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CORRELATION BETWEEN GROWTH AND PHYSICAL FITNESS OF SOCIALLY DISADVANTAGED GIRLS

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ABSTRACT

The intention of this study was to investigate the relationship between growth and physical fitness of girls between the ages seven and 18. The girls (N=302) were randomly selected from six randomly selected schools in an informal settlement in the Western Cape. Twenty anthropometric measurements were taken on each participant. Some of the measurements included heights, girths, skinfolds and breadths. Skinfold measurements were further used to calculate body composition and somatotypes. The following physical fitness components were included for assessment: flexibility (sit-and-reach test); grip strength (hand grip dynamometer); leg power (standing long-jump); speed (50m-sprint test); and cardiovascular endurance (three-minute step test). The relationship between growth and fitness characteristics was determined by means of a stepwise discriminant analysis. The participants were divided into 'under 13' and '13 and older' groups and were used to establish differences in the relationships between growth and fitness. The analysis showed the prominence of weight and height as predictors of fitness parameters, especially strength, speed and leg power.

Key words: Boys; Growth; Physical Fitness; Correlation; Stepwise discriminant analysis.

INTRODUCTION

Numerous researchers have reported on the relationship between body size, body composition and physical fitness (Malina, 1994; Benefice & Malina, 1996; Kim *et al*., 2005; Tomkinson & Olds, 2007; Travill, 2007; Travill *et al*., 2008a; Runhar *et al*., 2010). The interaction between these variables has potentially serious functional consequences for children. This is especially true for children who grow up under sub-optimal socio-economic conditions. Malnutrition which is one the major negative consequences of low socio-economic status, results in stunting and wasting which causes changes to body size and composition (Pariskova, 1987). Frongillo and Hanson (1995) see the developmental impairment of children, which arises from social deprivation as a major public health problem. The question that arises is to what extent retarded growth and muscle development affect the physical working capacity of the malnourished child. The intent of this research was to analyse the relationship between growth of girls who live and grow up under poor socio-economic circumstances, and their physical fitness.

METHODOLOGY

Population and sample

Stratified random sampling was employed to select the girls (N=302) between the ages of seven and 18 years from six randomly selected schools in an informal settlement in the Western Cape. Each age group consisted of 36 girls. Parental and subject consent were obtained by means of specially designed consent forms in the mother tongue of the majority of the people living in the area. The research was approved by the committee on human subjects (medical) of the University of the Witwatersrand (protocol number: M951112).

Physical fitness

The physical fitness components included the following: flexibility (sit-and-reach test); grip strength (hand grip dynamometer); leg power (standing long-jump); speed (50m-sprint test); and cardiovascular endurance (three-minute step test). Logical validity was accepted for the flexibility test, while face validity was accepted for the grip strength, leg power and speed tests. The validity of the step test as a measure of cardio-respiratory endurance is reflected in its correlation of 0.84 with the Balke Treadmill Test (Johnson & Nelson, 1986). The reliability coefficients of all the tests ranged between 0.79 and 0.84.

Anthropometric observations

Twenty anthropometric measurements were taken according to the standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK, 2001). Technical Errors of Measurement (TEM) were within acceptable standards (Norton & Olds, 1996). The variables measured included height (cm), weight (kg), girths (cm), skinfolds (mm) and breadths (cm). Body density ($g.cm^{-3}$) was determined by means of the Durnin and Womersley (1974) equations that are age and gender specific. Body density was converted to percentage fat by means of the formula of Brozek *et al*. (1963), namely %F=(4.570/D-4.142)100.

Data analyses

Data analyses were done using Statistical Analysis Software (SAS) and Statistical Package of Social Sciences (SPSSX) (Version 5) statistical packages at the University of the Western Cape and the Vrije University in Amsterdam. The relationship between growth and fitness characteristics was determined by means of a stepwise discriminant analysis. The participants were divided into 'under 13' (n=150) and '13 and older' (n=152) groups. These categories were used to establish whether differences existed in the relationships between growth and fitness characteristics of pre- and post-pubescent girls.

RESULTS

Travill *et al*. (2008b) reported that 75% of the households from which the children come had a combined income of less than R2000 per month; 26% of the fathers and 21.4% of the mothers had a maximum of 6 years of schooling while 53.4% of the fathers and 53.5% of the mothers had a maximum of 8 years of schooling; only 4.5% of the fathers and 4.8% of the mothers had a tertiary qualification, while 23% of parents were unemployed and 53% performed some form of unskilled labour.

Growth and grip strength

The results of the stepwise regression analysis regarding the relationship between growth and grip strength are illustrated in Table 1.

TABLE 1: **STEPWISE REGRESSION ANALYSIS REGARDING THE RELATIONSHIP BETWEEN GROWTH AND GRIP STRENGTH**

	Girls under 13 (n=150)		
Variables	**Model R^2**	**Beta**	**Sig T**
1. Height (cm)	0.654	0.809	0.000
2. Height (cm)	0.690	0.810	0.000
Mesomorphy		0.189	0.000
3. Height (cm)	0.715	0.901	0.000
Mesomorphy		0.265	0.000
Medial calf skinfold (mm)		-0.195	0.000
	Girls 13 and older (n=152)		
Variables	**Model R^2**	**Beta**	**Sig T**
1. Weight (kg)	0.387	0.622	0.000
2. Weight (kg)	0.465	0.392	0.000
Biacromial breadth (cm)		0.362	0.000
3. Weight (kg)	0.505	0.327	0.000
Biacromial breadth (cm)		0.298	0.000
Trunk height (cm)		0.231	0.001
4. Weight (kg)	0.529	0.474	0.000
Biacromial breadth (cm)		0.260	0.001
Trunk height (cm)		0.217	0.001
Suprailiac skinfold (mm)		-0.196	0.008

Height, mesomorphy and medial calf skinfold accounted for 71.5% of the variation in grip strength in girls under the age of 13 years. Weight, biacromial diameter, trunk height and suprailiac skinfold accounted for 52.9% of all variation in grip strength of girls over 13 years. All skinfolds included in the models for grip strength were negatively correlated to grip strength.

Growth and leg power

Height, abdominal skinfold, ectomorphy and hip girth accounted for 30.3% of the variation in the long-jump ability of girls under 13. In the girls older than 13, medial calf skinfold, biacromial diameter, arm girth contracted (left) and waist girth accounted for 25.9% of the variation in standing long-jump ability. Skinfolds interacted negatively with standing long-jump (Table 2).

TABLE 2: **STEPWISE REGRESSION ANALYSIS REGARDING THE RELATIONSHIP BETWEEN GROWTH AND LEG POWER**

	Girls under 13 (n=150)		
Step	**Model R^2**	**Beta**	**Sig T**
1. Height (cm)	0.190	0.446	0.000
2. Height (cm)	0.240	0.539	0.000
Abdominal skinfold (mm)		-0.223	0.000
3. Height (cm)	0.264	0.604	0.000
Abdominal skinfold (mm)		-0.345	0.001
Ectomorphy		-0.192	0.037
4. Height (cm)	0.303	0.873	0.000
Abdominal skinfold (mm)		-0.266	0.010
Ectomorphy		-0.373	0.001
Hip girth (cm)		-0.418	0.007
	Girls 13 and older (n=152)		
Step	**Model R^2**	**Beta**	**Sig T**
1. Medial calf skinfold (mm)	0.127	-0.357	0.000
2. Medial calf skinfold (mm)	0.214	-0.406	0.000
Biacromial breadth (cm)		0.298	0.000
3. Medial calf skinfold (mm)	0.237	-0.279	0.004
Biacromial breadth (cm)		0.407	0.000
Arm girth contracted L (cm)		-0.236	0.036
4. Medial calf skinfold (mm)	0.259	-0.337	0.001
Biacromial breadth (cm)		0.385	0.000
Arm girth contracted L (cm)		-0.338	0.006
Waist girth (cm)		0.216	0.038

Growth and speed

It can be seen from Table 3 that when triceps skinfold, contracted arm girth (left) and femur breadth were included in the model, the fitted regression function accounted for 29.2% of the variation in the sprinting speed of girls. When biacromial breadth was included in the model the fitted regression function accounted for 25.8% of the variation. Absolute size as reflected in acromial height and height interacted positively with speed.

TABLE 3: **STEPWISE REGRESSION ANALYSIS REGARDING THE RELATIONSHIP BETWEEN GROWTH AND SPEED**

	Girls under 13 (n=150)		
Step	**Model R^2**	**Beta**	**Sig T**
1. Height (cm)	0.225	-0.474	0.000
2. Height (cm)	0.258	-0.281	0.013
Biacromial breadth (cm)		-0.265	0.018
	Girls 13 and older (n=152)		
Step	**Model R^2**	**Beta**	**Sig T**
1. Medial calf skinfold (mm)	0.118	0.343	0.000
2. Medial calf skinfold (mm)	0.186	0.387	0.000
Biacromial breadth (cm)		-0.265	0.001

Growth and cardiovascular endurance

The medial calf skinfold explains 7% of all the variation in endurance in girls under 13. Skinfold, BMI and endomorphy, all indicators of relative fatness related positively with the step-test results (b/min) (Table 4). This positive interaction shows that cardiovascular fitness is negatively influenced by excess fat.

TABLE 4: **STEPWISE REGRESSION ANALYSIS REGARDING THE RELATIONSHIP BETWEEN GROWTH AND CARDIOVASCULAR ENDURANCE**

	Girls under 13 (n=150)		
Step	**Model R^2**	**Beta**	**Sig T**
1. Medial calf skinfold (mm)	0.070	0.265	0.002
	Girls 13 and older (n=152)		
Step	**Model R^2**	**Beta**	**Sig T**
1. BMI	0.050	0.223	0.006
2. BMI	0.082	0.438	0.000
Fore-arm girth (cm)		-0.281	0.023

Growth and flexibility

A combination of sitting height and bi-iliac breadth accounted for a small percentage of variation in the flexibility of girls under 13 (Table 5). No variables were included in the model for girls over 13 as none accounted for variations.

TABLE 5: **STEPWISE REGRESSION ANALYSIS REGARDING THE RELATIONSHIP BETWEEN GROWTH AND FLEXIBILITY**.

	Girls under 13 (n=150)		
Step	**Model R^2**	**Beta**	**Sig T**
1. Sitting height (cm)	0.060	0.245	0.004
2. Sitting height (cm)	0.091	0.448	0.001
Bi-iliac breadth (cm)		-0.269	0.035

DISCUSSION

Grip strength

Height was found to be the most important predictor of strength for girls of ages 7 to 12 years, while weight was found to be the strongest predictor of grip strength of girls 13 to 17 years. The impact of weight, which includes muscle weight, on strength is emphasised by these findings. The negative influence of skinfolds (although not as first predictors) is adequately reflected in their inclusion in all age categories.

Flexibility

The results suggest that anthropometric characteristics appear to have a limited impact on the flexibility of children. The only age categories in which significant relationships were established were for girls between ages 7 and 12 years. Sitting height and bi-iliac breadth were the only two measurements, which were entered in the final analysis.

Speed

Height measurements were found to be major contributors to explain variance in speed. Benefice and Malina (1996) also found height measurements to be strongly related to running performance. Height accounts for 22.5% of the variance in sprinting speed of 7- to 12-year-old girls. The inclusion of skinfolds in the final calculations emphasised the negative impact of the fat component on sprinting speed. Skinfolds were found to be the first predictors of speed in girls between the ages 13 to 17 years.

Cardiovascular endurance

Body composition as reflected in skinfold measurements, endomorphy and BMI were found to be key predictors in cardiovascular fitness of all age categories, which highlights the negative impact of excess fat on cardiovascular fitness.

Leg power

Medial calf skinfold was found to be the first predictor of standing long-jump in girls between the ages 12 to 17 years. Skinfolds were also found to correlate negatively with the standing long-jump in the other age categories.

The analysis of the relationship between growth and performance showed the prominence of weight and height as predictors of fitness parameters, especially strength, speed and leg power. Future studies should include children from different socio-economic backgrounds for comparative purposes.

CONCLUSION

Stepwise regression analysis highlighted the relationship between growth as reflected in especially height and weight and strength, power and speed. A reduction in absolute sizes implies a reduction in muscle mass needed to execute a specific function. Body fat was shown to be a key predictor of cardiovascular fitness when expressed as beats per second highlighting the negative impact of excess fat on endurance. The results of this study confirm the influence of reduced body dimensions on the fitness of children.

REFERENCES

BENEFICE, E. & MALINA, R. (1996). Body size, body composition and motor performance of mild-to-moderately undernourished Senegalese children. *Annals of Human Biology*, 23(4): 307-321.

BROZEK, J.; GRANDE, F.; ANDERSON, J.T. & KEYS, A. (1963). Densitometry analysis of body composition: Revision of some quantitative assumptions. *Annals of the New York Academy of Sciences*, 110: 113-140.

DURNIN, J.V.G.A. & WOMERSLEY, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16-72 years. *British Journal of Nutrition*, 32: 77-97.

FRONGILLO, E.A. & HANSON, K.M.P. (1995). Determinants of variability among nations in child growth. *Annals of Human Biology*, 22:395-411.

ISAK (INTERNATIONAL SOCIETY FOR THE ADVANCEMENT OF KINANTHROPOMETRY) (2001*).* International standards for anthropometric assessment, i-iv. Potchefstroom (South Africa): International Society for the Advancement of Kinanthropometry.

JOHNSON, B.L. & NELSON, J.K. (1986). *Practical measurements for the evaluation in physical education*. New York, NY: Macmillan.

KIM, J.; MUST, A.; FITZMAURICE, G.M.; GILLMAN, M.W.; CHOMITZ, V. & KRAMER, E. (2005). Relationship of physical fitness to prevalence and incidence of overweight among school children. *Obesity Research*, 13: 1246-1254.

MALINA, R.M. (1994). Anthropometry, strength and motor fitness. In S.J. Ulijaszek & C.G.N. Mascie-Taylor (Eds.), *Anthropometry: The individual and the population* (160). Cambridge: Cambridge University Press.

PARISKOVA, J. (1987). Adaptation of functional capacity and exercise. In K. Blaxter & J.C. Waterlow (Eds.), *Nutrition adaptation in man* (127–139). London: John Libbey.

RUNHAR, J.; COLLARD, D.C.M.; SINGH, A.S.; KEMPER, H.C.G.; VAN MECHELEN, W. & CHINAPAW, M. (2010). Motor fitness if Dutch youth: Differences over a 26-year period (1980-2006). *Journal of Science and Medicine in Sport*, 13(3): 323-328.

TOMKINSON, G.R. & OLDS, T.S. (2007). Secular changes in paediatric aerobic fitness test performance: The global picture. *Medicine and Sport Science*, 50: 46-66.

TRAVILL, A.L. (2007). Growth and physical fitness of socially disadvantaged boys and girls age 8-17 years, living in the Western Cape, South Africa. *African Journal for Physical, Health Education, Recreation and Dance*, 13(3): 279–293.

TRAVILL, A.L.; CAMERON, N. & KEMPER, H.C.G. (2008a). The interaction between socioeconomic status, nutrition and growth of socially disadvantaged children living in the Western Cape, South Africa. *African Journal for Physical, Health Education, Recreation and Dance,* 14(1): 36-47.

TRAVILL, A.L.; MADSEN, R.; CAMERON, N. & KEMPER, H.C. (2008b). Socio-economic status and menarcheal age in urban African schoolgirls in the Western Cape, South Africa. *South African Journal for Research in Sport, Physical Education and Recreation*, 30(1): 117-123.

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