Public Health Nutrition: 4(1), 11–17 DOI: 10.1079/PHN200050

Nutrition and handgrip strength of older adults in rural Malawi

Dorothy M Chilima* and Suraiya J Ismail
Public Health Nutrition Unit, London School of Hygiene and Tropical Medicine, 49–51 Bedford Square, London WC1B 3DP, UK

Submitted 20 November 1999: Accepted 18 April 2000

Abstract

Objective: To examine the relationship between the nutritional status and handgrip strength of older people in rural Malawi.
Design: Cross-sectional study.
Setting: Lilongwe rural, Malawi, situated approximately 35–50 km from the city.
Subjects: Ninety seven males and 199 females participated in this study.
Methods: Selected anthropometric measurements were taken and nutrition indices were computed using standard equations. Handgrip strength was measured using an electronic grip strength dynamometer.
Results: The mean handgrip strength (in kg) for men was significantly higher than for women (28.0 ± 5.9 vs. 21.7 ± 4.5). In addition, there was a significant decline in handgrip strength with age in both sexes. Furthermore, handgrip strength was positively correlated to the following nutritional status indicators: BMI ($r = 0.40$ in males and $r = 0.34$ in females), mid-upper arm circumference (MUAC) ($r = 0.45$ in males and $r = 0.38$ in females) and arm-muscle area (AMA) ($r = 0.39$ in males and $r = 0.37$ in females). After controlling for potential confounders, namely sex, height and age, the correlations between handgrip strength and the nutrition indices were still significant.
Conclusion: The results of this study support the hypothesis that poor nutritional status is associated with poor handgrip strength. Malawian males had both lower handgrip strength and lower arm muscle area than their counterparts from industrialised countries. However, Malawian females had similar handgrip strength despite lower arm muscle area, in comparison with women from industrialised countries, reflecting perhaps their higher level of physical activity. Further studies are required to determine whether by alleviating nutritional problems a concomitant improvement in handgrip strength can be obtained.

Keywords
Aged
Nutrition
BMI
MUAC
CAMA
Handgrip strength
Malawi

Handgrip strength is measured in either kilograms or Newtons by squeezing a handgrip strength dynamometer with one's maximum strength[1]. It is a measure of strength of several muscles in the hand and the forearm[2]. These muscles play a vital role in the performance of day to day activities of normal life such as using tools or transferring from one position to another, such as rising from a chair[3]. The relationship between handgrip strength and a number of variables has been extensively studied among elderly people in affluent societies. Variables studied include morbidity[4], mortality[5], the risk of falling[6], a range of functional ability variables[7,8] and nutritional status[9]. For instance, Phillips[5] showed that lower handgrip strength was significantly associated with a high risk of death, whereas Wickham *et al.*[6] showed that weaker handgrip strength was associated with an increased risk of falling. Very little is known about the association between nutrition and handgrip strength in Africa where malnutrition among the elderly is common[10,11]. In his review, Torres-Gil[12] indicates that good nutrition is crucial for keeping older people healthy, functioning and remaining independent at home. In developing countries, it is even more important since retirement is often not an option. This study therefore was initiated to test the hypothesis that poor nutritional status is associated with poor functional ability (as measured by handgrip strength) as a first step towards understanding the role of nutrition in the livelihoods of rural older people in developing countries such as Malawi.

Methods

The study was conducted among older people aged 55

*Corresponding author

Table 1 Means (SD) for age, handgrip strength and anthropometric measurements by sex

	Males		Females	
Variable	n	Mean	n	Mean
Age (years)	94	68.9 (8.1)	190	63.3 (6.1)†
Handgrip strength (kg)				
All	94	28.0 (5.9)	190	21.7 (4.5)†
55–59 years	12	32.3 (5.5)[a]	51	22.9 (4.0)[a]
60–69 years	40	29.0 (6.1)[a]	111	21.7 (4.9)[a]
70+ years	42	25.9 (5.1)[b]	28	19.7 (4.5)[b]
Height (cm)	92	165.7 (5.9)	188	155.2 (5.3)†
Weight (kg)	93	54.1 (7.3)	190	49.0 (8.0)†
MUAC (cm)	93	25.0 (2.4)	190	25.9 (3.2)*
AMA (cm^2)	93	41.5 (7.6)	190	38.7 (7.3)†
CAMA (cm^2)	93	31.5 (7.6)	190	32.0 (7.3)
BMI (kg/m^2)	92	19.8 (2.5)	188	20.3 (3.0)

MUAC, mid-upper arm circumference; AMA, arm muscle area; CAMA, corrected arm muscle area; BMI, body mass index.
† Significantly different from males ($P < 0.001$).
* Significantly different from males ($P < 0.05$).
[a,b]For handgrip strength with age, means with similar letters are not significantly different.

Table 2 Correlation coefficients (r) for handgrip strength among males and females

	Handgrip strength	
	Males ($n = 92$) r	Females ($n = 188$) r
AGE	−0.44*	−0.18**
MUAC	0.45*	0.38*
BMI	0.40*	0.34*
AMA	0.39*	0.37*
Triceps	0.26**	0.28*

* $P < 0.001$.
** $P < 0.05$.

years and over in selected rural areas of Lilongwe district in central Malawi. The subjects were recruited using a multi-stage cluster sampling technique. All subjects in the selected 11 villages who were aged 55 years and over were invited to participate in the study. More women than men in the age group 55–59 years were interviewed since more women were willing to participate than men. It is also possible that men in this age group did not consider themselves old or were engaged in employment elsewhere and hence were not available for the study. The study design and its methodology, particularly with regard to anthropometry, have been presented elsewhere[10].

Anthropometry

Weight, height, mid-upper arm circumference (MUAC), triceps skinfold and armspan were measured using standard methodologies[10] and BMI was computed as weight in kilograms divided by height in metres squared. For respondents with visible kyphosis ($n = 49$), height was estimated from armspan using regression equations developed from non-kyphotic respondents within the sample. Arm-muscle area was calculated using standard methodologies[13] as shown below:

$$\text{Mid arm muscle area (AMA)} = \frac{(\text{AMC})^2}{\pi} \text{ in cm}^2$$

where

$$\text{AMC (arm muscle circumference)} = \text{MUAC (cm)} - \frac{\pi \times \text{triceps (mm)}}{10} \text{ in cm}$$

$$\text{Corrected mid arm muscle area (CAMA): males} = \text{AMA} - 10 \text{ in cm}^2$$

$$\text{Corrected mid arm muscle area (CAMA): females} = \text{AMA} - 6.5 \text{ in cm}^2$$

Handgrip strength

An electronic grip strength dynamometer (TKK 5101, Grip-D, with 100 kg force maximum) was used to measure handgrip strength. After a demonstration, each subject held the dynamometer in the hand with the arm held across the body and squeezed to maximum force. Four trials were given on the dominant hand and three trials on the other hand (alternately). Subjects were encouraged verbally by the assessors and muscle strength was recorded to the nearest 0.1 kg[1]. The best score of all trials was used in the analysis.

Data analysis

Data were analysed using SPSS (Statistical Package for Social Science) version 6.1. Pearson correlations were carried out between nutrition indicators and handgrip strength. Multiple regression analyses were carried out with handgrip strength as a dependent variable and BMI, MUAC, AMA as independent variables controlling for sex, age and body size (height). Variables which did not make a significant contribution to handgrip strength were dropped. A 5% level of probability was used to indicate statistical significance.

Results

A total of 284 respondents (94 men and 190 women) were studied after excluding those with oedema ($n = 12$). Anthropometry and handgrip strength data are presented in Table 1. Men had significantly higher values for almost all the measurements except for CAMA and BMI. Other anthropometric characteristics of the respondents have been presented elsewhere[10]. Handgrip strength declined significantly by age group in both

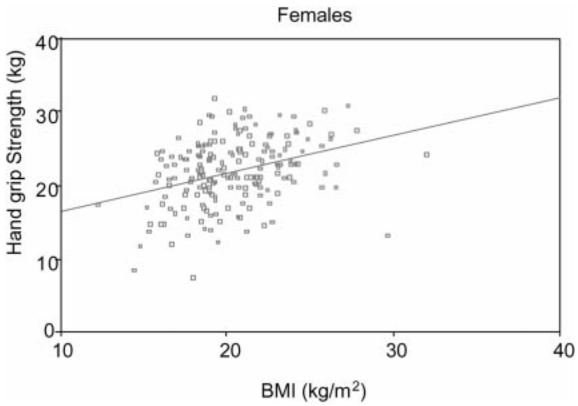

Fig. 1 Scatterplot of handgrip strength of females by BMI

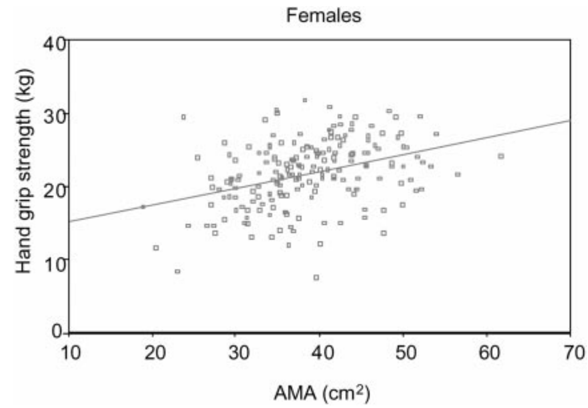

Fig. 3 Scatterplot of handgrip strength of females by AMA

sexes. A similar trend was also seen in MUAC and AMA in both sexes: older people aged 70 years and over had lower values although the decline with age was not statistically significant[10].

As shown in Table 2 and Figs 1–8, handgrip strength was positively correlated to all nutrition indices in both men and women ($P < 0.001$ for all except triceps skinfold where $P < 0.05$ for males). The fact that the correlation coefficients for handgrip strength with BMI and with AMA were similar is explained by the close correlation found between muscle mass and BMI in this study and in other studies[18,19]. This indicates that BMI is not only an indicator of adiposity, but also of muscle mass, perhaps even more so in populations with low fat mass. Even after controlling for potential confounders (sex, age and height), the association between handgrip strength and nutrition indices remained significant and positive in both men and women (see Tables 3 and 4). Each nutrition indicator explained more than 10% of the variation in handgrip strength (change in R^2%). Moreover, the mean handgrip strength increased significantly with increasing BMI (Table 5).

To estimate the independent contribution of BMI to handgrip strength, after controlling for AMA, we repeated the regression analyses, entering first age, height and AMA, then adding BMI. The additional contribution of BMI was 7.8% ($f = 8.7$; $P < 0.005$) for men and 4.1% ($f = 8.8$; $P < 0.005$) for women.

Discussion

The results of tests of handgrip strength agree with those reported in the literature: men are generally stronger than women and function declines with age[14,15]. In the longitudinal study conducted by Bassey and Harries[2], handgrip strength declined by 12% among men and 19% among women in the 4 year period. This decline in strength has been attributed to a number of reasons but mostly to reduction in muscle mass with age which may be caused by disuse, illness or to a decline in customary activity, or just to ageing as a result of alterations in muscle fibre composition[16] or a decrease in the number of muscle fibres[17].

The results of the study lend support to the findings

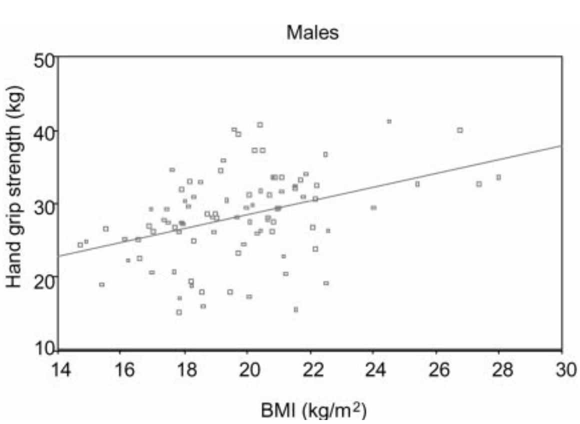

Fig. 2 Scatterplot of handgrip strength of males by BMI

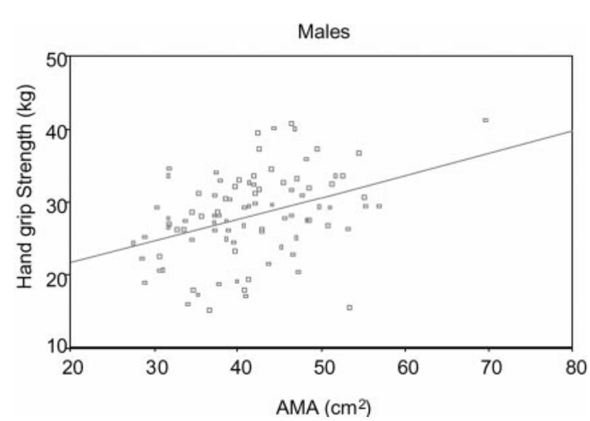

Fig. 4 Scatterplot of handgrip strength of males by AMA

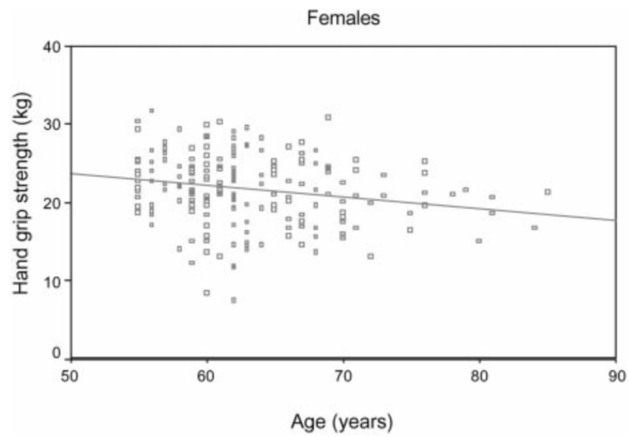

Fig. 5 Scatterplot of handgrip strength of females by age

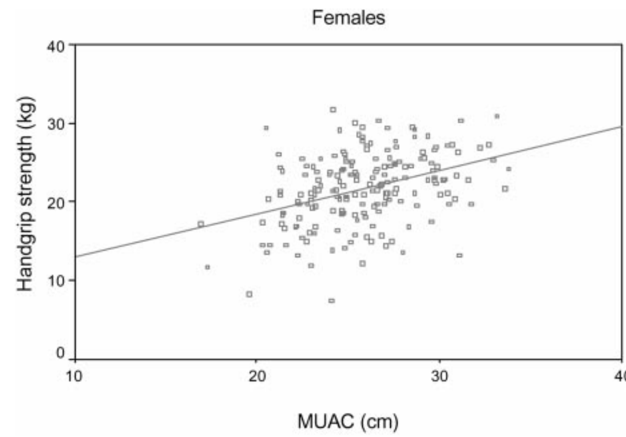

Fig. 7 Scatterplot of handgrip strength of females by MUAC

that handgrip strength is positively associated with nutritional status as reported in Japan by Guo *et al.*[9] and more recently by Manandhar[18] and Pieterse[19]. In this study, this association was evident even after controlling for potential confounders including health status and socio-economic conditions (results not shown). Table 5 also confirms these findings since those in the lower BMI category had lower mean handgrip strength. In a study conducted in urban India[20], there was a significant association between a low body mass index (BMI < 16) and an increased risk of low handgrip strength using multiple logistic regression (odds ratio $= 5.7085$, $P < 0.001$). Findings such as these have also been reported in young adults (aged 15–35 years) where chronic energy deficiency was associated with poor handgrip strength after correcting for stature and forearm muscle area[21]. Similarly, a study conducted in Nigeria[22] showed a positive correlation between handgrip strength and anthropometric measures (arm muscle area and arm muscle circumference) among young adults (aged 18–64 years), although only 10 people (six men and four women) aged between 55 and 64 years were included in the study. Low body mass index indicates low body fat and muscle. Thus, its association with poor handgrip strength is partly at least through the reduced muscle mass. Reduction in muscle mass has also been associated with a decline in muscle strength commonly associated with advancing age[3]. However, BMI made a significant contribution to handgrip strength even after controlling for AMA and age, indicating an independent contribution of undernutrition to reduced muscle strength.

Table 6 compares the mean handgrip strength of older adults in Malawi with those from other countries. All studies included in this table used the standard methodology[1] to measure handgrip strength. Handgrip strength of men was close to that reported in developing countries but lower than that reported in the UK. This could be attributed to earlier onset of ageing in developing countries because of illnesses or hard work[23] or could also reflect poorer nutritional status. Interestingly, however, despite having poorer nutritional status, Malawian

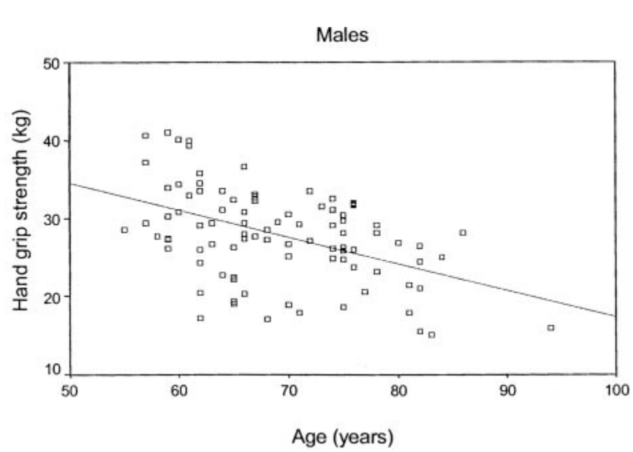

Fig. 6 Scatterplot of handgrip strength of males by age

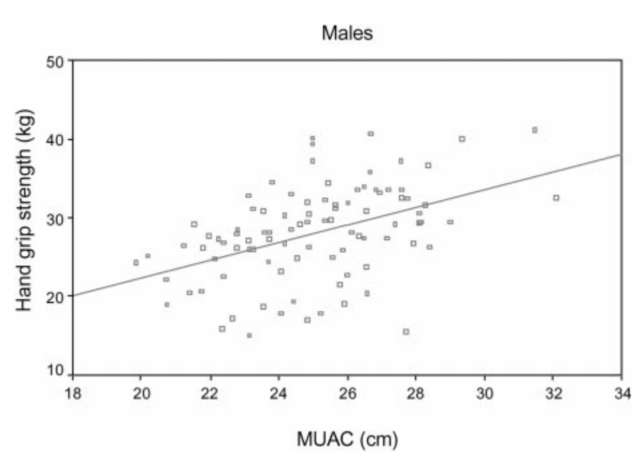

Fig. 8 Scatterplot of handgrip strength of males by MUAC

Table 3 Multiple regression results of handgrip strength with nutrition indices controlling for height and age (males)

	Variable*				
	Age	Height	BMI	MUAC	AMA
Standardised beta coefficients	−0.382	0.235	0.408		
Change in R^2 (%)	19.7	5.2	12.8		
Standardised beta coefficients	−0.386			0.403	
Change in R^2 (%)	21.0			14.6	
Standardised beta coefficients	−0.393				0.333
Change in R^2 (%)	19.7				10.8
Multiple R			0.614	0.597	0.553
R^2			0.377	0.356	0.306
Adjusted R^2			0.356	0.342	0.290
SE of the estimate			4.756	4.809	4.994
F			17.774	24.622	19.589
Degrees of freedom			91	91	91
P			0.000	0.000	0.000

* BMI, MUAC and AMA were entered separately, i.e. three separate analyses were performed.

women have a similar mean handgrip strength to their UK counterparts. This finding may reflect the continued high level of physical work carried out by older women in Malawi compared with older women in the UK. In the current study, 90% of the women were engaged in heavy agricultural activities, both in the past and at the time of the study. Sharpe *et al.*[24] have noted that physical activity itself has a role to play in preserving function, in addition to muscle mass. Notable are the differences observed between the Malawian and Indian women in terms of mean handgrip strength: Malawian women were stronger than their Indian counterparts. The difference could be attributed to differences in arm muscle areas and/or physical activity patterns, by nature of their location (urban vs. rural), but could also reflect genetic differences.

Older people may have problems in acquiring food depending on their physical strength and availability of resources. While this may be true to some extent in industrialised societies, it is especially true in rural Malawi, where poverty is widespread and households rely on subsistence agriculture for food. Poor handgrip strength may seriously limit the ability to engage in agricultural activities effectively, hence affecting productivity, as well as the ability to prepare one's own meals, hence having an impact on nutritional status. Thus, poor strength itself can have a bearing on the individual's nutritional status.

The study's cross-sectional design does not allow us to assume causality between poor handgrip strength and poor nutritional status. Cross-sectional studies are faced with the 'chicken or egg' dilemma since both exposure and outcome are assessed concurrently[25]. Furthermore, selective survival into old age of those who are better nourished and healthier could also have an effect on the results. Thus, confirmation of this hypothesis using a prospective study design or a trial intervention is required.

Conclusion

The study supports the hypothesis that poor nutritional status is associated with poor functional status as

Table 4 Multiple regression results of handgrip strength with nutrition indices controlling for height and age (females)

	Variable*				
	Age	Height	BMI	MUAC	AMA
Standardised beta coefficients	−0.162	0.320	0.336		
Change in R^2 (%)	2.6	10.7	11.8		
Standardised beta coefficients	−0.156	0.261		0.331	
Change in R^2 (%)	2.4	6.9		15.0	
Standardised beta coefficients	−0.151	0.281			0.325
Change in R^2 (%)	2.3	8.0			13.8
Multiple R			0.501	0.493	0.491
R^2			0.251	0.243	0.241
Adjusted R^2			0.238	0.231	0.229
SE of the estimate			3.955	3.974	3.980
F			20.504	19.730	19.468
Degrees of freedom			187	187	187
P			0.000	0.000	0.000

* BMI, MUAC and AMA were entered separately, i.e. three separate analyses were performed.

Table 5 Mean handgrip strength by BMI category

	Mean (±SD) handgrip strength (kg)			
	Males*		Females**	
BMI category	*n*	Mean	*n*	Mean
<17 kg/m^2	11	24.2 (3.0)	24	18.2 (4.5)
17–18.4 kg/m^2	20	26.2 (5.4)	28	21.0 (4.4)
≥18.5 kg/m^2	61	29.5 (6.0)	135	22.5 (4.3)

* $f = 5.7$, $P < 0.005$.
** $f = 10.7$, $P < 0.001$.

assessed by handgrip strength in both older men and women in this population. Malawian males had both lower handgrip strength and lower arm muscle area than their counterparts from industrialised countries. However, Malawian females had similar handgrip strength despite lower arm muscle area, in comparison with women from industrialised countries, reflecting perhaps their higher level of physical activity. Further studies are required to determine whether, by alleviating nutritional problems, a concomitant improvement in handgrip strength can be obtained.

Acknowledgements

Part of this paper was presented as a poster presentation at the Nutrition Society Summer meeting held in Guildford in 1998. We are grateful to all participants, research assistants and data entry clerks.

References

1 Bassey EJ. Tests of muscle strength. In: Collins KJ, ed. *Handbook of Methods for the Measurement of Work Performance, Physical Fitness and Energy Expenditure in Tropical Populations*. London: International Union of Biological Sciences, Medical Research, 1990: 59–65.
2 Bassey EJ, Harries UJ. Normal values for handgrip strength in 920 men and women aged over 65 years, and longitudinal changes over 4 years in 620 survivors. *Clin. Sci.* 1991; **84**: 331–7.
3 Skelton DA, Greig CA, Davies JM, Young A. Strength, power and related functional ability of healthy people aged 65–89 years. *Age and Ageing* 1994; **23**: 371–7.
4 Klidjian AM, Foster KJ, Kammerling RM, Cooper A, Karran SJ. Relation of anthropometric and dynamometric variables to serious post-operative complications. *Br. Med. J.* 1980; **281**: 899–901.
5 Phillips P. Grip strength, mental performance and nutritional status as indicators of mortality risk among female geriatric patients. *Age and Ageing* 1986; **15**: 3–56.
6 Wickham C, Cooper C, Margetts BM, Barker DJP. Muscle strength, activity, housing and the risk of falls in the elderly people. *Age and Ageing* 1989; **18**: 7–51.
7 Hughes S, Gibbs J, Dunlop D, Edelmas P, Singer R, Chang RW. Predictors of decline in manual performance in older adults. *J. Am. Geriatr. Soc.* 1997; **45**: 905–10.
8 Hyatt RH, Whitelaw MN, Bhat A, Scott S, Maxwell JD. Association of muscle strength with functional status of elderly people. *Age and Ageing* 1990; **19**: 330–6.
9 Guo C, Zhang W, Ma D, Zhang K, Huang J. Hand grip strength: an indicator of nutritional state and the mix of post-operative complications in patients with oral and maxillofacial cancers. *Br. J. Oral Maxillofac. Surg.* 1996; **34**: 325–7.
10 Chilima DM, Ismail SJ. Anthropometric characteristics of older people in rural Malawi. *Eur. J. Clin. Nutr.* 1998; **52**: 643–9.
11 Pieterse S, Manandhar M, Ismail S. The nutritional status of older Rwandan refugees. *Publ. Health Nutr.* 1998; **1**: 259–64.
12 Torres-Gil FM. Malnutrition and hunger in the elderly. *Nutr. Rev.* 1996; **54** (II): S7–8.
13 Frisancho AR. *Anthropometric Standards for the Assessment of Growth and Nutritional Status*. Ann Arbor, USA: The University of Michigan Press, 1990.
14 Lehmann AB, Bassey EJ. Longitudinal weight changes over four years and associated health factors in 629 men and women aged over 65. *Eur. J. Clin. Nutr.* 1996; **50**: 6–11.
15 Finch S, Doyle W, Lowe C, Bates CJ, Prentice A, Smithers G, Clarke PC. *National Diet and Nutrition Survey: People Aged 65 Years and Over. Vol. 1: Report of the Diet and Nutrition Survey*. London: HMSO, 1998.
16 Lexell J. Human aging, muscle mass and fiber type composition. *J. Gerontol.* 1995; **50A** (special issue): 11–16.
17 Grimby G. Muscle performance and structure in the elderly as studied cross-sectionally and longitudinally. *J. Gerontol.* 1995; **50A** (special issue): 17–22.
18 Manandhar MC. Undernutrition and impaired functional ability amongst elderly slum dwellers in Mumbai, India. PhD thesis, London School of Hygiene and Tropical Medicine, 1999.

Table 6 A comparison of mean (SD) handgrip strengths (kg) and nutrition indices between older adults in Malawi and those in developed countries and other developing countries

Country	Sample	Sample size	Age (years)	Median age	Handgrip (kg)	AMA (cm^2)	MUAC (cm)	BMI (kg/m^2)
Malawi*	Rural							
	Male	94	55–94	67	28.0 (5.9)	41.5 (7.6)	25.0 (2.4)	19.8 (2.5)
	Female	190	55–94	62	21.7 (4.5)	38.5 (7.3)	25.9 (3.2)	20.3 (3.0)
India[18]	Urban slums							
	Male	458	50–96	60	22.9 (6.5)	35.3 (8.2)	24.1 (3.3)	20.5 (3.8)
	Female	458	50–96	57	13.4 (4.5)	27.8 (6.6)	23.0 (3.8)	20.6 (4.3)
Rwanda[19]	Rural refugees							
	Male	413	50–92	61	30.3 (6.7)	43.2 (6.3)	25.1 (1.9)	20.2 (2.0)
	Female	415	50–92	60	22.3 (5.1)	40.2 (7.5)	26.1 (2.8)	21.3 (2.9)
UK[15]	Free living elderly							
	Male	526–569	65+	N/A	34.8 (10.5)	–	30.4 (3.3)	26.5 (3.7)
	Female	497–563	65+	N/A	20.0 (6.8)		29.7 (3.9)	26.8 (4.7)

* Present study.

19 Pieterse SGEM. Nutritional vulnerability of older refugees. PhD thesis, London School of Hygiene and Tropical Medicine, 1999
20 Manandhar MC, Anklesaria PS, Myatt M, Ismail SJ. Undernutrition and functional ability amongst poor elderly people in urban India. *J. Nutr. Health Aging* 1997; **1**: 75–6.
21 Vaz M, Thangan S, Prabhu A, Shetty PS. Maximal voluntary contraction as a functional indicator of adult chronic undernutrition. *Br. J. Nutr.* 1996; **76**: 9–15.
22 Harries AD. A comparison of hand-grip dynamometry and arm muscle size amongst most Africans in North-East Nigeria. *Hum. Nutr.: Clin. Nutr.* 1985; **39C**: 309–13.
23 Kalache A. Ageing in developing countries. In: Pathy MSJ, ed. *Principles and Practice of Geriatric Medicine*. Chichester, UK: John Wiley and Sons, 1991: 1517–28.
24 Sharpe PA, Jackson KL, White C, Vaca VL, Hickey T, Gu J, Otterness C. Effects of a one year physical activity intervention for older adults at congregate nutrition sites. *The Gerontologist* 1997; **37**: 208–15.
25 Hennekens CH, Buring JE. Descriptive studies. In: Mayrent SL, ed. *Epidemiology in medicine*. Boston, Toronto: Little, Brown and Company, 1987: 101–31.