The Relationship between Intelligence, Head Circumference, Body Weight and Height in Libya

Alsedig Abdalgadr Al-Shahomee*, Richard Lynn
Ulster Institute for Social Research, London, UK

Saleh El-Ghmary Abdalla
University of Omar Al-Mukhtar, El Beida, Libya

* E-mail address: Shahomee@yahoo.com

This study reports a relationship between intelligence, head circumference, body weight and height. Intelligence was measured by the Standard Progressive Matrices (SPM), a test of abstract non-verbal reasoning, in a sample of 720 school students aged 13-18 years in Libya. The results show statistically significant correlations of test scores with head circumference, body weight and height in all six age groups, with a mean of 0.27, 0.28 and 0.25 respectively. All three anthropometric measures were independent predictors in multiple regression models.
Key Words: Intelligence; Standard Progressive Matrices; Libya; Head circumference; Body weight; Body height.

A positive association between intelligence and head circumference was first reported by Galton (1888) in a study of students at the University of Cambridge. This study found that head circumference was greater by 2.5 to 5 percent in those who obtained top degrees, taken as a measure of higher intelligence, than in those who obtained less good degrees. This positive association has been confirmed in numerous subsequent studies showing that among both children and adults head circumference is positively correlated with intelligence measured by intelligence tests, summarized by Lynn (1994) and by Rushton (2000, p. 37) who reported results from 32 studies with an average correlation of .23. In these studies, head circumference was adopted as a proxy for brain size and it was argued that the explanation for the positive association is that larger brains confer greater cognitive ability. In more recent studies brain size has been measured directly by magnetic resonance imaging rather than being inferred from head circumference, and was shown to be positively associated with intelligence. The correlation was reported as .40 in the meta-analysis by Vernon et al. (2000, p. 248), and as .24 in an updated meta-analysis of associations between human brain volume and intelligence differences by Pietschnig et al. (2015 p. 411).

A number of other studies reported a positive relationship between intelligence and body height, e.g. Wilson et al. (1986), Walker et al. (2000), and Gale (2005). These studies have typically shown correlations between intelligence and body height of around .25. For example, in a large sample of 11-year olds in Scotland the correlations were .24 for boys and .25 for girls (Deary et al. 2009, p. 24). These studies have all been carried out on European and European-origin populations. This paper reports the results of a study of the associations of intelligence with head circumference, body weight and body height in Libya.

Methods

Intelligence was measured with Raven's Standard Progressive Matrices (SPM), which assesses abstract non-verbal reasoning ability with a set of 60 figurative matrices (Raven, Raven & Court, 2000). The test was administered in Libya in 2017 to a representative sample of 120 students (60 boys and 60 girls) from each of the six age groups 13 through 18 years old. Head circumference was measured in the coronal plane at its maximum just above the ears, and body weight and body height were also measured. Overall body size was operationalized as the average of the standardized total scores of head circumference, height and weight scores. The sampling procedure comprised a multi-stage random sampling method (cluster sampling). The students were randomly selected from schools in two cities and nine villages consisting of three villages each in coastal, mountain and desert regions. Children in Libya begin school at the age of seven years and boys and girls are educated together. This ensures that the boys and girls are matched for educational experience and family background.

The Standard Progressive Matrices (SPM) was modified to make it suitable for the Libyan sample. The modifications were: (1) instructions were given in the Arabic language; (2) English letters (A, B, C, D and E) in the five sets were changed into Arabic letters; (3) page order (direction) of the test booklet was changed from left to right, as in the Arabic way of writing and reading; and (4) a new answer sheet was designed with Arabic letters, and right to left direction for answering and writing.

The school principals were contacted by a letter from the director of education explaining the purpose of the study and the procedure to be followed in selecting and testing the students. All principals agreed to participate in the study. All participants were given an information sheet and were asked to sign a consent form before participation in the study. None of the participants declined to sign the consent form. The test was administered, untimed, in group settings.

The analysis was carried out in the following manner: (1) Kolmogorov–Smirnov, Shapiro–Wilk test and normal probability plots were used to determine the normality of the SPM data. (2) Construct validity (internal consistency) of SPM test scores was calculated using the Pearson product-moment correlation coefficient. (3) Reliability of SPM test scores was investigated using alpha (KR-20). Alpha (KR-20) was used to estimate how test items relate to each other and to the total test. It is useful for multiple choice items that are scored as right or wrong (Anastasi & Urbina, 1997; Gaye, Mills & Airasian, 2006). (4) Partial correlations controlled for gender were used to examine continuous variable correlational relationships between SPM test scores and head circumference, body height, body weight and body size. Partial correlations controlled for age and gender were used to examine continuous variable correlational relationships between head circumference, body height, body weight and body size. (5) Multiple regression stepwise analysis was carried out with SPM scores as the dependent variable to examine the contribution of the independent variables (head circumference, body weight, height, age and gender) in predicting SPM scores (intelligence).

Results

The SPM data were first examined for normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests. The p values were .340 and .253, respectively. Both values were above .05, indicating that no statistically significant deviation from the normal distribution could be demonstrated. This allowed the use of parametric tests to investigate and evaluate the presence of statistically significant relationships between intelligence, head circumference, body weight and body height in the data. Following the procedure described in Anastasi and Urbina (1997), construct validity as internal consistency was assessed by the correlation coefficients between SPM total score and its five components (A, B, C, D and E). The correlation coefficients ranged from .56 to .86 ($p<.01$) for males and .74 to .88 ($p<.01$) for females. The reliability of the SPM test scores was investigated and showed that alpha reliabilities (KR-20) for the SPM ranged from .88 to .94.

Descriptive statistics for males and females on the SPM scores are given in Table 1. Males scored slightly higher than females at all ages and, as expected, scores increased from age 13 to age 18. The correlations of SPM scores with head circumference, body weight, height and the composite measure of body size are given for each age in Table 2. The three anthropometric measures were correlated to moderate extents (Table 3).

Table 1. *SPM scores, head circumference, body weight and body height descriptive statistics in relation to gender in Libya. Mean age = 15.5; N = 60 for each gender-age category.*

Age	Gender	SPM Mean ± SD	Head circ. Mean ± SD	Body weight Mean ± SD	Body height Mean ± SD
13	M	38.7 ± 4.8	55.4 ± 1.9	46.7 ± 11.8	151.6 ± 10.4
	F	37.1 ± 4.9	55.9 ± 2.6	47.8 ± 11.5	151.5 ± 12.0
14	M	39.8 ± 4.6	55.8 ± 2.1	57.5 ± 16.6	157.7 ± 12.5
	F	39.3 ± 3.1	56.0 ± 2.5	52.4 ± 13.8	152.9 ± 10.4
15	M	40.5 ± 4.6	56.6 ± 4.3	56.2 ± 13.3	161.5 ± 14.1
	F	40.0 ± 3.9	56.6 ± 2.3	52.7 ± 10.1	155.9 ± 8.8
16	M	40.2 ± 4.6	56.2 ± 1.9	62.9 ± 12.5	167.0 ± 9.5
	F	40.0 ± 4.7	57.4 ± 2.3	60.9 ± 11.1	158.3 ± 10.7
17	M	40.8 ± 3.1	56.5 ± 1.7	64.9 ± 12.0	169.6 ± 8.5
	F	40.3 ± 7.5	57.3 ± 2.3	58.6 ± 12.6	158.3 ± 7.0
18	M	43.0 ± 5.1	58.2 ± 2.3	70.8 ± 16.6	173.5 ± 8.1
	F	41.8 ± 5.8	57.9 ± 2.2	60.0 ± 10.5	160.6 ± 5.0
Total	M	40.5 ± 4.7	56.8 ± 2.7	59.8 ± 15.8	163.5 ± 12.9
	F	39.8 ± 5.7	55.4 ± 2.5	55.4 ± 12.6	156.3 ± 9.7
	All	40.1 ± 5.1	57.6 ± 2.6	57.6 ± 14.5	159.9 ± 12.0

Table 2. *Partial correlations of SPM scores with head circumference, body height, weight and body size, with gender controlled (df = 117). * p<.05; ** p<.01.*

	Age						Mean
	13	14	15	16	17	18	
Head circumference	.287**	.260**	.265**	.296**	.296**	.292**	.28
Body weight	.250**	.204*	.285**	.276**	.329**	.307**	.28

Body height	.239**	.230**	.220*	.339**	.285**	.204*	.25
Body size	.325**	.291**	.359**	.402**	.432**	.388**	.37

Table 3. *Partial correlations between body size, head circumference, height and weight, with age and gender controlled (df = 117). All correlations are statistically significant with p<.01.*

	Head circ.	Height	Weight
Head circumference	1		
Body height	.359	1	
Body weight	.391	.508	1
Body size	.750	.788	.810

Multiple regression stepwise results are shown in Tables 4 and 5. They show that the three anthropometric measures head circumference, body weight and body height were about equally strong predictors of SPM scores. When predictors were entered one after the other starting with weight, weight alone explained 12.1% of the variance in SPM scores. Head circumference added another 4.2% of explained variance, and finally height added another 2%. The three variables together predicted 18.3% of the variance in SPM scores. All these models were highly significant statistically, with p values less than .0001.

Table 4. *Stepwise regression for independent variables and SPM score as dependent variables. All β coefficients are statistically significant at p<.001 (two-tailed t test).*

Model	Unstandardized β	Standard error	Standardized β
(Constant)	33.366	709	
Body weight	.119	.012	.348
(Constant)	10.978	3.784	
Body weight	.091	.013	.265
Head circumference	.424	.070	.222
(Constant)	4.222	4.090	
Body weight	.064	.014	.188
Head circumference	.379	.071	.198
Body height	.068	.016	.165

Table 5. *Model summaries for the models in Table 4.*

Model	R	R^2	adj. R^2	Std.error of estimate	Change statistics		
					R^2 change	F change	Sig. F change
Weight	.348	.121	.120	4.632	.121	98.98	.000
+ Headcirc.	.404	.163	.161	4.523	.042	36.21	.000
+ Height	.427	.183	.179	4.474	.019	16.80	.000
All	.433	.187	.182	4.467	.187	32.94	.000

Discussion

There are five points of interest in the study. First, there are statistically significant correlations between intelligence and head circumference in all six age groups with a mean of .28 and approximately the same as the average of .23 of 32 studies of adult European-origin populations reported by Rushton (2000, p. 37).

Second, there are statistically significant correlations of Raven scores with height (mean r = .25) and weight (mean r = .28) in all six age groups. The correlation for height is the same as that typically reported in European-origin populations noted in the introduction. In addition, the results showed there are statistically significant correlations between intelligence and a composite measure of body size (mean r = .37).

Third, the likely explanation for these positive correlations is that the quality of nutrition both prenatally and during childhood affects the development of the brain, intelligence, body height and body weight, bringing them into positive correlation. This is suggested by studies showing that intelligence, brain size and body height have increased since the 1920s in many economically developed nations, most likely as a result of improved nutrition (Lynn, 1990) and possibly reduced exposure to infectious diseases.

Fourth, an explanation for the positive correlations between intelligence and head size proposed by Vernon et al. (2000) is that a larger brain contains more neurons and therefore has more processing power, analogous to larger computers possessing more processing power than smaller computers. It is improbable that there is any direct causal relationship between body height and intelligence. Wilson et al. (1986) found no evidence that an increase in body height caused a rise in intelligence in a study of 2,177 children studied longitudinally in the American National Health Examination Survey, in which changes in body height between the ages of 8 and 13 years were not related to changes in scores on tests of intelligence or academic achievement.

Fifth, the practical implication of this research is that governments could likely improve the intelligence of their populations by ensuring that pregnant women, infants and children have good nutrition. This could be achieved by the provision of free school meals and nutritional supplements for pregnant women and schoolchildren. Evidence for the positive effect of nutritional supplements on intelligence has been reported by Lynn and Harland (1998) and Walker et al. (2000).

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