	0.0084	SES Mid (Δb_0)	0.0131	0.0083
SES High (Δb_0)	0.0528	0.0142	SES High (Δb_0)	0.0380	0.0141
Girls (Δb_0)	-0.3077	0.0016	Girls (Δb_0)	-0.2586	0.0019
Dage	0.0246	0.0017	Dage	0.0216	0.0017
			Ln(Mass)	-0.1843	0.0056
			Ln(Stature)	1.0460	0.0224
Variance of Random variable	**Constant (a)**	**SE**		**Constant (a)**	**SE**
Level 2 (Schools)	0.0028	0.0002	Level 2 (Schools)	0.0028	0.0002
Level 1 (Individuals)	0.0224	0.0002	Level 1 (Individuals)	0.0211	0.0002

Values are means ± SE. Jump height was recorded as cm and entered as [Ln (cm)]. Age was measures as decimal age (Dage) in years. Boys from the very lowest SES, with the lowest family income and from an urban background were used as the constant baseline measure in equation 2 (b_0), and other groups were compared with it, indicated by (Δb_0).