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ANTHROPOMETRIC INDICATORS OF NUTRITIONAL STATUS AND PHYSICAL FITNESS OF ELLISRAS RURAL PRIMARY SCHOOL CHILDREN, SOUTH AFRICA

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ABSTRACT

The aim of this study was to examine the relationship between «nutritional status» and physical fitness of 903 (484 boys and 419 girls), 7-14-year-old Ellisras rural primary school children of South Africa. «Nutritional status» was determined from anthropometric indices, i.e. weight-for-age z-scores (WAZ) and height-for-age z-scores (HAZ). Physical fitness was assessed by 10x5 m shuttle run (SHR), standing long jump (SLJ), sit and reach (SAR), sit-ups (SUP), flamingo balance (FLB), bent arm hang (BAH), plate tapping (PLT), 50m sprint and 1600m run as described in EUROFIT and AAHPERD test batteries. Regression analysis was used to investigate the relationship between anthropometric indicators of «nutritional status» and physical fitness parameters. Gender and age were included in the analysis as covariates. Results revealed that anthropometric indicators of «nutritional status» were positively related to SLJ, SHR, SAR, FLB and PLT, but inversely to BAH, 1600 meter run and 50m sprint. It can be concluded that «lower nutritional status» was partially related to lower physical fitness. Especially the fitness tests, which were not inversely related to body weight per se.

Key words: nutritional status, physical fitness, anthropometry, South African children

Introduction

Poor nutritional status is a major problem in children of developing countries. Poor nutritional status constrains the well-being and full potential of a child (28) which might have a negative health impact later in life (9). Poor nutritional status is acute in provinces, which are predominantly rural like in the Limpopo Province of South Africa, because of its socio-economic status (8). Malnutrition can be classified as stunting (lower height-for-age), which reflects chronic malnutrition and as wasting (lower weight-for-age and weight-for-height), which reflects acute malnutrition for children (6). Low weight-for-height in African children were generally distinguished from European children by a "tendency towards lower weight-for-age at a given height". Moreover, the long-term consequences of stunting in children might be a loss of physical work capacity and health in later life (18).

Studies of undernutrition and physical fitness of children in developed countries have been done in Mexico (13, 14, 17), Brazil (2, 24), Colombia (26) and few in developing countries like Zaire (12), Senegal (3, 4), and Mozambique (23). These studies generally show relatively lower physical performances in undernourished children compared with well-nourished children, but also stress the role of small body size in the outcomes (3, 4, 23, 12, 24).

In South Africa, despite high prevalence of malnutrition (7, 19), little work has been undertaken concerning the relationships between anthropometric indicators of nutritional status and physical fitness in rural areas. A study conducted by Sloan (25) on the interracial high school children in Cape Town indicated that malnutrition (indicated by height and weight) impaired performance of African children than other racial groups. Similar findings were observed by Pienaar et al., (22) on growth and motor performances in urban South African children, which revealed that the undernourished children suffered from motor deficiency. It is not known that the same trend will hold for rural primary school children residing in Ellisras areas. The purpose of this report is therefore, to present initial cross-sectional data on the relationship between anthropometric indicators of «nutritional status» (as indicated by height-for-age and weight-for-age) and physical fitness of Ellisras rural children of South Africa. It is assumed that «lower nutritional status» as far as estimated by anthropometric measurements of height and weight will have a negative effect on the performance of physical fitness.

Methods

Geographical location

The participants of the study were 903 children (484 boys and 419 girls), between 7-14 years of age who were drawn, from rural villages situated within the north western area of the Limpopo Province of South Africa. These villages, situated approximately 70 km from the regional town of Ellisras (23^0 40S 27^0 44E), are adjacent to the Botswana border. The Iscor coal mine and Matimba electricity power station are the major sources of employment for many of the Ellisras rural residents, whereas the remaining workforce are involved in subsistence farming and cattle rearing, and a minority in education and civil service. Unemployment in the province is high, being 46% in the 1996 Census. Many families neither have access to electricity nor have running water (27).

Subjects

The study was undertaken at 12 primary schools randomly selected from a total of 68 primary schools within the Ellisras area. Each of the 12 schools was assigned an age category (7, 8, 9, 10, 11, 12, 13, 14), and only children whose verified age was within the category for a particular school were assessed. This means that in all selected schools children within the age 7 and 14 were measured. Birth records were obtained from the principals of each school. Only those birth records that had been verified against health clinic records were used to determine the ages of the participants. Out of 930 children 27 children were excluded due to non verified age. The study therefore consisted of a total number of 903 children (7-14 years) who participated in the anthropometric measures and physical fitness tests in 2001. The measurements for anthropometric measurements were collected between April and May, and tests for physical fitness were performed between June and July by a team of 18 trained research assistants. The project was approved by the Research Ethics Committee of the University of the North. Prior to the study, the children and their parents were informed about its objectives and procedures. Written consent was obtained for each participant.

Anthropometric Measurements

Height and weight were measured according to the standard procedures described by the International Society for Advancement of Kinanthropometry (ISAK) (21). A Martin anthropometer was used to measure height to the last complete 0.1 cm and a Schoenle electronic scale to measure weight to the last complete 0.1 kg. Before the survey was conducted all research team members participated in an intensive two weeks special training course conducted by KD Monyeki (Level 3 – Criteria of ISAK) to show a quality control of the survey. In all the survey the intra-tester technical error of measurement (TEM) (between two anthropometrist at the same station) ranged from 0.1 to 0.5 cm for height and 0.1 to 0.2 kg for weight. The intra-tester (anthropometrist and Level 3 criterion) TEM was between 0.1 to 0.3 cm for height and 0 to 0.2 kg for weight. This falls within the recommendations of Norton and Olds (21). Intra and inter tester correlation coefficients for height and weight were r=0.98. All the anthropometric measurements were taken inside the different classroom by sex. Height-for-age (HAZ) and weight-for-age (WAZ) values were based on the NHANNES II reference sample (11) and were used as indicators for nutritional status.

Physical Fitness Measurements

Nine physical fitness tests (taken from the EUROFIT (10) and AAHPERD (1) test batteries) were performed by each subject. The seven EUROFIT tests included: (1) 10 x 5 m shuttle runs (SHR), designed to measure running speed and expressed in seconds. (2) Standing long jump (SLJ), designed to measure explosive strength and expressed in cm. (3) Sit and reach (SAR), designed to measure back/upper thigh flexibility and expressed in cm; (4) Sit-ups (SUP), designed to measure functional strength, and expressed in the number of sit-ups in 30 seconds. (5) Flamingo balance (FLB), designed to measure static balance, and expressed in seconds. (6) Bent arm-hang (BAH), designed to measure static arm strength and expressed in seconds. (7) Plate tapping (PLT), designed to measure arm speed and expressed in the time (in seconds) to achieve 25 taps. Additionally, 50m sprinting and a 1600m run (both expressed in seconds) were performed by each participant according to the protocol of American Association for Health, Physical Education, Recreation and Dance (AAHPERD). Each school was visited once a day for a period of six weeks (3 weeks scheduled for anthropometric measures and 3 weeks for physical fitness). The tests were carried out in an open field in the morning, to avoid hot temperature. The order of the measurements was as follow: anthropometric measurements were taken during April/May and followed by physical fitness test in June/July. The physical fitness tests were arranged into 9 stations: 1) shuttle run, 2) plate tapping, 3) standing long jump, 4) flamingo balance, 5) 50m sprint, 6) sit and reach, 7) sit-ups, 8) bent arm hang, and 9) 1600m and sprint. For all tests which are stressful, 1 hour rest was allowed so that children could recover between tests in agreement with the observations by Benefice (3). Prior to the survey, a pilot survey was conducted to ascertain the reliability of the EUROFIT and AAHPERD tests items. A total of 46 subjects of the same age groups as the ones in the study who were not part of the study, but residing within the area repeated the tests at 5 days interval. The following Pearson's test-retest reliability coefficients were obtained: plate tapping (r=0.56-0.75), standing long jump (r=0.76-0.86), flamingo balance (0.31-0.55), sit and reach (r=0.58-0.74), 10x5m shuttle run (r=0.48-0.68), sit-ups (0.51-0.75), bent arm hang (0.33-0.60), 50m sprint (0.59-0.77), 1600m run (0.58-0.79). This test-retest among the research assistant was satisfactory.

Statistical Analysis

Since the data were approximately normally distributed means and standard deviations have been reported for all variables. Measurements of height-for-age z-score (HAZ) and weight-for-age z-score (WAZ) were used as continuous variables and values of less than –2 SD were used as indicators for a «low nutritional status». Differences between boys and girls and between different ages were analyzed with independent sample t-tests. To analyze the relationship between physical fitness (outcome variables) and «nutritional status» (independent variables) linear regression analyses were used, adjusting for age and gender. Furthermore, interactions between the indicators for «nutritional status» and both gender and age were added to all linear regression models in order to investigate whether the observed relationships were different between age groups or between boys and girls. All statistical analysis were performed by the Statistical Package for the Social Sciences (SPSS). The statistical significance level was set at $p<0.05$.

Results

Table 1 shows the gender and age specific means and standard deviations (SD) of height-for-age z-score (HAZ) and weight-for-age z-score (WAZ). A significant difference between boys and girls was observed in WAZ in ages 7, 9 to 11 years. No significant differences were noticed in HAZ between boys and girls. Table 2 shows the gender and age specific means and SD of the 9 fitness tests. The mean age as derived from calendar age was 10 (SD=1.90) years for boys (n=484), and that of girls (n=419) was 10 (SD=1.80) years. All motor performances increase significantly ($p<0.05$) with age. Significant sex differences were found for standing long jump, sit and reach, sit ups, bent arm hang, sprinting and 1600m run.

Table 1. *Mean (M) and standard deviation (SD) of anthropometric characteristics of the 7-14 years old Ellisras rural children*

Age (Years)	Boys n	Girls n	Height-for-age z-scores		Weight-for-age z scores	
			Boys M SD	Girls M SD	Boys M SD	Girls M SD
7	48	37	-0.06 (1.19)	-0.07 (1.08)	-0.46 (0.91)	-0.79 (0.87)*
8	61	56	-0.23 (0.92)	-0.30 (0.98)	-0.94 (0.67)	-0.80 (0.56)
9	73	67	-0.49 (1.02)	-0.33 (0.70)	-1.05 (0.57)	-0.84 (0.45)*
10	85	75	-0.55 (0.95)	-0.44 (0.82)	-1.10 (0.54)	-0.84 (0.63)*
11	71	74	-0.46 (0.78)	-0.42 (0.71)	-1.01 (0.37)	-0.88 (0.48)*
12	93	72	-0.68 (0.82)	-0.73 (0.88)	-1.03 (0.45)	-1.04 (0.51)
13	35	26	-0.95 (1.00)	-1.02 (1.00)	-1.29 (0.53)	-1.25 (0.34)
14	18	12	-1.73 (0.98)	-1.92 (1.63)	-1.83 (0.50)	-1.61 (0.65)

*=indicate a significant difference between boys and girls ($p<0.05$).

Table 2. *Mean (M) and standard deviation (SD) of physical fitness characteristics of the 7-14 years old Ellisras rural children*

Age (Years)			SHR (sec)		SLJ (cm)		FLB (sec.)		SUP (sec.)		SAR (cm)		PLT (sec.)		BAH (sec)		50m sprint (sec)		1600m run (sec)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
	n	n	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD	M SD
7	48	37	24.6 (2.3)	24.3 (3.1)	111 2 (14.9)	113.7 (19.4)	11.5 (7.8)	12.0 (5.9)	13.8 (4.2)	14.8 (6.2)	14.1 (4.2)	14.4 (5.1)	24.8 (4.1)	24.2 (4.5)	3.6 (3.7)	2.9 (3.7)	10.5 (1.0)	10.5 (1.1)	516 (36.5)	546* (42.8)
8	61	56	22.8 (1.8)	23.3 (1.8)	117.0 (15.0)	117.2 (14.7)	11.7 (5.5)	10.3 (5.4)	15.1 (6.3)	15.3 (5.4)	15.5 (4.8)	16.5 (3.8)	22.4 (3.3)	21.2 * (2.9)	6.3 (6.6)	3.8* (4.7)	9.7 (1.1)	10.1 * (0.9)	486 (32.1)	528* (60.4)
9	73	67	22.0 (1.5)	22.6 (1.7)	125.6 (16.2)	119.5* (14.9)	10.3 (6.0)	10.9 (5.6)	15.2 (6.7)	16.0 (6.5)	14.3 (5.1)	15.6 (4.6)	20.6 (3.6)	20.3 (3.6)	7.1 (7.2)	4.6 * (7.8)	9.7 (1.0)	9.9 * (0.9)	474 (43.0)	522* (65.1)
10	85	75	22.0 (2.2)	22.8 (1.9)	131.9 (15.4)	124.2* (14.6)	9.8 (5.1)	10.5 (8.3)	17.2 (5.8)	17.0 (6.3)	14.4 (5.1)	15.8 * (4.6)	20.3 (3.9)	19.0 * (2.8)	7.3 (7.5)	5.8 (8.2)	9.3 (0.8)	9.8 * (0.8)	456 (39.6)	510* (53.0)
11	71	74	21.8 (1.9)	22.1 (1.7)	137.3 (15.3)	133.4 (17.6)	9.6 (5.3)	9.3 (4.9)	18.1 (6.1)	15.0 * (6.6)	15.7 (5.1)	16.9 (5.1)	18.3 (2.8)	17.3 * (2.4)	17.3 * (0.8)	17.3 * (4.9)	9.1 (1.0)	9.4 (1.1)	450 (41.0)	498* (50.3)
12	93	72	21.8 (1.6)	21.9 (1.5)	140.9 (17.5)	134.6* (15.5)	9.3 (4.6)	10.2 (4.8)	17.5 (4.4)	17.5 (6.4)	13.8 (4.8)	17.8 * (5.0)	17.3 (2.9)	16.9 (2.6)	8.9 (8.4)	4.7* (5.7)	8.9 (0.9)	9.1 (0.6)	450 (40.4)	510* (44.1)
13	35	26	21.3 (1.2)	21.6 (1.3)	149.1 (14.1)	142.2* (14.5)	8.9 (4.8)	8.9 (4.5)	17.9 (4.7)	13.8* (7.0)	12.8 (5.3)	17.6 * (4.2)	16.7 (2.4)	17.0 (2.9)	11.2 (7.9)	4.3 * (4.3)	8.6 (1.0)	9.3 (1.8)	438 (34.4.5)	504* (83.7)
14	18	12	20.7 (1.2)	504* (1.1)	151.6 (24.3)	138.0 * (16.5)	8.8 (5.1)	9.3 (4.6)	19.8 (6.1)	11.4 (7.3)	14.1 (5.2)	19.5 * (6.2)	15.2 (2.2)	18.1* (4.1)	11.5 (10.1)	5.3 (9.9)	8.3 (0.7)	9.0 (1.6)	408 (56.7)	528* (89.9)

SHR = shuttle run; SLJ = standing long jump; FLB= flamingo balance; SUP= sit ups; SAR = sit and reach; PLT = plate tapping; BAH = bent arm hang, cm= centimeter, sec.=seconds, *=indicate a significant difference between boys and girls (p<0.05).

Table 3. *Regression coefficients and 95% confidence intervals (CI) from the regression analysis relating height-for-age z-scores and weight-for-age z-scores to strength parameters*

	Standing long jump	Bent arm hang	Sit-ups
Heigh-for-age z-scores	3.83 (2.71 to 4.94)*	-0.26 (-0.75 to 0.24)	-0.21 (-1.18 to 0.77)
Weight-for-age z-scores	2.88 (1.20 to 4.55)*[1,3] 5.32 (2.64 to 7.99)*[2]	-0.90 (-1.51 to –0.29)*	0.10 (-1.11 to 1.32)

[1] Data for boys [2] Data for girls [3] A positive interaction with age
* = p<0.05

Table 4. *Regression coefficients and 95% confidence intervals (CI) from the regression analysis relating height-for-age z-scores and weight-for-age z-scores to running parameters*

	Shuttle run	1600 m run	50 meter sprints
Height-for-age z-scores	-0.08 (-0.21 to 0.06)	1.10 (-2.47 to 4.65)	-0.16 (-0.32 to -0.09)*
Weight-for-age z-scores	0.23 (0.03 to 0.42)*[1] -0.26 (-0.60 to 0.08)[2]	6.26 (1.87 to 10.65)*	-0.14 (-0.23 to -0.06)*

[1] Data for boys [2] Data for girls
* = p<0.05

Table 5. *Regression coefficients and 95% confidence intervals (CI) from the regression analysis relating height-for-age z-scores and weight-for-age z-scores to flexibility, balance and arm speed*

	Sit and reach	Flamingo balance	Plate tapping
Height-for-age z-scores	0.12 (-0.24 to 0.47)	0.63 (0.26 to 1.01)*	-0.47 (-0.78 to –0.16)*[1] -0.75 (-1.08 to –0.42)*[2]
Weight-for-age z-scores	0.74 (0.30 to 1.18)*	0.42 (-0.06 to 0.89)[3]	-0.25 (-0.60 to 0.10)[1,4] -1.19 (-1.17 to –0.66)*[2]

[1] Data for boys [2] Data for girls [3] A positive interaction with age [4] A negative interaction with age
* = p<0.05

Tables 3, 4 and 5 show the results of the linear regression analyses relating anthropometric indicators of «nutritional status» (indicated by HAZ and WAZ) to physical fitness of Ellisras rural children, corrected for age and gender. Standing long jump (Table 3) was positively related to both HAZ and WAZ. A significant interaction with gender was observed for WAZ, so separate coefficients were calculated for boys and girls. For boys, also a positive significant interaction with age was found, which indicates that the relationship between WAZ and standing long jump for boys increased with age. Bent arm hang was inversely related to anthropometric indicators of «nutritional status», although only for WAZ (regression coefficient (B) = -0.90, 95% CI [-1.51; -0.29]), this inverse relationship was significant. Sit-ups were not significantly related to both HAZ and WAZ. Table 4 shows the results regarding the running parameters. For shuttle run (only for boys) and 1600 meter run, a positive and significant relationship was found for WAZ (B =6.26, 95% CI [1.87; 10.65]), while for 50 meter sprint an inverse and significant (B = -0.14, 95% CI [-0.23;-0.06]) relationship was found. The latter was also true for HAZ (B = - 0.16, 95% CI [-0.32; -0.09]), and these negative associations indicates a better performance. Looking at flexibility, balance and arm speed (Table 5) anthropometric indicators of «nutritional status» were related to a better performance, i.e. positive relationships were found between anthropometric indicators of «nutritional status» and sit and reach, and flamingo balance. Inverse relationships were found between anthropometric indicators of «nutritional status» and plate tapping. For the relationship between flamingo balance and WAZ, a positive interaction with age was found, indicating that the magnitude of the relationships increase with age, while for the relationship between plate tapping and WAZ for boys a negative interaction with age was observed.

Discussion

In this study, it was possible to analyze the relationship between anthropometric indicators of «nutritional status» as indicated by height-for-age and weight-for-age and physical fitness of 903 boys and girls age 7-14 years in Ellisras rural area.

Regarding the relationship between anthropometric indicators of «nutritional status» and physical fitness, the present results could not fully confirm the hypothesis that «lower nutritional status» as far as estimated by measurements of height and weight is associated with a poorer performance in physical fitness tests. In general, such a relationship was found for standing long jump, sprinting, sit and reach, flamingo balance, and plate tapping, while the opposite was found for bent arm hang and endurance running. So it seems that the performance on tests which requires muscle power, flexibility or balance are inversely influenced by anthropometric indicators of «nutritional status». In all the speed test the negative associations with anthropometric indicators of nutritional status shows a better performance. Fitness tests such as bent arm hang require muscle power, but are probably more influenced by the amount of body weight per se, and therefore for these physical fitness tests «lower nutritional status» was positively related to performance.

The results of the present study are somewhat different from the results reported in other developed countries. In Brazilian children for instance (24), it was revealed that malnourished children generally score lower in tests of running speed, jumping strength, long distance running and throwing when compared to «normal» nourished children. Comparable findings were reported in Senegal (4). In this study in Senegalese children, two groups were formed according height-for-age and weight-for-age. It was found that the «normal» group performed better on all motor fitness tests than the «undernourished» group. In a more recent study performed in Mozambique (23) not all fitness test performances were influenced by «lower nutritional status». The Mozambique study was based on children aged 8 to 15 years. No differences between «nutrition» groups were observed in sit and reach and 1600 meter running, while significant differences were found in handgrip and 2400 meter running in both boys and girls, and in 10 x 5 meter shuttle run (only for boys) and in sit-ups only for girls. Comparable to the results in the present study, the significant differences in the long distance running were in favor of the «lower nutritional status» group. All other significant differences were in favor of the «normal» group.

One must realize that although many of the relationships were statistically significant ($p<0.05$), the amount of explained variance by «nutritional status» was rather low. This is probably due to the fact that there are many other factors influencing the results of the motor fitness tests performed in the present study. First of all, body size seems to play an important role in the performance. Malina (15) and Spurr et al. (26)

observed that in tasks where speed and power are required, performance is normally reduced in small individuals coming from populations at nutritional risk. Cultural factors are also suggested to have a strong effect on performance of physical fitness tests. Lack of motivation has been reported as negatively affect fitness performances in works done on African children (12, 20). Inter-individual variation in maturation at the onset of puberty also needs to be considered because, especially in the case of boys; early maturers tend to be stronger and better in physical fitness than late maturers (16). Unfortunately, reliable information on maturation was not available in the present study. Other factors that can influence the performance on the physical fitness tests are the amount of habitual physical activity (which is in general very high for the population under study), socio-economic status (which is in general very low for the population under study, and which is partly reflected in the anthropometric indicators of «nutritional status») and genetic predisposition. Nevertheless despite all these possible influences not assessed in the present study, significant relationships were observed between anthropometric indicators of «nutritional status» and physical fitness. It should further be noted that the relationships between «nutritional status» and physical fitness were more or less the same for «chronic low nutritional status» (as indicated by low height-for-age) and «acute low nutritional status» (as indicated by low weight-for-age).

From the results it can further be seen that «acute low nutritional status» (as indicated by low weight-for-age) of the boys seems to be more reduced than for the girls (except for children aged 7 years). However, this difference was not found for «chronic low nutritional status» (as indicated by low height-for-age). Furthermore, there is an increasing trend in low nutritional status with age. Similar findings were also reported about African children in Gambia (5) and Senegal (4). If we look at the proportion of children who can be defined as wasted (i.e. have values for weight-for-age z-score lower than –2 SD), the proportion was about 7% for boys and 5% for girls. The proportion of subjects who were stunted (i.e. have lower values for height-for-age z scores lower than –2 SD) was about 6% for both boys and girls. For both stunting and wasting the proportion of subjects generally increased with age.

An interesting aspect of the present study is that a longitudinal study will be undertaken, wherein the repeated measurements are planned for both the anthropometric indicators of «nutritional status» and of the physical fitness tests in the future. With this longitudinal information we will be able to investigate whether the observed relationships are consistent over time and whether changes in anthropometric indicators of «nutritional status» are related to changes in physical fitness.

From the present study it can be concluded that «lower nutritional status « as indicated by height-for-age z-scores and weight-for-age z-scores was associated with lower physical fitness for those physical fitness tests for which muscle power, flexibility or balance are important requirements. «Low nutritional status» as indicated by height-for-age z-scores and weight-for-age z-scores was on the other hand associated with better physical fitness for those physical fitness tests, which are more dependent on body weight per se.

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