



# THE RELATIONSHIP BETWEEN STRENGTH MEASUREMENTS AND ANTHROPOMETRIC INDICATORS (BMI AND SKINFOLD THICKNESS) IN ELLISRAS RURAL ADOLESCENTS AGED 9–15 YEARS: ELLISRAS LONGITUDINAL STUDY

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## ABSTRACT

**Purpose.** Handgrip strength and arm hang have been recognized as predictors of muscle strength and presented as biomarkers for important health outcomes and overall fitness of an individual. The aim of the study was to investigate the relationship between arm hang and handgrip strength with BMI and skinfold thickness.

**Method.** The total of 769 children (391 boys and 378 girls) aged 9–15 years underwent a series of anthropometric and strength measurements with the use of standard procedures. Linear regression was applied to assess the relationship of arm hang and handgrip strengths with body mass index and skinfold thickness.

**Results.** The prevalence of undernutrition and low strength measurements was high (1.7–85%) while the prevalence of overweight and obesity was low (1.5–4.2%) in the Ellisras children aged 9–15 years. Boys showed a significantly higher ( $p < 0.05$ ) mean arm hang (9.6–13.1 kg) than girls (4.0–5.1 kg) aged 11–15 years. There was a significant ( $p < 0.05$ ) association between low strength and underweight among Ellisras rural children when unadjusted (OR = 0.650; 95% CI = 0.487–0.867) and adjusted (OR = 0.650; 95% CI = 0.489–0.868) for age and gender.

**Conclusions.** The prevalence of undernutrition and poor strength was high. An association was observed between arm hang and anthropometric indicators while handgrip showed no significant association with anthropometric indicators. Further studies are needed to investigate the association between strength and undernutrition over time.

**Key words:** undernutrition, upper body strength, rural South African children

## Introduction

Malnutrition is a risk factor for ill health and contributes greatly to the burden of disease in low- to middle-income countries [1]. It increases the risk of cardiovascular diseases among children and adults in the developed and developing countries [2–5]. Body mass index (BMI) has been used widely as an indicator for malnutrition, although it has been recently argued that BMI reflects also the relative leg length, body frame size, and fat free mass in addition to fatness [6, 7].

Koley and Kaur [8] suggest that skinfold thickness, arm hang, and handgrip strength can be used in addition to BMI to screen malnutrition. Skinfold thickness has been reported as a good indicator for malnutrition as it can measure the distribution of subcutaneous adipose fat [9]. Poor strength was proved to be associated with underweight, while good strength was bound with overweight in an individual [10].

Koley and Singh [11] reported a significant association between handgrip strength and BMI among Amritsar youth aged 6–25 years, while Freedman et al. [12] observed a significant association between handgrip strength and skinfold thickness among children and adolescents aged 5–18 years from the USA. Monyeki et al. [13, 14] described an inverse relationship of bent arm hang with weight for age z-score, sum of four skinfolds, and fat free mass while the prevalence of undernutrition was high amongst Ellisras rural children. The association of BMI with skinfold thickness, handgrip, and arm hang strength has received little attention in rural South Africans. Therefore, the aim of this study was to investigate 1) the prevalence of malnutrition and muscle strength, 2) the relationship of arm hang and handgrip strength with BMI and skinfold thickness, 3) the risk of developing undernutrition among Ellisras rural children aged 9–15 years.

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## Material and methods

### Geographical area

Ellisras is a deep rural area situated within the north western area of the Limpopo province, South Africa. The population is about 50,000 people, residing in 42 settlements [15]. These villages are approximately 70 km away from the Ellisras town (231 40S 271 44W), now known as Lephalale, 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 residents, whereas the remaining workforce is involved in subsistence farming and cattle rearing, and a minority – in education and the civil service. Unemployment, poverty, and low life expectancy seem to play a significant role in the rural South African population, to which the Ellisras rural area people are not an exception [16].

### Sample and research design

Details of the Ellisras Longitudinal Study design and sampling have been reported elsewhere [17, 18]. The total of 769 subjects (391 boys and 378 girls) aged 9–15 years who completed all the anthropometric and strength measurements were included in the analysis. The Ethics Committee of the University of Limpopo granted ethical approval prior to the survey, and the participants' parents or guardians provided their written informed consents.

### Anthropometric measurement

All the children underwent a series of anthropometric measurements according to the standard procedures recommended by the International Society of the Advancement of Kinanthropometry (ISAK) [19]. Weight was measured on an electronic scales and rounded to the nearest 0.1 kg, and a Martin anthropometric was used to define height rounded to the nearest 0.1 cm. Skinfolks (suprailiac, subscapular, triceps, biceps) were measured three times with the use of a Slim Guide skinfold caliper, and the values were rounded to the nearest 0.1 mm. BMI was defined as weight (kg)/height (m)<sup>2</sup>.

### Arm hang and handgrip strength measurements

Arm hang and handgrip strength were measured with standard procedures described by the European tests of physical fitness [20]. Arm hang was determined with the use of a horizontal bar, a chair, and a stopwatch. The participant grabbed the bar with an overhand and gripped so that the palms were facing away, then the participant raised their body off the floor/chair so that the chin went above the bar, the elbows were flexed, and the chest was near the bar. The stopwatch was started immediately when the participant was at the hanging

position. The position was maintained for as long as possible. Handgrip was measured in both hands with a dynamometer. The participant's elbow was flexed at the 90° angle, with the forearm parallel to the floor. The dynamometer was maximally squeezed for a 3-second count while, simultaneously lowering the arm to full extension. The participants practiced this procedure once per hand, after which measurements were recorded and rounded to the nearest 0.5 kg. The instrumental precision error was 1.0% [21].

### Statistical analysis

Descriptive statistics were expressed for handgrip, arm hang strengths, BMI, and skinfold thickness. The t-test was used to compare the significant differences between genders by age group. Subscapular and triceps skinfolks of the Ellisras rural children were compared with the National Health and Nutrition Examination Survey III (NHANES) reference population. The international cut-off points for underweight (grade one, two, and three) by sex for exact ages defined to pass through the BMI of 16, 17, and 18 kg/m<sup>2</sup> were used [22]. The children were categorized as normal and over fatness with the use of the sum of four skinfolks (subscapular, triceps, biceps, and suprailiac) above 90<sup>th</sup> percentiles [23]. The following cut off points for strength measurements were used: scores below 25<sup>th</sup> percentile were poor, above the 25<sup>th</sup> percentile but below the 50<sup>th</sup> percentile – minimal fitness, above the 50<sup>th</sup> percentile but below the 75<sup>th</sup> percentile – good strength, and scores at or above the 75<sup>th</sup> percentile represented excellent strength. Chi-squared tests were applied to compare sets of nominal data that had larger frequency counts, whereas Fisher's exact test was used when frequency cells were small (less than five or ten) between genders.

Pearson correlation coefficient was performed to determine the relationship between handgrip, arm hang strength, BMI, and skinfold thickness by gender. Linear regression coefficient analysis was used to assess the relationship between handgrip, arm hang strengths, BMI, and skinfolks thickness, both unadjusted and adjusted for age and gender. Logistic regression allowed to estimate the association between strength measurements and the odds of incident malnutrition (underweight) while adjusting for covariate known to be associated with malnutrition (age, gender). All the data were analysed with a statistical package for social science (SPSS), version 23. The statistically significant difference was assumed at  $p < 0.05$ .

## Results

Figures 1 and 2 show a comparison between triceps and subscapular skinfolks of the NHANES III reference population and Ellisras children aged 9–15 years. The NHANES III reference population showed higher

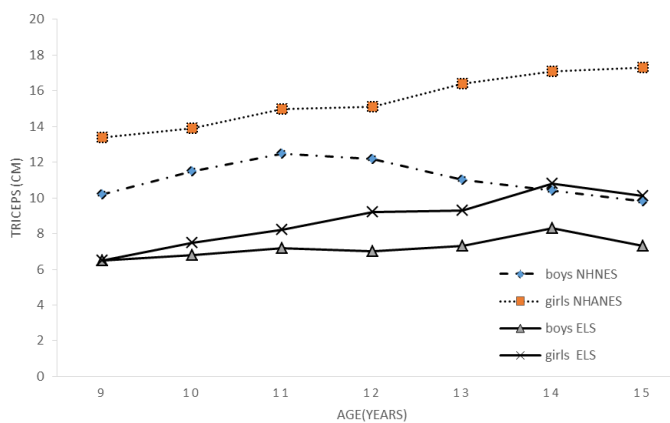


Figure 1. Comparison of the National Health and Nutrition Examination Survey III (NHANES) reference population and Ellisras (ELS) rural children aged 9–15 years with reference to triceps skinfold thickness

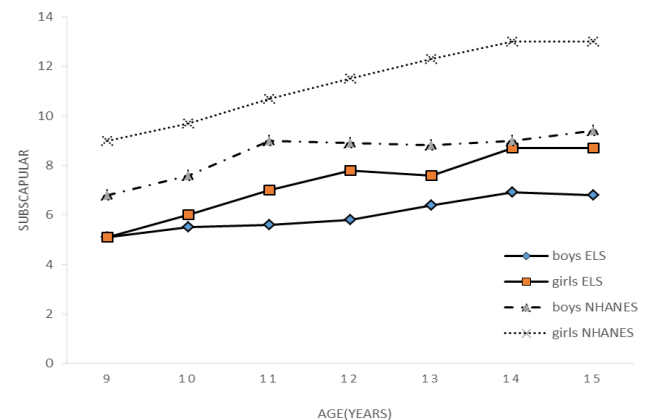


Figure 2. Comparison of the National Health and Nutrition Examination Survey III (NHANES) reference population and Ellisras (ELS) rural children aged 9–15 years with reference to subscapular skinfold thickness

triceps and subscapular skinfolds than the Ellisras rural children throughout the age range (9–15 years).

Table 1 shows the descriptive statistics of absolute body size, handgrips (left and right), and arm hang strength of Ellisras rural children aged 9–15 years. Girls aged 11–13 years represented significantly higher ( $p < 0.05$ ) mean BMI values (15.5–16.5 kg/m<sup>2</sup>) compared with boys (14.7–15.4 kg/m<sup>2</sup>) of the same age. In turn, girls aged 11–12 years had significantly higher ( $p < 0.05$ ) mean

sum of four skinfolds (26.3–29.6 cm) than boys (21.5–22.1 cm) of the same age. In boys, a significantly higher ( $p < 0.05$ ) mean arm hang was observed (9.6–13 s) than in girls (4.0–5.1 s) at the age of 11–15 years.

In Table 2, the prevalence of strength measurements among Ellisras children aged 9–15 years is presented. The prevalence of poor strength (arm hang and hand grip) was higher among girls (41–73%) than in boys (20–55.3%) at the age of 12–15 years.

Table 1. The descriptive statistics of absolute body size, handgrips (left and right), and arm hang strengths in Ellisras rural children aged 9–15 years ( $N = 769$ )

Age (years)			Right handgrip (kg)		Left handgrip (kg)		Arm hang (s)		BMI (kg/m <sup>2</sup> )		Biceps (mm)		Suprailiac (mm)		Sum of skinfolds (mm) (biceps, triceps, suprailiac, subscapular)	
	Boys ( $n = 391$ )	Girls ( $n = 378$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )	boys $m$ ( $SD$ )	girls $m$ ( $SD$ )
9	35	24	15.3 (6.1)	13.6 (5.9)	13.9 (5.8)	12.1 (5.2)	14.5** (11.7)	5.2** (4.3)	14.4 (1.3)	14.4 (2.3)	3.9* (0.9)	4.5* (2.4)	4.5 (1.2)	4.4 (2.3)	20.3* (4.4)	20.7* (9.2)
10	47	52	15.3 (6.2)	12.9 (5.7)	14.1 (6.2)	12.0 (5.4)	7.2 (5.9)	4.6 (4.4)	14.6 (1.3)	14.6 (1.4)	4.1* (1.1)	4.7* (1.4)	4.6 (1.4)	4.9 (1.8)	21.0 (4.9)	23.2 (5.8)
11	68	55	13.1 (5.2)	13.7 (6.0)	12.0 (4.9)	12.4 (5.9)	10.0* (8.1)	5.1* (4.3)	14.7* (1.4)	15.5* (2.1)	4.2* (1.5)	5.4* (2.0)	5.1 (1.9)	5.7 (1.8)	22.1* (6.7)	26.3* (8.5)
12	69	76	15.1 (6.2)	13.5 (5.8)	14.3 (5.7)	12.4 (6.9)	9.6* (8.3)	4.0** (3.5)	15.1* (1.4)	16.4* (2.5)	4.0* (1.0)	5.6* (2.5)	4.8* (1.5)	7.1* (3.9)	21.5* (4.9)	29.6* (12.4)
13	68	65	14.0 (5.0)	14.4 (6.9)	13.0 (5.0)	13.2 (6.7)	13.1** (10.6)	4.9** (7.1)	15.4* (1.5)	16.5* (2.6)	4.4 (1.6)	5.5 (2.0)	5.6* (2.7)	7.0* (3.2)	23.8 (8.1)	29.6 (10.3)
14	61	60	15.0 (6.6)	14.3 (5.3)	13.9 (6.6)	13.0 (5.3)	11.6** (9.6)	4.6** (3.9)	16.2 (1.7)	17.2 (1.7)	4.6 (1.7)	5.8 (1.9)	6.1 (3.0)	9.2 (4.0)	26.0 (9.3)	34.5 (11.3)
15	43	46	13.7 (6.1)	13.7 (5.1)	12.8 (5.6)	12.9 (5.3)	12.4* (7.6)	5.1* (5.0)	16.9 (1.6)	17.8 (1.2)	4.3 (1.7)	5.6 (1.3)	6.0 (2.0)	7.7 (2.5)	24.4 (7.3)	32.1 (8.7)

$N$  – number of population,  $m$  – mean,  $SD$  – standard deviation, \*  $p < 0.05$ , \*\*  $p < 0.001$

Table 2. The prevalence of strength measurements (left and right handgrip and arm hang) in Ellisras children aged 9–15 years

Age (years)	Left handgrip			Right handgrip			Arm hang		
	minimal strength % (n)	good % (n)	excellent % (n)	minimal strength % (n)	good % (n)	excellent % (n)	minimal strength % (n)	good % (n)	excellent % (n)
Boys									
9	40.0 (14)	28.6 (10)	31.4 (11)	37.1 (13)	20.0 (7)	42.9 (15)	20 (7)	34.3 (12)	45.7 (16)
10	40.5 (19)	29.8 (14)	29.8 (14)	31.9 (15)	36.2 (17)	31.9 (15)	55.3 (26)	19.1 (9)	25.5 (12)
11	50 (34)	30.9 (21)	19.1 (13)	48.5 (33)	32.4 (22)	19.1 (13)	25 (17)	32 (26)	36.8 (25)
12	40.6 (28)*	27.5 (19)	31.9 (22)	39.1 (27)*	30.4 (21)	30.4 (21)	43.5 (30)	21.7 (15)	34.8 (24)
13	45.6 (31)	30.9 (21)	23.5 (16)	41.2 (28)*	35.3 (24)	23.5 (16)	26.5 (18)*	23.5 (16)	50 (34)
14	45.9 (28)*	21.3 (13)	32.8 (20)	41.1 (25)	26.2 (16)	62.8 (20)	29.5 (18)*	29.5 (18)	41 (25)
15	46.5 (20)	25.6 (11)	22.9 (12)	51.2 (22)	20.9 (9)	27.9 (12)	25.6 (11)*	16.3 (7)	58.1 (24)
Girls									
9	45.8 (11)	12.5 (3)	41.7 (10)	50 (12)	33.3 (8)	16.7 (4)	58.3 (14)	29.2 (7)	12.5 (3)
10	55.8 (29)	23.1 (12)	21.2 (11)	53.8 (28)	28.8 (15)	17.3 (9)	73.1 (38)	21.2 (11)	5.8 (3)
11	49.1 (27)	30.9 (17)	20.0 (11)	47.3 (26)	29.1 (16)	23.6 (13)	67.3 (37)	18.2 (10)	14.5 (8)
12	55.3 (42)	22.4 (17)	22.4 (17)	51.3 (39)*	27.6 (21)	21.1 (16)	72.4 (55)	23.7 (18)	3.9 (3)
13	62.3 (34)	20.0 (13)	22.4 (18)	50.8 (33)*	21.5 (14)	27.7 (18)	69.2 (45)*	24.6 (16)	6.2 (4)
14	50 (30)*	23.3 (14)	26.7 (16)	41.0 (25)	36.7 (22)	21.7 (13)	65.0 (39)*	28.3 (17)	6.7 (4)
15	50 (23)	26.1 (12)	23.9 (11)	50.0 (23)	28.3 (13)	21.7 (10)	63.0 (29)*	21.7 (10)	15.2 (7)

\*  $p < 0.05$ 

Table 3. The prevalence of malnutrition (severe, moderate, and mild underweight, overweight, obese, and over fatness) as established by the body mass index and sum of four skinfolds (triceps, biceps, suprailiac, and subscapular) among Ellisras rural children aged 9–15 years

Age group (years)	(N = 769)		Severe underweight		Moderate underweight		Mild underweight		Overweight		Obese		Over fatness	
	boys (n = 391)	girls (n = 378)	boys % (n)	girls % (n)	boys % (n)	girls % (n)	boys % (n)	girls % (n)	boys % (n)	girls % (n)	boys % (n)	girls % (n)	boys % (n)	girls % (n)
9	35	24	2.9 (1)	12.5 (3)	22.9 (8)	16.7 (4)	28.6 (10)	33.3 (8)	–	4.2 (1)	–	–	8.6 (3)	8.3 (2)
10	47	52	12.8 (6)	3.8 (2)	–	11.5 (6)	44.7 (21)	36.5 (19)	–	–	–	–	8.5 (4)	9.6 (5)
11	68	55	8.8 (6)	5.5 (3)	14.7 (10)	9.1 (5)	36.8 (25)	32.7 (18)	1.5 (1)	3.6 (2)	–	–	8.8 (6)	9.1 (5)
12	69	76	8.7 (6)	7.9 (6)	10.1 (7)	7.9 (6)	42.0 (29)	23.7 (18)	–	2.6 (2)	–	–	8.7 (6)	9.2 (7)
13	68	65	10.3 (7)	12.3 (8)	10.3 (7)	16.9 (11)	50.0 (34)	29.2 (19)	–	3.1 (2)	–	–	8.8 (6)	9.2 (6)
14	61	60	13.1 (8)	1.7 (1)	14.8 (9)	13.3 (8)	23.0 (14)	85.0 (51)	–	–	–	–	9.8 (6)	10.0 (6)
15	43	46	9.3 (4)	4.3 (2)	16.3 (7)	6.5 (3)	25.6 (11)	30.4 (14)	–	–	–	–	9.3 (4)	8.7 (4)

Table 3 illustrates the prevalence of malnutrition in Ellisras children aged 9–15 years. The majority of Ellisras rural children were underweight (1.7–85%), and few were overweight (1.5–4.2%). The prevalence of over fatness ranged from 8.3 to 10.0%, and the difference between genders was insignificant.

The Pearson correlation between handgrip strength, arm hang strength, and other anthropometric indicators can be seen in Table 4. There was a significant ( $p < 0.001$ ) negative association ( $r^2$  ranged from  $-0.24$  to  $-0.13$ ) between arm hang strength and all other anthropometric indicators.

Table 5 presents the linear regression analysis. A significant ( $p < 0.05$ ) positive association was observed

between right handgrip and triceps ( $\beta = 0.191$ ; 95% CI =  $0.026$ – $0.356$ ), unadjusted. Moreover, right handgrip showed a significant positive association with biceps ( $\beta = 0.168$ ; 95% CI =  $0.00$ – $0.337$ ), unadjusted. When adjusted for age and gender, left handgrip was negatively associated with biceps ( $\beta = -0.186$ ; 95% CI = from  $-0.353$  to  $-0.018$ ) among Ellisras rural children.

The logistics regression of the association between poor strengths and nutrition status among Ellisras rural children aged 9–15 years is illustrated in Table 6. There was a significant ( $p < 0.05$ ) association between poor strength and underweight, both unadjusted (OR =  $0.60$ ; 95% CI =  $0.43$ – $0.85$ ) and adjusted (OR =  $0.60$ ; 95% CI =  $0.43$ – $0.84$ ) for age and gender among Ellisras rural children.

Table 4. The Pearson moment correlation coefficient of absolute body size and strength measurements of Elliras children aged 9–15 years

Variable	Right handgrip		Left handgrip		Arm hang	
	boys	girls	boys	girls	boys	girls
BMI	−0.02	−0.03	−0.01	−0.06	−0.13*	−0.21**
Triceps	0.02	−0.03	0.04	−0.06	−0.23**	−0.21**
Biceps	−0.03	−0.02	−0.04	−0.07	−0.24**	−0.20**
Subscapular	−0.03	−0.04	−0.00	−0.07	−0.14**	−0.19**
Suprailiac	−0.05	−0.05	−0.04	−0.08	−0.19**	−0.18**
Sum of skinfold	−0.01	−0.02	0.01	−0.06	−0.20**	−0.18**

BMI – body mass index, \*  $p < 0.05$ , \*\*  $p < 0.001$ Table 5. Linear regression coefficients,  $p$  value, and 95% confidence intervals for the association of skinfolds and body mass index with handgrips and bent arm hang among Elliras children aged 9–15 years

Variable	Unadjusted				Adjusted (age and gender)			
	$\beta$	$p$ value	95% CI		$\beta$	$p$ value	95% CI	
Right handgrip								
BMI	−0.10	0.344	−0.30	0.10	−0.07	0.537	−0.30	0.16
Triceps	0.19	0.023*	0.03	0.36	−0.04	0.425	−0.15	0.06
Biceps	−0.01	0.943	−0.16	0.15	0.17	0.050*	0.00	0.34
Subscapular	−0.05	0.416	−0.16	0.07	−0.00	0.964	−0.15	0.15
Suprailiac	0.01	0.720	−0.02	0.03	−0.05	0.399	−0.16	0.07
Sum of skinfolds	−0.03	0.181	−0.07	0.01	−0.02	0.371	−0.07	0.03
Left handgrip								
BMI	−0.03	0.644	−0.15	0.09	−0.06	0.345	−0.19	0.07
Triceps	0.08	0.157	−0.03	0.18	0.08	0.150	−0.03	0.19
Biceps	−0.22	0.009*	−0.38	−0.05	−0.19	0.030*	−0.35	−0.02
Subscapular	−0.00	0.988	−0.15	0.15	−0.01	0.891	−0.16	0.14
Suprailiac	0.01	0.801	−0.10	0.13	0.01	0.895	−0.11	0.12
Sum of skinfolds	−0.039	0.075	−0.083	0.004	−0.036	0.144	−0.083	0.012
Arm hang								
BMI	−0.81	0.000	−0.08	−0.55	−0.70	0.000	−0.98	−0.35
Triceps	−0.69	0.000	−0.86	−0.53	−0.52	0.000	−0.69	−0.35
Biceps	−1.29	0.000	−1.59	−0.99	−0.86	0.000	−1.16	−0.57
Subscapular	−0.81	0.000	−1.03	−0.57	−0.55	0.000	−0.78	−0.31
Suprailiac	−0.68	0.000	−0.87	−0.49	−0.51	0.000	−0.71	−0.32
Sum of skinfolds	−0.24	0.000	−0.31	−0.19	−0.18	0.000	−0.24	−0.12

CI – confidence interval, BMI – body mass index, \*  $p < 0.05$ 

Table 6. Odds ratio and 95% confidence interval for the association of poor strengths and undernutrition among Elliras rural children aged 7–11 years

Variable	Unadjusted				Adjusted for age and gender			
	OR	<i>p</i> value	95% CI		OR	<i>p</i> value	95% CI	
Poor strength								
Underweight	0.60	0.003**	0.43	0.84	0.60	0.004**	0.43	0.85
Over fatness	1.50	0.195	0.81	2.75	1.52	0.190	0.81	02.84

CI – confidence interval, \*\*  $p < 0.001$



## Discussion

The aim of the study was to investigate the association between handgrip, arm hang strength, BMI, and skinfold thickness of rural Ellisras children aged 9–15 years. The strength test was used to evaluate the performance of hand muscle by measuring the maximum grip force that could be executed by one muscular contraction [24]. There were significant associations between skinfold, BMI, and arm hang strength in the population. No significant associations were recorded between anthropometric indicators and grip strength measurements.

Generally, boys showed higher muscular strength than girls (left and right handgrip and arm hang) [2], though in another study [25] no significant difference between genders was observed. The grip strength was reported to be higher in the dominant hand but no such significant differences between genders could have been documented [26] as in the current study, in which boys had significantly higher handgrip and arm hang strength than girls. Similar results were reported among European and Indian children aged 6–17 years [7, 27, 28].

The prevalence of underweight and low fatness was high among Ellisras rural children aged 9–15 years. Furthermore, NHANES III reference children presented higher subscapular and triceps measurements than Ellisras rural children. Similar results were earlier reported with regard to poor nutritional status among rural South African children [29–32]. The prevalence of poor muscle strength was high in the current study. Furthermore, Monyeki et al. [13] observed low physical activity in the sample as compared with children studied in other parts of the world. Poor muscle strength was reported to be significantly associated with lower body weight or undernutrition, presence of chronic diseases, and physical inactivity [33, 34], while good strength could be an indicator of better childhood and early life nutrition [35].

In the present study, arm hang strength was negatively associated with BMI and skinfold thickness. Handgrip strength did not show any significant association with other anthropometric indicators. The study results remain in contrast with previous studies which reported a significant positive association between hand grip strength and skinfold thickness among children and adolescents [12, 35]. A decrease in muscle mass reduces physical strength, with low energy available to be used owing to low fatness among Ellisras rural children.

Our findings suggest that underweight children with low body fatness were more likely to develop low strength than children with normal body fatness. The results were similar to a previous study by Must et al. [36], who reported that underweight was significantly associated with poor strength among Indian youth. Physiologically, this could be due to poor dietary or energy intake that leads to underweight and poor strength [5, 37]. Furthermore, thinner people often have poor strength, higher illness prevalence, and greater mortality than those with

normal body weight [35]. Poor muscle strength could be a risk for diseases later in life.

The major limitation of the study is that our sample only included children from rural areas of South Africa, dominated by an indigenous knowledge system [38]; as a result; extrapolation of the outcomes to urban areas should be made with caution. In our study, we did not consider the education level of the subjects, which has been reported to be associated with poor muscular strength [39]. Maturation stage, physical fitness, physical activity, and the family socioeconomic level of the participants could not be included in the analysis.

## Conclusions

The prevalence of undernutrition and low strength measurements were high in the Ellisras rural children. There was a significant association between arm hang and other anthropometric indicators, while handgrip showed no significant association with other anthropometric indicators. Further studies are needed to investigate the association between strength and undernutrition overtime.

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