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Chapter

Health Status and Permanent Loss to Follow up of Ellisras Longitudinal Study Subjects: Rural South African Context

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Abstract

Noncommunicable diseases (NCDs) are responsible for two out of three deaths worldwide with their profile changing from one country to another. But evidence to sustained these changes are still very limited in rural South African population. The well-characterized Ellisras Longitudinal Study (ELS) provides a unique opportunity of mapping some of these changes in vulnerable adolescent and young adults. The objective is we determined the extent of NCD risk factors derived from anthropometric and blood pressure measurements affected Ellisras Longitudinal Study (ELS) subjects over time for those who died or permanently lost to follow-up. A total of 2238 subjects aged 3–10 years (born between 1994 and 1986) were randomly selected to take part of the Ellisras Longitudinal Study (ELS) in November 1996. The attrition rate of ELS subjects based on death ranges between 0.71 and 3.73% for boys and 0.75 and 4.89% for girls. The prevalence of sever undernutrition ranges from 3.2 to 53%, moderate undernutrition ranges from 9.7 to 28.8%, while mild undernutrition ranges from 17.9 to 59.1% for both males and females. The prevalence of undernutrition was high while hypertension, obesity, and overweight were low in the population. The identification of appropriate NCD indicators for mortality in rural South African population needs more consideration and evaluation.

Keywords: mortality, epidemiology, nutritional status, cause of death, lifestyle

1. Introduction

Noncommunicable diseases (NCDs) are a group of diseases that share similar risk factors resulting from long exposure to unhealthy diets, smoking, lack of exercise, and possibly stress [1]. Major risk factors are high blood pressure (BP), tobacco addictions, poor lipids profile, and diabetes. These result in high mortality rates due to stroke, heart attacks and nutrition-induced cancers, chronic bronchitis, and many others [1, 2].

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NCDs are responsible for two out of three deaths worldwide with their profile changing from one country to the other [3]. Africa is expected to experience the largest increase in NCD-related mortality globally with about 46% of all mortality expected to be attributed to NCDs by 2030 [3, 4]. Exposure to the known risk factors account for about two-thirds of premature NCD deaths with an estimated half of NCD deaths attributed to weak health systems and poverty in sub-Saharan Africa [5]. However, the rising NCD burden will add great pressure to the overstretched health systems and pose a major challenge to the development in Africa given the fragmented literature information and the indigenous knowledge system deep rooted in rural areas of South Africa [6, 7]. While low-cost solutions and high-impact essential NCD interventions delivered through primary health-care approach have been shown to have impacts on population level, the existing literature shows that the changing profile of NCDs has been inadequate and fragmented [8]. A well-formulated cohort study in Africa could answer major questions relating to the changing magnitude of NCD risk factor profiles in Africa. Furthermore, NCDs are no longer just an issue for older people, there were in fact 16 million deaths from NCDs in people under the age of 17 years in 2005 of which the World Heart Federation has plan to reduce these deaths by 25% in 2025 [9]. Documenting the profiles of NCDs over time will not only assist the policy makers to get to the bottom of the problem but the population will also be aware of their health status as they grow older. The South African National Development Plan vision of reducing NCDs mortality by 28% in 2030 requires a cohort study that focuses on NCDs from younger ages to older ages. The Ellisras Longitudinal Study and the Birth to Twenty Study are among other cohort studies in South Africa which are geared to achieving this goal [10, 11]. The concepts of relying on indigenous knowledge system to combat NCDs among rural South African population will be replaced by well-researched concepts of NCD profiles from young age to adulthood [7].

In South Africa, NCD such as cardiovascular disease (CVD) is the second leading cause of death after HIV accounting for up to 43% of deaths among adults [12]. The Ellisras Longitudinal Study (ELS) from rural areas of Ellisras in South Africa clearly reported that NCD profiles are changing rapidly over time from childhood to young adults.

The attrition rate for the ELS ranges from 2.4 to 70.3% (**Table 1**) due to migration to urban areas, illness, pregnancy, and death. However, the attrition rate of ELS subjects based on death ranges between 0.71 and 3.73% for boys and 0.75 and 4.89% for girls. Therefore, the aim of the study was to determine the extent of NCD risk factors derived from anthropometric and blood pressure measurements which affected ELS subjects over time who died or permanently lost to follow-up.

2. Methods

2.1 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 residing in 42 settlements [13]. These villages are approximately 70 km from the Ellisras town (23°40S 27°44 W), now known as Lephalale, adjacent to Botswana border. The Iscor coal mine, Matimba and Medupi electricity power stations are the major sources of employment for many of the Ellisras residents, whereas the remaining workforce is involved in subsistence farming and cattle rearing, while the minority is in education and civil services [14, 15].

Period of measurements	Males		Females		Total	
	N	%	N	%	N	%
November 1996	1201		1054		2255	
May 1997	1106		969		2075	
Dropouts	95	7.9	55	5.2	150	6.7
November 1997	1146		1054		1890	
Dropouts	55	4.5	0	0	55	2.4
May 1998	999		891		1890	
Drop outs	202	16.8	133	12.6	335	14.9
November 1998	1007		894		1901	
Dropouts	194	16.2	130	12.3	324	14.4
May 1999	1033		941		1974	
Dropouts	168	14.0	83	7.9	251	11.1
November 1999	998		920		1918	
Dropouts	217	18.1	117	11.1	334	14.8
May 2000	1006		918		1924	
Dropouts	195	16.2	106	10.1	301	13.3
November 2000	936		877		1813	
Dropouts	265	22.1	147	14.0	412	18.3
May 2001	962		904		1866	
Dropouts	239	19.9	120	11.4	359	15.9
November 2001	914		855		1769	
Dropouts	287	23.9	169	16.0	456	20.2
May 2002	890		823		1713	
Dropouts	311	25.9	201	19.1	512	22.7
May 2003	942		878		1820	
Dropouts	259	21.6	146	13.9	405	18.0
November 2003	911		828		1739	
Dropouts	328	27.3	196	18.6	524	23.2
November 2009	854		800		1654	
Dropouts	347	28.9	224	21.3	571	25.3
November/December 2013	520		541		1061	
Dropouts	681	56.7	483	45.8	1164	51.6
November/December 2015	356		372		728	
Dropouts	845	70.3	652	61.9	1497	66.4

Table 1.
Number and percentages (%) of longitudinal participants and dropouts over the years of measurements.

2.2 Study design and sampling

This study is part of the ongoing Ellisras Longitudinal Study (ELS), for which the details of the sampling procedure were reported elsewhere [16]. For the purpose of the current study, only the subjects who died were included in the analysis. The cause of death for the majority of the subjects was unknown as it is a family secret given the indigenous knowledge system followed in the Ellisras rural population [6, 7]. A total of 373 boy and 613 girl subjects aged 8–26 years who were permanently lost to follow-up over time (November 1996–December 2015) (see **Tables 2** and **3**) were included in the analysis.

2.3 Anthropometry

All participants underwent a series of anthropometric measurements [weight, height, waist circumference, hip circumference, and skinfold thickness (triceps, subscapular, biceps, and supraspinale)] were taken according to the standard procedures recommended by the International Society of the Advancement of Kinanthropometry (ISAK) from November 1996 to December 2015 [17, 18]. The weight was measured on an electronic scale to the nearest 0.1 kg. Martin anthropometric measurement was used to measure height to the nearest 0.1 cm, and waist circumference measurements were taken to the nearest 0.1 cm, using a soft measuring tape. Skinfold measurements were taken using a slime guide caliber to the nearest 10 mm.

2.4 Blood pressure

Using an electronic Micronta monitoring kit, at least three blood pressure (BP) readings of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken after the child had been seated for 5 min or longer [19]. The bladder of the device contains an electronic infrasonic transducer that monitors the BP and pulse rate, displaying these concurrently on the screen. This versatile instrument has been designed for research and clinical purposes [19]. In a pilot study, conducted before the survey, a high correlation of 0.93 was found between the readings taken with the automated device and those with a conventional mercury sphygmomanometer. Hypertension, defined as the average of three separate BP readings where the SBP or DBP is ≥95th percentile for age and sex, was determined [20].

2.5 Statistical analysis

Descriptive statistics for absolute body size were presented. Body mass index (BMI) was defined as weight (kg)/height $\times$ height $(m)^2$. All children (under 18 years) were classified as underweight, normal, overweight, and obese according to Cole et al. [21, 22] cutoff points and the WHO [3] for adults using BMI. Waist-to-height ratio (WHtR) cutoff point of 0.5 was used [23, 24] while cutoff point for the waist circumference [25], waist-to-hip ratio (WHR) was derived from the WHO [3]. Over fatness was defined as the 95% percentile by age and gender for the sum of four skinfolds thickness [26]. The correlation coefficient moment was used to assess the association between NCDs risk factors fat (i.e., sum of four skinfolds, BMI, WC, WHR, WHtR, BP, and pulse rate) at the first measurement and at all repeated measurements by gender. Statistical significance was set at $p < 0.05$. All the statistical analyses were done using the Statistical Package for the Social Sciences (SPSS).

3. Results

Tables 2 and **3** present the development over time of cardiovascular risk factors derived from anthropometric measurements and blood pressure measurements of

	November 1996	May 1997	November 1997	May 1998	November 1998	May 1999	November 1999	May 2000	November 2000	May 2001	November 2001	May 2002	May 2003	November 2003	November 2015
N	16	17	42	31	31	33	34	35	28	28	22	23	28	25	8
Age	8.0 (1.29)	8.6 (1.36)	9.2 (1.68)	9.9 (1.59)	10.4 (1.60)	10.6 (1.76)	11.2 (1.74)	11.5 (1.75)	11.8 (1.79)	12.5 (1.73)	13.0 (1.95)	13.5 (1.79)	14.5 (1.76)	14.8 (1.79)	25.9 (2.10)
Ht	125.4 (9.11)	129.6 (8.26)	130.4 (10.48)	132.7 (9.12)	135.0 (8.84)	136.0 (9.61)	138.9 (9.34)	141.9 (10.66)	141.8 (10.14)	145.2 (10.37)	147.1 (10.70)	150.0 (10.79)	153.7 (10.41)	157.8 (10.81)	173.4 (8.54)
Wt	20.5 (3.33)	22.7 (3.51)	23.7 (4.36)	25.8 (4.12)	26.7 (4.52)	27.6 (4.65)	28.4 (5.16)	30.1 (7.18)	30.6 (6.02)	32.4 (8.09)	33.1 (7.01)	35.2 (8.21)	38.0 (9.01)	40.8 (9.75)	71.3 (21.47)
Waist	52.0 (5.43)	54.7 (4.04)	53.4 (4.12)	54.4 (3.96)	55.6 (3.93)	55.9 (4.00)	56.7 (3.35)	57.9 (4.13)	57.5 (4.11)	58.3 (5.27)	58.8 (4.35)	60.1 (5.59)	59.2 (4.39)	60.1 (5.46)	81.5 (21.24)
Hip	56.4 (6.25)	59.2 (5.66)	60.6 (5.22)	61.3 (4.00)	63.4 (4.74)	63.3 (5.19)	64.8 (5.32)	65.4 (6.27)	65.7 (5.95)	66.3 (8.12)	66.2 (5.84)	69.7 (7.69)	69.8 (7.54)	69.6 (7.56)	96.7 (17.11)
BMI	13.1 (1.96)	13.6 (1.63)	13.9 (1.33)	14.6 (1.39)	14.5 (1.27)	14.8 (1.31)	14.6 (1.47)	14.8 (1.92)	15.1 (1.34)	15.1 (2.16)	15.1 (1.60)	15.5 (2.17)	15.8 (2.08)	16.4 (2.27)	24.0 (8.63)
WHtR	0.42 (0.04)	0.42 (0.02)	0.41 (0.03)	0.41 (0.02)	0.41 (0.02)	0.41 (0.02)	0.41 (0.02)	0.41 (0.03)	0.41 (0.02)	0.40 (0.45)	0.40 (0.02)	0.40 (0.03)	0.39 (0.09)	0.38 (0.03)	0.47 (0.13)
WHR	0.92 (0.05)	0.93 (0.08)	0.88 (0.41)	0.90 (0.04)	0.88 (0.05)	0.88 (0.03)	0.88 (0.04)	0.89 (0.05)	0.88 (0.05)	0.89 (0.06)	0.86 (0.05)	0.87 (0.05)	0.85 (0.06)	0.87 (0.05)	0.83 (0.07)
S4sk	19.3 (1.84)	18.9 (2.65)	20.1 (4.35)	21.0 (4.98)	21.7 (3.5)	21.5 (3.18)	19.7 (4.16)	20.6 (4.12)	20.8 (3.32)	24.8 (9.94)	24.2 (10.71)	22.1 (12.75)	22.5 (6.48)	27.6 (12.5)	29.4 (18.72)
SBP (mmHg)	–	–	–	–	–	97.1 (9.26)	99.2 (9.67)	101.9 (12.60)	101.9 (7.97)	93.1 (8.42)	90.9 (8.10)	102.2 (13.0)	105.4 (9.03)	101.6 (12.56)	134.6 (20.88)
DBP (mmHg)	–	–	–	–	–	60.3 (7.51)	61.1 (7.89)	65.60 (9.94)	67.0 (10.12)	62.8 (6.80)	61.0 (7.60)	60.0 (10.27)	67.9 (7.67)	59.9 (9.89)	76.0 (19.6)
Heart rate (beat/min)	–	–	–	–	–	69.9 (12.57)	76.1 (13.60)	80.37 (15.52)	75.61 (11.66)	74.9 (11.2)	74.6 (7.92)	74.0 (10.57)	79.1 (12.95)	75.5 (11.59)	78.8 (18.74)

Ht—height in cm; Wt—weight in kg; BMI—body mass index in kg/m^2; WHtR—waist-to-height ratio; WHR—waist-to-hip ratio; S4sk—sum of four (triceps, subscapular, biceps, and supraspinale) skinfold in mm.

Table 2.
Development over time of absolute body size and blood pressure of Ellisras rural males who dropped out of the study presently due to death aged 7–26 years.

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	November 1996	May 1997	November 1997	May 1998	November 1998	May 1999	November 1999	May 2000	November 2000	May 2001	November 2001	May 2002	May 2003	November 2003	November 2015
N	31	28	54	51	51	52	52	47	46	46	47	45	44	45	8
Age	7.6 (1.51)	8.1 (1.53)	8.8 (1.74)	9.3 (1.65)	9.8 (1.65)	10.5 (1.45)	10.9 (1.51)	11.3 (1.54)	11.8 (1.53)	12.3 (1.56)	12.95 (1.43)	13.3 (1.56)	14.20 (1.52)	14.8 (1.54)	26.2 (2.01)
Ht	121.3 (8.40)	123.6 (7.95)	127.6 (10.54)	129.6 (8.62)	132.0 (8.57)	135.9 (8.32)	138.7 (8.82)	142.3 (9.22)	145.2 (8.96)	147.1 (9.46)	150.0 (9.15)	152.6 (8.39)	155.5 (7.94)	158.4 (7.0)	163.0 (8.86)
Wt	19.0 (3.67)	19.8 (2.80)	22.3 (4.69)	23.4 (3.89)	24.7 (4.14)	26.4 (4.25)	27.6 (4.93)	29.6 (5.87)	31.5 (5.83)	33.7 (6.79)	35.7 (7.18)	38.2 (7.62)	40.4 (7.71)	44.1 (7.22)	61.1 (9.25)
Waist	51.0 (4.08)	50.3 (2.74)	51.3 (3.20)	52.3 (3.86)	53.8 (3.56)	55.5 (3.32)	56.0 (3.79)	55.8 (4.57)	56.4 (3.90)	57.8 (4.47)	58.1 (4.09)	60.2 (4.81)	60.1 (5.10)	60.3 (4.90)	79.4 (10.4)
Hip	55.8 (4.59)	58.3 (3.44)	60.4 (5.00)	60.7 (4.04)	63.3 (4.41)	63.1 (8.40)	66.7 (5.20)	68.1 (6.1)	69.5 (6.40)	67.5 (6.22)	71.9 (6.63)	77.0 (8.43)	75.8 (7.73)	77.4 (8.35)	100.4 (6.96)
BMI	12.8 (1.98)	13.0 (1.26)	13.7 (2.09)	13.9 (1.27)	14.1 (1.39)	14.2 (1.38)	14.4 (1.55)	14.5 (1.92)	14.8 (1.56)	15.43 (1.89)	15.75 (2.09)	16.28 (2.29)	16.57 (2.06)	17.53 (2.46)	23.11 (3.75)
WHtR	0.42 (0.04)	0.41 (0.03)	0.40 (0.04)	0.40 (0.03)	0.41 (0.03)	0.41 (0.02)	0.40 (0.02)	0.40 (0.03)	0.4 (0.02)	0.40 (0.04)	0.39 (0.03)	0.39 (0.03)	0.39 (0.03)	0.38 (0.03)	0.49 (0.07)
WHR	0.92 (0.06)	0.86 (0.05)	0.85 (0.05)	0.86 (0.05)	0.85 (0.05)	0.9 (0.43)	0.8 (0.05)	0.8 (0.04)	0.8 (0.04)	0.86 (0.07)	0.81 (0.05)	0.79 (0.58)	0.80 (0.06)	0.78 (0.06)	0.79 (0.06)
S4sk	20.02 (3.16)	19.4 (2.44)	22.1 (5.07)	23.9 (4.88)	24.5 (4.78)	24.1 (4.34)	25.0 (6.40)	26.7 (7.73)	28.5 (7.14)	26.5 (12.23)	27.63 (13.88)	31.92 (8.99)	30.56 (12.90)	34.71 (10.84)	33.8 (10.52)
SBP (mmHg)						99.4 (11.62)	100.4 (10.79)	104.3 (10.67)	103.3 (12.48)	99.1 (7.11)	97.6 (8.63)	104.9 (12.41)	109.5 (9.39)	105.1 (12.3)	106.1 (8.75)
Diastolic BP (mmHg)						61.2 (8.28)	61.9 (9.05)	67.6 (8.74)	67.4 (9.54)	64.8 (6.46)	63.8 (7.10)	61.9 (8.08)	68.7 (6.84)	62.0 (8.05)	70.8 (14.74)
Pulse (beats/min)						79.1 (10.73)	75.3 (13.54)	77.4 (16.00)	82.9 (14.24)	77.8 (11.37)	79.1 (11.16)	84.3 (15.68)	82.8 (12.53)	83.9 (15.52)	92.1 (12.33)

Ht—height in cm; Wt—weight in kg; BMI—body mass index in kg/m^2; WHtR—waist-to-height ratio; WHR—waist-to-hip ratio; S4sk—sum of four (triceps, subscapular, biceps, and supraspinale) skinfold in mm.

Table 3.
Development over time of absolute body size and blood pressure factors of Ellisras rural females who dropped out of the study presently due to death aged 7–26 years.

Ellisras rural males and females mean aged 7–26 years who died. There was a gradual increase in mean height (125.4 cm SD 9.11), weight (20.5 kg SD 3.33) for males from November 1996 to November 2015 (height = 173.4 cm SD 8.54, weight = 71.3 kg SD 21.47) (**Table 2**).

Females showed a gradual growth increase in mean height (121.3 cm SD 8.40) and mean weight (19.0 kg SD 3.67) from November 1996 to November 2015 (mean height 163.0 = cm SD 8.86) and mean weight 61.1 kg SD 9.25) (**Table 3**). Similar trend was observed for blood pressure (mean systolic blood pressure = 97.1 mmHg SD 9.26 and mean diastolic blood pressure = 60.3 mmHg SD 7.51) from May 1999 to November 2015 (mean systolic blood pressure = 134.6 SD 20.88 and mean distolic blood pressure = 78.8 mmHg SD 18.74) for males (**Table 2**). For girls, mean systolic blood pressure (99.4 mmHg SD 11.62) and diastolic blood pressure (61.2 mmHg SD 8.28) increased from November 1996 to November 2015 (mean systolic blood pressure = 106.1 mmHg SD 8.75 and diastolic blood pressure = 70.8 mmHg SD 14.74).

Table 4 shows the development of the prevalence of cardiovascular risk factors of Ellisras rural males and females aged 7–26 who died. The prevalence of sever undernutrition ranges from 3.2 to 53%, moderate undernutrition ranges from 9.7 to 28.8% while mild undernutrition ranges from 17.9 to 59.1% for both males and females. The prevalence of abdominal obesity ranges from 0 to 37.5%, while obesity, overweight, and over fatness was low (ranges from 0 to 12.5%) (**Table 4**).

Table 5 presents moment correlation coefficient for the first measurement and subsequent measurements for the cardiovascular risk factors derived from anthropometric measurements for Ellisras rural males and females over time (November 1996 to November 2015). The correlation coefficient was low and insignificant for males and females for all cardiovascular risk factors over time. The correlation for blood pressure was significant (p ranges from 0.001 to 0.05) for systolic blood pressure (r^2 ranges from 0.42 to 0.95) and diastolic blood pressure (r^2 ranges from 0.28 to 0.77) over time.

4. Discussions

The current study aimed to determine the extent of NCD risk factors derived from anthropometric and blood pressure measurements which affected ELS subjects over time who died or permanently lost to follow-up. The prevalence of undernutrition was high while obesity, overweight, abdominal obesity and hypertension was low. However, there was significant positive correlation between systolic and diastolic over time. The data presented the mortality rate owing to NCD in rural communities of Ellisras areas which differs to the urban area counterparts reported by Miranda et al. and Kengne et al. [27, 28].

In Amsterdam, Kemper et al. [29] reported a clear increase in prevalence of obesity from youth to adulthood with a decrease in physical activity. However, undernutrition and low physical activity was high in the Ellisras rural population [30, 31]. This might indicate that undernutrition as an indicator of NCD could be the cause of death or leads to permanent loss of follow-up of the ELS participants.

The burden of NCD in rural South African population is substantial, and patients with this condition make significant demands on the health-care resources. Epidemiological data from South Africa and Tanzania reveal high prevalence of diabetes and hypertension [32, 33]. The burden of NCD is likely to increase in the next coming decade in rural South African population. The projection from Global Burden of Diseases Study suggests that by the year 2020, the proportion of overall burden in Africa due to NCD will increase to 42% among adults aged 15–59 years [34].

	November 1996	May 1997	November 1997	May 1998	November 1998	May 1999	November 1999	May 2000	November 2000	May 2001	November 2001	May 2002	May 2003	November 2003	November 2015
	% (n)	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**% (n)**
Males															
High SBP	–	–	–	–	–	3.0 (1)	2.9 (1)	8.6 (3)	3.6 (1)	–	–	8.7 (2)	–	8.0 (2)	62.5 (5)
High DBP	–	–	–	–	–	–	–	5.7 (2)	7.1 (2)	–	–	4.3 (1)	3.6 (1)	4.0 (1)	25.0 (2)
Hypertension	–	–	–	–	–	–	–	–	–	–	–	–	–	–	25 (2)-
BMI—undernutrition															
BMI—severe	37.5 (6)	17.6 (3)	11.9 (5)	3.2 (1)	3.2 (1)	6.1 (2)	11.8 (4)	5.7 (2)	3.6 (1)	17.9 (5)	9.1 (2)	21.7 (5)	10.7 (3)	20.0 (5)	
BMI—moderate	12.5 (2)	17.6 (3)	28.6 (12)	12.9 (4)	16.1 (5)	21.2 (7)	14.7 (5)	22.9 (8)	17.9 (5)	14.3 (4)	13.6 (3)	8.7 (2)	25.0 (7)	12.0 (3)	
BMI—mild	25.0 (4)	35.3 (6)	31.0 (13)	38.7 (12)	41.9 (13)	24.2 (8)	35.3 (12)	40.0 (14)	39.3 (11)	32.1 (9)	59.1 (13)	34.8 (8)	32.1 (9)	24.0 (6)	
BMI—overweight	–	–	–	3.2 (1)	–	–	–	–	–	–	–	–	–	–	12.5 (1)
BMI—obese	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12.5 (1)
WHtR abdominal	25 (4)	17.6 (3)	9.5 (4)	9.7 (3)	6.5 (2)	6.1 (2)	2.9 (1)	8.6 (3)	3.6 (1)	21.4 (6)	–	8.7 (2)	–	4.0 (1)	25.0 (2)
WHP obese	75.0 (12)	70.6 (12)	38.1 (16)	48.4 (15)	41.9 (13)	30.3 (10)	32.4 (11)	42.9 (15)	32.1 (9)	42.9 (12)	27.3 (6)	30.4 (7)	25.0 (7)	28.0 (7)	12.5 (1)
Over fatness	–	–	7.1 (3)	9.7 (3)	6.5 (2)	9.1 (3)	2.9 (1)	2.9 (1)	3.6 (1)	7.1 (2)	9.1 (2)	8.7 (2)	3.6 (1)	8.0 (2)	12.5 (1)
Females															
High SBP	–	–	–	–	–	5.8 (3)	7.7 (4)	4.3 (2)	6.5 (3)	–	–	4.4 (2)	4.5 (2)	4.4 (2)	–
High DBP	–	–	–	–	–	3.8 (2)	7.7 (4)	8.5 (4)	13.0 (6)	4.3 (2)	2.1 (1)	–	2.3 (1)	–	12.5 (1)
Hypertension	–	–	–	–	–	–	3.8 (2)	–	4.3 (2)	–	–	–	–	–	–

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	November 1996	May 1997	November 1997	May 1998	November 1998	May 1999	November 1999	May 2000	November 2000	May 2001	November 2001	May 2002	May 2003	November 2003	November 2015
	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)	% (n)
BMI—undernutrition															
BMI—severe	48.4 (15)	53.6 (15)	27.8 (15)	21.6 (11)	19.6 (10)	17.3 (9)	17.3 (9)	25.5 (12)	8.7 (4)	6.5 (3)	4.3 (2)	2.2 (1)	4.5 (2)	2.2 (1)	12.5 (1)
BMI—moderate	9.7 (3)	10.7 (3)	14.8 (8)	15.7 (8)	13.7 (7)	28.8 (15)	25.0 (13)	12.8 (6)	21.7 (10)	15.2 (7)	19.1 (9)	13.3 (6)	4.5 (2)	15.6 (7)	–
BMI—mild	19.4 (6)	17.9 (5)	37.0 (20)	39.2 (20)	39.2 (20)	28.8 (15)	32.7 (17)	40.4 (19)	39.1 (18)	37.0 (17)	46.8 (22)	37.8 (17)	47.7 (21)	28.9 (13)	–
BMI—overweight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	25.0 (2)
BMI obese	–	–	1.9 (1)	–	–	–	–	2.1 (1)	–	–	–	–	–	2.2 (1)	–
WHtR abdominal	19.4 (6)	7.1 (2)	7.4 (4)	5.9 (3)	7.8 (4)	5.8 (3)	5.8 (3)	6.4 (3)	2.2 (1)	10.9 (5)	4.3 (2)	4.4 (2)	4.5 (2)	4.4 (2)	37.5 (3)
WHP obese	87.1 (27)	67.9 (19)	64.8 (35)	64.7 (33)	54.9 (28)	73.1 (38)	44.2 (23)	34.0 (16)	32.6 (15)	50.0 (23)	17.0 (8)	11.1 (5)	25.0 (11)	6.7 (3)	12.5 (1)
Overfatness	3.2 (1)	–	3.7 (2)	5.9 (3)	5.9 (3)	–	3.8 (2)	4.3 (2)	4.3 (2)	8.7 (4)	8.5 (4)	6.7 (3)	4.5 (2)	–	12.5 (1)

BMI—body mass index; SBP—systolic blood pressure; DBP—diastolic blood pressure; WHtR—waist-to-height ratio.

Table 4.
Development over time of prevalence cardiovascular risk factors of Ellisras rural males and females who died aged 7–26 years.

	May 1997	November 1997	May 1998	November 1998	May 1999	November 1999	May 2000	November 2000	May 2001	November 2001	May 2002	May 2003	November 2003	November 2015
Waist	0.201	0.316	0.342	0.475	0.613*	0.651*	0.626*	00.775**	−0.031	0.416	0.128	0.542	0.128	−0.180
WHP	−0.103	−0.169	−0.505	0.001	0.085	−0.069	0.185	−0.121	−0.391	−0.195	−0.052	0.291	−0.052	0.877
WHtR	0.118	0.198	0.109	0.313	0.453	0.530	0.599*	0.512	0.176	0.226	0.034	0.315	−0.073	0.676
BMI	0.454	0.411	0.409	0.364	0.271	0.273	0.062	0.194	0.235	0.492	0.521	0.094	0.603	0.785
Sum4sk	−0.076	−0.074	−0.126	−0.289	−0.122	−0.003	−0.349	−0.226	−0.077	−0.139	−0.418	−0.513	−0.417	−0.150
Systolic	–	–	–	–	–	0.21	−0.12	−0.29	−0.00	−0.52	−0.48	0.88	0.45**	−0.30
Diastolic	–	–	–	–	–	−0.22	−0.12	0.37	0.52	0.53	−0.05	0.94	0.05	0.38
Pulse	–	–	–	–	–	0.23	−0.07	0.18	0.26	0.12	−0.19	0.13	−0.19	0.65
Girls														
Waist	−0.071	0.129	−0.228	−0.097	0.131	−0.015	0.280	0.043	−0.188	0.061	−0.136	−0.057	−0.136	0.123
WHR	−0.115	0.088	−0.162	0.030	−0.177	−0.024	0.041	−0.133	−0.181	0.100	−0.191	−0.041	−0.191	−0.468
WHtR	0.373	0.449*	0.142	0.230	0.455*	0.221	0.394*	0.344	0.333	0.210	0.076	0.103	−0.035	0.179
BMI	0.192	0.239	−0.047	0.071	0.021	−0.053	−0.127	−0.010	−0.074	−0.112	−0.112	−0.216	−0.021	0.488
Sum4sk	−0.079	−0.042	−0.030	−0.022	−0.003	−0.129	−0.017	−0.169	−0.182	−0.141	−0.208	−0.202	−00.445*	−00.969**
Systolic	–	–	–	–	–	0.26	−0.10	0.95**	0.14	0.25	00.43**	0.67**	0.42**	0.02
Diastolic	–	–	–	–	–	0.63**	0.28*	0.77**	0.07	0.12	0.012	0.72**	0.08	0.66**
Pulse	–	–	–	–	–	−0.08	0.01	−0.11	−0.12	−0.08	−0.36	−0.20	0.35	0.64**

*WHR—waist-to-hip ratio; WHtR—waist-to-height ratio; BMI—body mass index. * $P < 0.05$; ** $P < 0.01$*

Table 5.
Moment correlation coefficient for the first measurement and subsequent measurements for cardiovascular risk factors measured over time among diseases Ellisras Longitudinal Study children.

By not taking action on NCDs in sub-Saharan Africa would mean that the development of effective measure for preventing and managing these NCDs will be compromised. Ideal health promotion should reach an individual at school-going age to ensure the adoption of a healthy lifestyle. Community involvement must empower people to promote and adopt a healthy lifestyle throughout their lives and identify and reach appropriate target groups. South Africa's school health curriculum needs to be developed. A health curriculum planning group representing stakeholders of various disciplines, particularly in rural area, needs to revise current curricula to address health promotion issues in all public schools in the rural areas. Education methods used in this curriculum should allow children to make healthy choice while simultaneously increasing their self-esteem. The curriculum should address smoking prevention, abstinence from alcohol usage, establishing healthy eating pattern, and exercise habits that could be sustainable for life time. The community should develop discernment skills to evaluate the impact of the advertising industry on their lives.

Despite the clear pattern of NCD risk that has emerged from the current study, there are some short comings that need to be considered when assessing the overall value of the present data. The small number of subjects could probably provide a biased sample, and these data must be viewed in the light of this situation. The socioeconomic status of the subjects and the cause of death might impact negatively on the major findings of the present study.

The early diagnosis and cost-effective management of patients with risk factors and early target organs damage particularly of those with high level of cardiovascular diseases risk is needed [35]. A comprehensive surveillance system should include indicators that monitor both the prevention and health service aspects of the program.

5. Conclusion

The prevalence of undernutrition was high, while hypertension, obesity, and overweight were low in the population. The blood pressure showed a significant correlation over time, while other NCD risk indicators do not show significant correlation over time. The identification of appropriate NCD indicators for mortality in rural South African population needs more consideration and evaluation. Death information and feasibility and cost of generating such indicators are critical issues as most rural South African population regard the cause of death as a family issue. Death registration information and cost of generating such information are critical issues in moving away from the indigenous knowledge system. More thorough analysis of the variable data will be essential to investigate the quality of the information, and additional information is needed to assess the validity of the indicators.

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