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Defining nutritional status of women in developing countries

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Abstract

Objective: To define a *de facto* reference body mass index (BMI) for women in developing countries and compare its performance with the Quetelet BMI.
Design: A logarithmic equation for elite wt/ht references was developed using the weight (wt) and height (ht) of 10 524 non-pregnant elite mothers. Functional outcomes were compared using both BMIs.
Setting: Forty-six national surveys from 36 developing countries.
Subjects: Mothers 15–49 years old.
Results: The *de facto* reference standard deviation showed 2.2% of elite women were undernourished and 6.3% overnourished; lower and upper limits for 'ideal' wt/ht were 73% and 137%, respectively. Compared with the age-based and medium frame standards of the First and Second National Health and Nutrition Examination Surveys (NHANES I & II), the *de facto* reference defined fewer women as undernourished (5.3% vs. 10.5% and 14.4%, respectively), but more as overnourished (20.4% vs. 13.7% and 15.9%, respectively). In the *de facto* reference, BMI = $wt/ht^{1.6}$. Using the age-based and medium-frame-based Quetelet BMI (wt/ht^2), 28.5% and 31.7% had a low and 13.0% and 14.7% a high BMI, respectively. For the *de facto* reference, 18.4% of the elite mothers had a low BMI and 19.3% a high BMI. Applying the *de facto* reference to all women showed that the distribution of BMI was similar irrespective of the reference used. Functional outcomes were similar for both BMIs.
Conclusions: The NHANES I & II growth curves define more women as overnourished than the *de facto* curve, but the opposite for defining the undernourished. Functional outcomes were similar for both BMIs, suggesting there is no great advantage to using a *de facto* BMI based on national-level data from these 46 national surveys.

Keywords
Body mass index
Anthropometric references
Women
Developing countries
Pregnancy outcome
Mortality rates
Birth size

The Demographic and Health Survey Program (DHS) collects demographic and health data on women and their children. Maternal weight and height measurements are standard practice in the DHS, but problems have arisen in their use because no accepted international nutrition reference exists for adult women.

Site-specific studies have collected weight and height data on adult women in developing countries[1–4]. The purpose of these studies was to describe the population rather than produce a reference for assessing its nutritional status.

A number of reference data exist, including cross-sectional representative data of 25–74-year-old non-institutionalised US civilians in the First National Health and Nutrition Examination Survey (NHANES I, 1971–1974) and Second National Health and Nutrition Examination Survey (NHANES II, 1976–1980)[5], the 1970–1972 Nutrition Canada National Survey[6] and the 1980 United Kingdom adult survey[7]. Frisancho[5] gives the percentile distribution of weight-for-height by frame size for 25–54 and 55–74 year olds, where frame size corresponds to <15th, 15th–85th and the 85th+ sex- and age-specific percentile of elbow breadth. Elbow breadth is relatively independent of adiposity and age[8]. The sex-specific Canadian reference data are available as percentile distributions of weight-for-height for five groups of 10-year age intervals covering 20–69 years. The United Kingdom reference data include tables of the percentage distribution of weight at each height for all ages and for the age groups 16–19, 20–29, 30–39, 40–49 and 50–64 years[8]. The new Metropolitan Life Insurance height and weight tables are based on measurements of 25–59-year-old life insurance policyholders[9]. This reference is problematic for several reasons. (1) It is based on individuals who purchased life insurance from 25 companies in the USA and Canada. Policyholders were followed until the policy was cancelled, the individual died, or until the end of the study; thus, mortality rates varied with the follow-up period that was on average 6.6 years. (2) The weight and height tables do not refer to weights that minimise illness or incidence of disease. (3) Weight is related to an elbow-based definition of frame

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size – small, medium or large – that is assumed to represent 25%, 50% and 25% of the population, respectively. (4) The tables have no cut-off points for classification, either in terms of standard deviations – as with the NCHS/CDC/WHO standard for children[10] – or in percentage of the median or percentiles. To our knowledge, none of the above reference data have been evaluated on a national population for developing countries.

Body mass indices (BMIs) have been developed using the ratio of weight to height. In the Quetelet index, a quadratic relationship between ideal weight (wt) and height (ht) – i.e. BMI = wt (kg)/ht $(m)^2$ – gives approximately the same value for short, medium and tall groups for the Fogarty standard[11]. Below 150 cm or >190 cm, however, BMI was strongly non-linear in its relationship with height[12]. The Fogarty standard, developed by the Metropolitan Life Insurance Company in the early 1940s, was based on mortality of US adults over 25 years old[13,14]. For 25–29 year olds, ideal weight corresponded to average weight. Because of the drawbacks in using the above references, standards and indices, we used the DHS maternal weight and height data to define a *de facto* reference for use in developing countries.

We also assess whether the BMI and *de facto* standard are associated with functional outcomes and compare their predictive performance.

Methods

The DHS are nationally representative surveys of women of reproductive age (15–49 years old). Weights and heights are collected for mothers with children <5 years old. Data are currently available for 46 surveys conducted between 1991 and 1998 in 36 countries. The surveys are implemented by national census and survey organisations with technical assistance from Macro International, Inc. Specially trained personnel, standardised prior to the implementation of fieldwork, take the anthropometric measurements. Continuous supervision of field operations is provided.

Mother's height is measured to the nearest 0.1 cm using a portable anthropometer made in the USA specifically for the DHS. Weight is measured to the nearest 0.1 kg using Seka battery-operated electronic scales. Mothers complete a questionnaire that includes social and economic characteristics of the household including her education, type of toilet, source of drinking water, type of floor material, ownership of a television, radio, refrigerator and electric cooker, availability of electricity, and type of transport owned, as well as basic demographic characteristics including her age, marital status, total number of times given birth and number of living children. Neonatal, infant and under-five mortality, birth weights, sizes at birth and pregnancy outcomes are also reported by each woman interviewed. Mortality data included in the analyses were restricted to the events that occurred in the preceding five years. No data were collected on maternal health conditions.

To compare the nutritional status of mothers with the NHANES I & II reference data, an elite set of mothers was selected from all of the available mothers. In all countries except Bangladesh, Bolivia, the first Kenya survey, Malawi and Nepal, these mothers were defined as those who had attended at least secondary school, came from households that owned either a car or motorbike, and whose homes had both electricity and a fridge. In Bangladesh, Malawi and Nepal, data on whether households owned a fridge were not available. Similarly, in Bangladesh, Bolivia, the first Kenya survey and Nepal, data on whether households owned a motor vehicle were not available. For the above countries, owning a motor vehicle or having both electricity and a refrigerator were substituted by the availability of a flush toilet in the household.

Data were entered in computers using the Integrated Survey Systems Analysis software and analysed using SPSS PC+ Version 10. Analysis of variance (ANOVA) was used to test whether the data came from normal populations with equal variances. 'Ideal' or predicted weight for a given height was determined from regression analyses after controlling for confounders.

Results

Height data are available for 11 306 elite mothers and weight for 10 573 non-pregnant elite mothers. Based on the distribution, and starting at 140 cm, height was grouped into 14 categories in intervals of 2 cm except for both the first two and the last two categories, where intervals of 5 cm were used. Descriptive statistics for the weight of non-pregnant mothers were obtained for each height category. Within each height category, non-pregnant mothers whose weights were plus or minus four standard deviations (±4SD) above or below the median were excluded from the analysis because they were considered to be extreme and not representative of well-nourished women. Forty-six mothers were excluded because they fell outside the 4SD limits and another 11 mothers were excluded because they exceeded overall limits on weight (<35 kg and >130 kg) and height (<135 cm and >180 cm) as determined from scatter plots. After these exclusions, data from 10 524 elite mothers were used to develop the *de facto* references.

Over 50% of the non-pregnant elite mothers came from seven country surveys: Uzbekistan (12.1%), Kazakstan (10.6%), 1996 Dominican Republic survey (9.3%), Kyrgyz Republic (8.0%), 1992/93 Egypt survey (7.7%) and Nicaragua (6.5%). Twenty-six countries each contributed less than 100 elite women, comprising 8.2% of the sample.

Among elite mothers, height was normally distributed: 158.0 ± 6.3 cm (mean ± SD) (Table 1). Compared with all

Table 1 Descriptive statistics for height and weight of elite mothers by country

			Height (cm)					Weight (kg)				
Country	Year	*n*	Mean	SD	Median	Min	Max	Mean	SD	Median	Min	Max
Bangladesh	1996/97	235	152.4	5.9	152.3	139.5	180.0	51.3	10.1	49.6	35.2	90.1
Benin	1996	26	161.4	6.7	162.0	147.8	173.0	64.9	13.0	61.5	47.6	99.2
Bolivia	1993/94	178	154.3	5.8	154.1	136.6	177.0	56.8	8.9	55.7	43.1	93.1
Bolivia	1998	435	154.9	5.9	154.6	142.2	175.1	60.6	10.3	59.1	38.2	105.5
Brazil	1996	535	158.8	6.1	158.4	140.8	179.0	60.5	10.1	59.2	35.7	106.0
Burkina Faso	1992/93	88	163.9	5.6	163.8	150.0	178.0	67.8	13.8	65.6	44.5	105.8
Central African Republic	1994/95	19	160.2	7.0	160.2	150.0	179.1	58.6	13.7	54.7	44.0	93.4
Chad	1996/97	18	164.8	6.6	165.2	149.0	174.7	65.6	13.3	65.7	38.3	89.2
Colombia	1995	324	156.4	5.6	156.2	140.3	173.1	60.2	10.0	59.6	40.7	104.9
Comoros	1996	8	155.3	5.9	154.6	148.4	163.2	60.2	13.1	57.5	45.0	87.5
Cote d'Ivoire	1994	43	160.8	6.0	159.9	149.5	178.0	62.4	11.1	62.9	43.9	87.8
Dominican Republic	1991	205	157.7	5.6	157.5	143.6	173.9	60.0	10.8	58.4	38.7	100.0
Dominican Republic	1996	975	157.7	6.0	157.4	139.1	179.9	60.5	11.9	58.6	35.7	111.4
Egypt	1992/93	778	158.9	5.6	159.0	139.0	179.2	72.6	12.8	71.2	38.0	120.8
Egypt	1995/96	331	159.3	5.6	159.4	142.5	179.0	69.7	13.3	66.7	40.0	113.5
Ghana	1993	21	160.3	5.5	159.1	150.4	170.6	70.4	12.1	71.0	49.3	90.2
Ghana	1998/99	11	160.9	5.5	159.4	154.5	175.1	76.3	13.2	76.2	54.7	99.9
Guatemala	1995	182	154.4	5.7	154.1	140.5	170.0	61.4	10.9	60.3	36.6	98.5
Guatemala	1998/99	105	154.2	5.9	154.5	138.0	168.8	65.2	12.5	63.8	36.0	91.4
Haiti	1994/95	35	159.9	4.9	159.9	150.0	170.5	62.2	12.2	59.1	43.7	86.9
Kazakstan	1995	1110	159.6	5.8	159.6	142.2	179.4	63.7	14.0	60.8	38.0	128.2
Kenya	1993	37	159.0	6.2	159.7	144.1	175.6	63.5	8.6	64.1	43.8	78.8
Kenya	1998	32	160.4	5.6	160.3	151.5	173.4	61.0	10.9	59.5	45.7	93.6
Kyrgyz Republic	1997	843	159.0	5.6	159.0	142.0	176.6	59.7	11.6	57.5	37.6	117.0
Madagascar	1997	4	155.9	9.0	155.8	146.5	165.5	54.5	8.8	55.1	43.4	64.5
Malawi	1992	17	160.9	5.2	160.0	153.5	169.5	67.3	13.5	66.7	41.7	95.3
Mali	1995/96	51	164.8	5.1	166.2	154.9	175.1	66.3	11.2	66.7	41.2	92.8
Morocco	1992	136	159.4	5.1	159.1	147.1	173.0	64.9	11.9	62.3	42.4	94.0
Mozambique	1997	21	158.5	6.2	158.3	147.7	171.0	62.1	10.1	64.1	43.8	75.5
Namibia	1992	175	162.1	6.3	162.6	144.3	178.5	65.2	12.5	63.4	40.3	104.5
Nepal	1996	36	152.2	4.7	153.6	136.3	160.1	49.2	7.0	49.1	36.1	64.0
Nicaragua	1997/98	684	156.6	5.6	156.4	138.7	173.6	60.5	11.3	59.0	36.2	99.2
Niger	1992	44	163.9	6.1	163.7	152.3	179.5	71.7	11.9	73.1	43.2	94.6
Niger	1998	43	161.5	4.7	160.7	149.4	171.5	66.7	13.1	66.3	44.8	104.1
Peru	1991/92	365	154.2	6.2	154.3	140.6	179.2	58.9	9.2	58.5	38.7	88.3
Peru	1996	600	153.9	5.7	153.7	139.7	171.6	61.1	10.1	60.6	35.2	110.1
Senegal	1992/93	39	164.9	5.2	165.4	153.3	174.8	70.1	12.1	67.2	45.4	99.4
Tanzania	1991/92	11	161.4	5.6	162.4	150.8	170.0	71.5	12.9	70.5	53.4	93.6
Tanzania	1996	24	159.3	6.0	159.4	146.0	169.5	66.5	10.0	66.7	45.3	86.0
Togo	1998	36	162.7	4.9	162.9	150.0	172.0	64.2	11.1	63.2	47.8	93.0
Turkey	1993	187	157.1	5.7	157.5	138.1	175.6	62.1	10.6	60.6	42.1	102.0
Uganda	1995	12	159.9	8.1	162.6	145.9	171.8	67.0	12.3	67.4	46.8	90.6
Uzbekistan	1996	1277	159.7	6.0	159.6	141.7	179.9	59.4	11.0	58.0	36.4	105.6
Zambia	1992	53	159.4	6.1	159.0	147.5	173.1	62.5	12.8	63.2	41.1	96.2
Zambia	1996	37	161.9	6.5	162.4	149.4	175.5	62.0	10.6	62.9	44.8	90.8
Zimbabwe	1994	98	160.8	6.1	161.3	146.7	173.5	68.2	13.0	66.0	45.2	105.0
Total		10 524	158.0	6.3	158.0	136.3	180.0	62.1	12.4	60.1	35.2	128.2

mothers, elite mothers were 1.8 cm taller (Table 2). The Levene statistic, which tests for homogeneity of variance, showed that variances in height among the elite women were equal ($P = 0.590$). ANOVA showed that elite mother's height did not differ by age group based on 5-year intervals ($P = 0.104$).

Weight of elite mothers was also normally distributed: 62.1 ± 12.4 kg (mean ± SD) (Table 1). Overall, elite mothers were 5.8 kg heavier than all mothers (Table 2). Elite mothers put on weight with increasing age (Fig. 1); for any given height an older woman was more likely to be heavier than a younger woman.

The BMI for the median height and weight of the elite population was 24.1, which was slightly higher than the BMI for the median of the entire population at 22.4.

Development of the de facto *reference*

Median weights were calculated for each of the 14 elite women height categories. Regressing the median weights on the medians of the height categories using linear and quadratic functions gave R^2 values of 0.977 and 0.990, respectively. Both equations predicted similar weights for heights under 170 cm, but beyond 170 cm the quadratic equation predicted lower weights than the linear equation. Figure 2 shows the age- and frame-based reference curves

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Table 2 Descriptive statistics for height and weight of all mothers by country

		Height (cm)						Weight (kg)					
Country	Year	*n*	Mean	SD	Median	Min	Max	*n*	Mean	SD	Median	Min	Max
Bangladesh	1996/97	3694	150.8	5.3	150.6	135.0	180.0	3694	43.5	6.4	42.2	35.0	101.4
Benin	1996	2263	158.4	6.1	158.3	138.3	178.3	2263	53.2	8.8	51.7	35.2	114.6
Bolivia	1993/94	2318	151.0	5.5	150.6	136.0	177.0	2362	55.3	9.3	53.5	35.0	121.0
Bolivia	1998	4014	151.3	5.8	151.0	135.0	176.0	4014	58.1	9.9	56.6	37.0	129.0
Brazil	1996	3059	156.3	6.4	156.0	135.7	179.0	3059	58.7	11.3	57.5	35.4	115.2
Burkina Faso	1992/93	3659	161.5	5.8	161.5	137.0	179.3	3660	54.8	8.2	53.8	35.0	124.4
Central African Republic	1994/95	2039	158.6	6.5	158.6	135.6	179.1	2039	52.9	8.0	51.9	35.2	98.0
Chad	1996/97	3736	162.5	6.2	162.4	136.0	180.0	3736	54.3	8.4	53.7	35.2	115.5
Colombia	1995	3248	154.5	6.0	154.4	135.7	175.8	3248	58.5	10.2	57.3	35.7	111.3
Comoros	1996	783	154.7	5.4	154.9	139.4	170.1	783	53.7	9.5	52.0	35.9	102.3
Cote d'Ivoire	1994	3139	158.8	5.9	158.6	136.5	179.4	3138	55.8	9.3	54.3	36.2	112.3
Dominican Republic	1991	2073	156.4	5.8	156.3	135.4	175.2	2080	56.6	11.0	55.1	35.3	115.2
Dominican Republic	1996	7422	156.8	6.1	156.7	135.8	179.9	7422	59.8	12.4	57.8	35.0	125.3
Egypt	1992/93	4787	156.9	5.5	157.1	139.0	179.2	4785	66.1	13.8	64.2	35.4	129.9
Egypt	1995/96	6590	157.5	5.9	157.5	135.3	179.0	6595	65.3	13.2	63.0	35.9	129.5
Ghana	1993	1764	158.5	5.7	158.4	139.3	179.4	1765	54.7	9.4	53.2	35.8	104.5
Ghana	1998/99	2007	158.5	6.0	158.4	136.3	177.0	2007	55.5	10.4	53.3	35.7	114.6
Guatemala	1995	4663	148.3	6.1	147.9	135.0	177.0	4663	53.4	10.3	51.1	35.0	116.0
Guatemala	1998/99	2268	148.5	6.1	148.2	135.0	169.0	2268	55.3	11.2	52.9	35.0	106.0
Haiti	1994/95	1897	158.5	6.3	158.5	136.3	177.1	1896	53.3	9.2	52.0	35.1	107.8
Kazakstan	1995	3546	159.0	5.9	159.0	138.4	179.4	3546	62.6	14.4	59.5	35.4	128.5
Kenya	1993	3368	159.2	6.1	159.0	138.5	180.0	3366	55.7	9.1	54.5	35.3	109.5
Kenya	1998	3243	160.0	6.1	159.7	136.0	179.9	3243	56.1	9.2	55.0	35.2	103.5
Kyrgyz Republic	1997	3566	157.9	5.7	158.0	137.0	178.0	3566	58.4	11.3	56.0	36.0	123.0
Madagascar	1997	2747	152.9	5.7	152.8	136.9	172.2	2747	47.8	6.6	47.0	35.0	95.3
Malawi	1992	2358	156.0	5.6	156.0	135.9	176.5	2358	52.6	7.7	51.9	35.2	129.3
Mali	1995/96	4308	161.3	6.1	161.3	136.8	180.0	4308	55.0	8.7	53.9	35.3	112.0
Morocco	1992	2881	157.0	5.5	157.0	135.6	179.0	2881	59.3	11.4	57.2	36.5	114.4
Mozambique	1997	3262	155.5	6.2	155.4	136.0	178.1	3262	52.1	8.3	51.2	35.2	112.8
Namibia	1992	2273	160.5	6.3	160.5	135.3	179.5	2228	58.2	12.0	56.0	35.6	122.4
Nepal	1996	3287	150.6	5.2	150.5	135.5	175.5	3287	45.2	5.4	44.6	35.0	87.1
Nicaragua	1997/98	12 273	154.1	5.8	154.0	135.0	179.4	12 273	59.2	12.0	57.2	35.0	128.0
Niger	1992	3435	160.2	6.0	160.1	135.9	180.0	3435	53.4	8.8	52.1	35.3	118.2
Niger	1998	3566	160.2	5.9	160.0	141.7	178.9	3566	53.2	8.8	51.7	35.4	115.5
Peru	1991/92	4811	150.3	5.6	150.1	135.0	179.2	4808	56.0	9.1	54.5	35.8	111.5
Peru	1996	9892	150.5	5.6	150.2	135.0	179.3	9892	56.8	9.2	55.4	35.0	112.3
Senegal	1992/93	2941	162.3	5.8	162.1	142.3	179.5	2936	57.6	10.4	55.8	36.2	122.2
Tanzania	1991/92	4499	155.9	6.2	155.6	136.5	179.7	4492	52.8	8.2	51.7	35.0	101.0
Tanzania	1996	3808	156.3	6.1	156.0	135.3	178.0	3808	53.7	8.9	52.4	35.3	110.7
Togo	1998	3186	158.6	5.9	158.4	138.0	179.9	3186	54.4	9.1	52.9	35.7	119.4
Turkey	1993	2395	155.3	5.5	155.2	135.4	180.0	2395	62.2	12.1	60.5	36.4	121.0
Uganda	1995	3381	158.2	6.3	158.2	135.5	180.0	3380	53.8	7.5	53.0	35.7	104.8
Uzbekistan	1996	4069	159.3	6.2	159.0	138.0	180.0	4071	57.6	10.4	55.8	35.2	125.3
Zambia	1992	3282	158.1	5.9	158.1	138.4	179.2	3274	54.6	9.1	53.2	35.2	106.2
Zambia	1996	3849	158.1	6.0	158.0	137.5	179.5	3849	54.9	8.9	53.5	35.0	124.4
Zimbabwe	1994	1908	159.3	5.9	159.2	139.9	178.2	1912	58.7	10.3	57.0	35.0	126.5
Total		167 557	156.2	7.0	156.2	135.0	180.0	167 544	56.3	11.0	54.4	35.0	130.0

from NHANES I & II plotted alongside the elite quadratic growth curve.

To establish the predictability of a *de facto* reference and to provide information on SDs, weight was regressed on height using the pooled individual data rather than summarised data. An ANOVA for height by country was carried out to determine whether genetic and socio-economic variations resulted in differences in stature that could affect the analysis of weight-for-height. This analysis showed that height differed by country ($F = 53.09$, $P = 0.000$). Elite mothers in Senegal, Mali, Chad, Niger, Burkina Faso and Togo were taller than mothers in the other countries while those in Nepal, Bangladesh, Peru, Guatemala and Bolivia were shorter than elsewhere (Table 1). Thus, nationality was included in the regression to predict weight. The Dominican Republic was taken as the reference category because mean height of the elite mothers in that country was closest to the overall mean for all elite mothers.

To control for the effect of age on weight, mother's age group was included in the individual regression equations. Mother's age was grouped into 5-year intervals except for age 40–49 years, which was taken as one group due to smaller numbers. Age grouping rather than a single continuous variable was used so that a simple tabular adjustment for age could be applied when using the *de*

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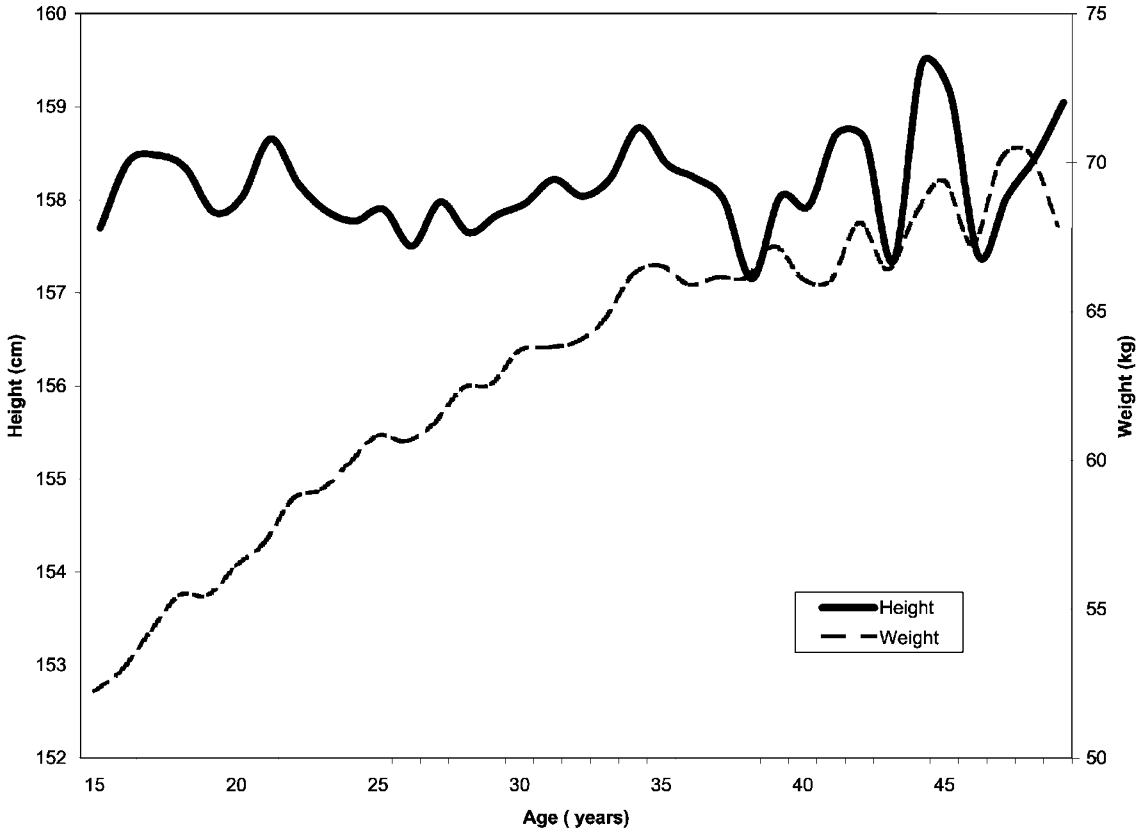

Fig. 1 Mean height and weight of elite mothers by age

facto reference. Also, using dummy variables for age groups allows greater flexibility than using a single function on age. Mothers of age 25–29 years were used as the control group. Because equation intercept is sensitive to the mix of countries and country sample size, country dummy variables were included to control this variation, with the Dominican Republic used as the reference group.

Controlling for both nationality and age group, a linear equation was estimated to develop the elite wt/ht reference. The residuals from the linear equation showed

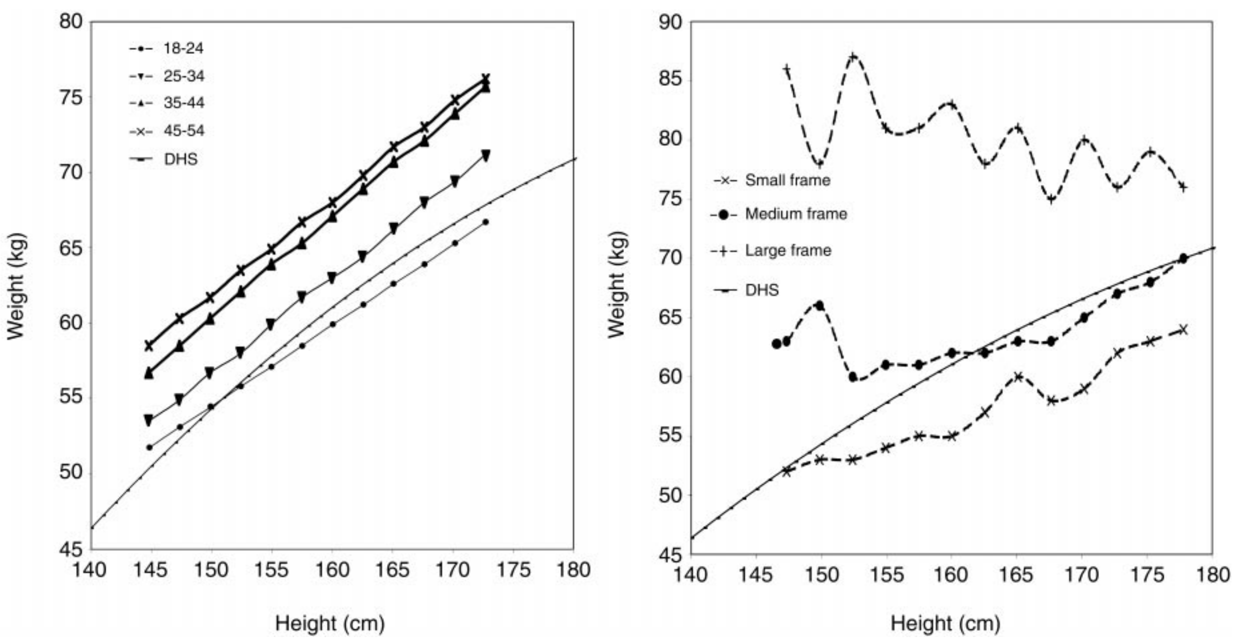

Fig. 2 Age-based and frame-based weight-for-height NHANES references for women compared with the *de facto* standard regression

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substantial heteroscedasticity, resulting in small t-values. To control for this, a multiplicative model – i.e. $wt = a \times ht^b$ – was used. The logarithmic form of this equation was estimated with the following results:

$$\log_{10}(\mathrm{wt}) = 1.45 + 1.63\log_{10}(\mathrm{ht}) + A + C, \quad R^2 = 0.316$$
$$t\text{-value} \quad (166.21) \quad (37.97)$$

where $\log_{10}$(wt) and $\log_{10}$(ht) are the logarithms of weight and height, respectively; $A = -0.041$ ($t = -16.15$), -0.009 ($t = -8.21$), 0.0, 0.004 ($t = 8.04$), 0.007 ($t = 14.58$) and 0.008 ($t = 19.89$) for mothers' ages 15–19, 20–24, 25–29, 30–34, 35–39 and 40–49 years, respectively; and C = country (see Appendix). The residuals from this equation were examined by regressing them on the square of the $\log_{10}$(ht). The resulting equation was not significant ($P = 0.841$). An additional examination of the interaction between country and $\log_{10}$(ht) was made and, except for Namibia ($P = 0.049$), none were significant.

To establish Z-scores for the *de facto* equation, SDs were calculated for the residuals from the logarithmic equation and regressed across the 14 height groups. As expected, the association with height was not significant. Rather than use the SD of the residuals taken directly from the regression results (0.06923), the mean for the SDs for the height groups was used (0.06830). The mean was chosen to give equal weight to each of the height groups, rather than a weighting determined by the number of women in the sample in each of the height groups. ±2SD were taken as the cut-off points for under- and overnutrition and are equal to a lower limit of 73% and an upper limit of 137% of the 'ideal' weight, respectively.

Nutrition status

Women <145 cm or <45 kg are classified as being at high risk for an adverse pregnancy outcome[15]. According to these criteria, among the 10 524 DHS elite non-pregnant mothers, 0.5% were both short and thin, 1.9% were short only, 4.6% were thin only (<45 kg), and 94.0% were neither short nor thin. Table 3 shows the distributions of nutritional status using the different wt/ht indices.

Table 3 Distribution of NHANES I & II and DHS *de facto* wt/ht reference standards of elite mothers ($n = 10\,524$)

Percentage of median weight-for-height	NHANES I & II (age-based) (%)	NHANES I & II (medium frame) (%)	DHS *de facto* (%)
50–59	0.1	0.3	0.0
60–69	1.6	3.0	0.5
70–79	8.8	11.1	4.8
80–89	20.1	19.4	15.3
90–99	24.9	22.0	22.8
100–109	19.1	17.2	21.9
110–119	11.7	11.3	14.3
120–129	6.7	7.4	9.4
130–139	3.8	3.9	5.1
140–149	1.9	2.5	3.2
150–159	0.9	1.2	1.4
160–169	0.3	0.5	0.8
170–179	0.1	0.3	0.4
180–189	0.0	0.1	0.1
Total	100.0	100.0	100.0

The logarithmic regression between predicted weight and height for the *de facto* reference gave a *de facto* BMI for height using the power of 1.63, i.e. *de facto* BMI = $wt/ht^{1.6}$.

James *et al.*[16] classify undernutrition using the Quetelet BMI using three cut-off points, namely 16.0, 17.0 and 18.5. The World Health Organization[10] classifies overnutrition using the cut-off points 25.0, 30.0 and 40.0. We adjusted these cut-off points for the average wt/ht ratio and applied them to the median wt/ht of the NHANES I & II age-based and medium frame references and to the median wt/ht for the *de facto* BMI (Table 4). Among elite mothers, 28.5% and 13.0% were classified as having a low and high BMI, respectively, using the Quetelet BMI for the NHANES I & II age-based reference; 31.7% and 14.7% were classified as having a low and high BMI, respectively, using the Quetelet BMI for the NHANES I & II medium frame reference; and 18.4% of the elite mothers were classified as being low in wt/ht and 19.3% as being high for the *de facto* BMI.

Natural cut-off points can be derived from the distribution of the elite mothers by using ±2SD of $\log_{10}$ (wt). Using these cut-offs, 2.2% of the elite mothers were defined as undernourished and 6.3% as overnourished.

The distributions of BMI using both indices for all mothers in the 46 national surveys are shown in Table 5. According to the averages of Quetelet and *de facto* BMIs, 9–10%, 64–65% and 25–26% of mothers were classified as being undernourished, normal and overnourished using each index, respectively. With the exception of Bangladesh and Nepal, where more women were classified as undernourished using the *de facto* BMI, the distribution of nutritional status was similar for the *de facto* and the Quetelet BMI.

Table 4 Undernutrition of elite mothers using NHANES I & II Quetelet and DHS *de facto* BMI ($n = 10\,524$)

BMI	NHANES I & II (age-based) (%)	NHANES I & II (medium frame) (%)	DHS *de facto* (%)
Very low (<16)	6.7	10.2	3.1
Moderately low (16–16.9)	6.8	8.2	4.2
Slightly low (17–18.4)	15.0	13.3	11.1
Normal (18.5–24.9)	58.6	53.6	62.4
Slightly high (25–29.9)	10.8	11.6	15.2
Moderately high (30–39.9)	2.2	3.1	4.1
Very high (40+)	0.0	0.0	0.0
Total	100.0	100.0	100.0

Table 5 Undernutrition of mothers by country using Quetelet and DHS *de facto* BMI

			Quetelet BMI								*De facto* BMI							
Country	Year	*n*	Very low	Mod low	Low	Normal	High	Mod high	Very high	Total	Very low	Mod low	Low	Normal	High	Mod high	Very high	Total
Bangladesh	1996/97	3695	4.4	12.9	29.3	50.4	2.4	0.5	0.1	100.0	6.9	13.2	36.0	41.2	2.2	0.4	0.0	100.0
Benin	1996	2262	0.9	2.2	11.3	76.5	7.0	1.9	0.1	100.0	0.8	1.5	12.7	75.6	7.5	1.8	0.1	100.0
Bolivia	1993/94	2313	0.0	0.3	1.8	64.3	26.1	7.1	0.5	100.0	0.0	0.3	2.1	67.7	23.5	6.0	0.3	100.0
Bolivia	1998	4014	0.0	0.2	0.6	52.5	35.5	10.8	0.4	100.0	0.1	0.1	1.1	55.7	33.1	9.5	0.4	100.0
Brazil	1996	3058	0.3	1.1	4.8	59.1	25.0	9.3	0.4	100.0	0.3	0.9	5.6	58.9	24.9	9.2	0.3	100.0
Burkina Faso	1992/93	3660	1.0	2.3	11.7	78.3	5.9	0.8	0.1	100.0	0.8	1.5	11.8	78.2	6.8	0.8	0.1	100.0
Central African Republic	1994/95	2039	0.7	2.0	12.1	78.7	5.5	1.0	0.0	100.0	0.6	1.8	13.3	77.3	5.6	1.3	0.0	100.0
Chad	1996/97	3736	2.1	4.4	14.3	74.0	4.4	0.8	0.0	100.0	1.9	3.1	15.0	73.5	5.6	0.9	0.0	100.0
Colombia	1995	3248	0.1	0.5	3.1	55.8	31.4	8.9	0.3	100.0	0.1	0.4	3.8	56.3	31.0	8.2	0.3	100.0
Comoros	1996	783	0.5	1.4	7.9	70.1	16.0	4.0	0.1	100.0	0.6	1.3	9.5	69.5	15.3	3.7	0.1	100.0
Cote d'Ivoire	1994	3137	0.3	1.4	6.3	77.9	11.1	2.8	0.1	100.0	0.3	1.1	7.0	76.9	11.7	3.0	0.1	100.0
Dominican Republic	1991	2069	0.5	1.8	6.3	65.7	18.7	6.4	0.4	100.0	0.7	1.4	8.0	64.1	19.3	6.1	0.3	100.0
Dominican Republic	1996	7422	0.5	1.1	5.8	54.4	26.1	11.2	0.8	100.0	0.4	1.1	6.8	53.1	26.8	11.0	0.7	100.0
Egypt	1992/93	4782	0.0	0.1	1.2	41.3	34.0	21.3	2.2	100.0	0.1	0.1	1.5	40.5	34.3	21.4	2.0	100.0
Egypt	1995/96	6588	0.1	0.2	1.1	46.7	31.7	18.2	1.9	100.0	0.0	0.2	1.4	45.3	33.3	18.0	1.8	100.0
Ghana	1993	1764	0.5	1.8	9.0	76.2	9.2	3.2	0.1	100.0	0.5	1.2	10.1	74.8	10.1	3.2	0.1	100.0
Ghana	1998/99	2006	0.5	1.3	9.2	73.1	11.1	4.6	0.1	100.0	0.5	0.9	10.5	71.9	11.3	4.7	0.1	100.0
Guatemala	1995	4662	0.2	0.4	2.7	62.4	26.4	7.6	0.4	100.0	0.2	0.6	4.0	65.2	23.1	6.5	0.4	100.0
Guatemala	1998/99	2268	0.2	0.1	1.3	54.5	31.7	11.6	0.6	100.0	0.2	0.2	3.3	57.2	28.5	10.1	0.4	100.0
Haiti	1994/95	1896	1.5	3.6	13.2	70.5	8.9	2.4	0.0	100.0	1.4	2.8	14.7	69.2	9.4	2.4	0.0	100.0
Kazakstan	1995	3546	0.5	1.2	6.0	53.8	21.9	14.7	1.9	100.0	0.6	1.0	6.4	52.4	22.8	15.1	1.8	100.0
Kenya	1993	3363	0.6	1.3	8.1	76.2	11.4	2.2	0.1	100.0	0.7	1.0	8.9	74.1	12.8	2.4	0.1	100.0
Kenya	1998	3244	0.6	1.9	9.2	73.5	12.2	2.5	0.1	100.0	0.6	1.4	9.8	72.5	12.8	2.7	0.1	100.0
Kyrgyz Republic	1997	3566	0.3	1.3	5.2	65.6	19.1	8.0	0.4	100.0	0.3	1.1	5.7	65.1	19.5	7.9	0.5	100.0
Madagascar	1997	2748	0.9	3.1	15.6	76.7	3.3	0.4	0.0	100.0	1.3	3.2	20.3	71.7	3.1	0.4	0.0	100.0
Malawi	1992	2358	0.3	1.4	7.5	81.8	8.0	0.9	0.1	100.0	0.6	1.1	9.4	79.7	8.4	0.8	0.1	100.0
Mali	1995/96	4308	1.2	3.0	11.7	75.7	7.2	1.2	0.0	100.0	1.0	2.3	11.9	75.3	8.1	1.4	0.0	100.0
Morocco	1992	2881	0.1	0.5	3.1	63.7	22.1	9.9	0.6	100.0	0.2	0.4	3.8	62.8	22.7	9.7	0.4	100.0
Mozambique	1997	3262	0.4	1.4	8.9	80.1	7.7	1.5	0.1	100.0	0.3	1.3	10.5	79.3	7.0	1.5	0.1	100.0
Namibia	1992	2225	0.9	2.1	10.2	65.9	13.9	6.7	0.4	100.0	0.9	1.7	10.5	64.7	15.0	6.9	0.3	100.0
Nepal	1996	3286	1.6	4.8	19.4	72.5	1.6	0.1	0.0	100.0	2.4	5.5	25.3	65.4	1.3	0.1	0.0	100.0
Nicaragua	1997/98	12 272	0.2	0.7	3.4	53.5	28.7	12.4	1.0	100.0	0.3	0.5	4.3	54.1	28.1	11.9	0.9	100.0
Niger	1992	3436	1.7	3.4	13.6	73.8	6.3	1.1	0.0	100.0	1.7	2.5	15.0	72.4	7.1	1.3	0.0	100.0
Niger	1998	3566	0.9	3.2	16.3	72.2	5.9	1.5	0.0	100.0	0.8	2.6	16.4	72.1	6.3	1.7	0.1	100.0
Peru	1991/92	4805	0.0	0.1	0.9	59.0	31.2	8.5	0.3	100.0	0.0	0.1	1.6	62.4	28.5	7.2	0.2	100.0
Peru	1996	9892	0.0	0.1	1.0	54.1	35.5	9.0	0.3	100.0	0.1	0.1	1.4	58.0	32.7	7.5	0.2	100.0
Senegal	1992/93	2936	1.4	2.3	11.1	69.5	12.0	3.4	0.2	100.0	1.2	1.7	10.9	68.9	13.2	3.9	0.2	100.0
Tanzania	1991/92	4491	0.4	1.4	7.5	79.7	9.3	1.8	0.0	100.0	0.4	1.3	9.3	78.1	9.0	1.8	0.0	100.0
Tanzania	1996	3807	0.6	1.8	6.7	77.5	10.9	2.3	0.1	100.0	0.8	1.4	8.0	76.8	10.6	2.3	0.1	100.0
Togo	1998	3186	0.6	1.2	9.0	78.0	9.0	2.1	0.2	100.0	0.8	0.9	9.4	77.0	9.3	2.4	0.2	100.0
Turkey	1993	2395	0.0	0.3	2.1	47.3	31.7	17.6	0.9	100.0	0.0	0.3	2.5	48.0	31.2	17.2	0.7	100.0
Uganda	1995	3381	0.4	1.3	8.2	81.7	7.3	1.1	0.0	100.0	0.4	1.1	9.0	80.7	7.7	1.0	0.0	100.0
Uzbekistan	1996	4070	0.8	1.6	7.8	68.2	16.2	5.1	0.2	100.0	0.6	1.3	8.2	67.0	17.5	5.2	0.2	100.0
Zambia	1992	3271	0.5	1.8	8.5	75.2	11.7	2.3	0.0	100.0	0.5	1.6	9.9	73.7	11.8	2.4	0.0	100.0
Zambia	1996	3850	0.5	1.0	7.5	78.1	10.6	2.2	0.1	100.0	0.5	0.7	8.6	76.4	11.3	2.3	0.1	100.0
Zimbabwe	1994	1908	0.1	0.6	4.3	72.0	17.3	5.6	0.1	100.0	0.2	0.4	4.5	70.9	18.0	5.9	0.1	100.0
Total		167 455	0.6	1.6	7.2	65.1	18.4	6.7	0.4	100.0	0.7	1.4	8.2	64.6	18.3	6.4	0.4	100.0

Table 6 Mortality rates, reported size at birth, birth weight and pregnancy outcome by distribution of Quetelet BMI and *de facto* BMI according to age groups

Age group	15–24 years						25–34 years						35–49 years						
	Quetelet BMI			*De facto* BMI			Quetelet BMI			*De facto* BMI			Quetelet BMI			*De facto* BMI			
Mortality rate (/000)	Low	Normal	High	< −2SD	Normal	2+SD	Low	Normal	High	< −2SD	Normal	2+SD	Low	Normal	High	< −2SD	Normal	2+SD	*n*
Neonatal	45	35	25	48	34	27	35	27	23	38	26	21	36	33	31	35	32	30	220 761
Infant	95	81	62	96	79	53	76	66	48	79	62	45	83	74	60	80	70	58	220 761
Under 5	157	142	91	152	135	71	147	118	74	150	111	65	152	134	86	150	120	79	220 761
Size at birth (%)																			
Larger than average	24.0	26.8	27.1	22.4	25.8	26.7	26.2	24.4	28.8	25.2	26.6	27.2	24.8	27.9	26.8	24.2	26.3	26.3	49 103
Average	47.0	49.8	52.6	47.8	50.7	54.6	46.7	54.7	54.4	47.6	53.3	57.9	47.2	49.7	53.8	47.9	52.1	55.9	97 707
Smaller than average	29.0	23.5	20.3	29.9	23.5	18.7	27.1	20.9	16.8	27.1	20.1	14.9	28.0	22.4	19.4	27.9	21.6	17.8	4751
Birth weight (%)																			
<2.5 kg	16.6	12.7	8.6	17.7	12.3	6.8	11.7	9.9	6.8	12.1	8.9	5.9	13.8	11.2	7.9	15.0	9.8	7.6	8269
≥2.5 kg	83.4	87.3	91.4	82.3	87.7	93.2	88.3	90.1	93.2	87.9	91.1	94.1	86.2	88.8	92.1	85.0	90.2	92.4	72 726
Had a terminated pregnancy (%)																			
Yes	10.0	8.7	12.0	12.5	9.4	13.6	21.8	22.1	23.7	22.2	21.9	25.7	30.5	32.8	37.9	30.5	34.8	43.1	22 920
No	90.0	91.3	88.0	87.5	90.6	86.4	78.2	77.9	76.3	77.8	78.1	74.3	69.5	67.2	62.1	69.5	65.2	56.9	84 852

Functional outcomes: age group

Four reproductive outcomes were tabulated according to both the BMI standards for age groups 15–24, 25–34 and 35–49 years (Table 6). In general, mortality rates were lower the higher the value of either BMI. As expected, the mortality rates were 'U'-shaped with respect to age. Mortality rates for low BMI in each standard within each age group were very similar, although mortality rates for high BMI within each age group were generally lower when based on the *de facto* standard than on the Quetelet. These differences were greatest for women 15–24 years old, and were larger the greater the age range of the mortality rate. However, the neonatal mortality rate for 15–24-year-old women with a high BMI according to the *de facto* standard was slightly higher than that of women with a high BMI according to the Quetelet standard. The differences in mortality rates between low and high categories were mostly greater in the *de facto* standard than in the Quetelet standard.

For both size at birth and birth weight, women classified as low BMI in either standard were more likely to have had a small sized baby or one with a low birth weight than one with either a normal or high BMI. Again, the *de facto* standard gave a somewhat better distinction in terms of difference in low birth weight or small size by level of BMI.

Pregnancies that did not terminate in a live birth, i.e. ending either by a miscarriage or a still birth, were more likely to have occurred to high BMI women 25 years and over. For women under 25 years old, terminated pregnancies were more likely to have occurred if the woman had either a low or a high BMI than for women with a normal BMI. Again, the differences by BMI category given by the *de facto* standard were wider than that given by the Quetelet standard.

Functional outcomes: height group

The four reproductive outcomes were also tabulated according to both of the BMI standards by height groups <145 cm, 145–159 cm and 160–200 cm (Table 7). These groups were chosen to represent women above and below the average height of the elite women (rounded up from 158 cm). The below average group was divided into women <145 cm, who are known to be at greater risk of delivery complications due to small pelvic structure[15]. For women in all height groups, infant and child mortality is lower the higher the value of either BMI. Women who were both short and of low BMI, irrespective of the index, had a much higher neonatal mortality rate; otherwise the difference by height was not large. In general, the trends are similar between both the Quetelet and *de facto* indices. The dispersion between low and high BMI groups is greater for the *de facto* index for tall women for infant and under-five mortality but the opposite is true for under-five mortality for short women.

For both size at birth and birth weight, women classified as low BMI in either standard were more likely to have had

Table 7 Mortality rates, reported size at birth, birth weight and pregnancy outcome by distribution of Quetelet BMI and *de facto* BMI according to height groups

Height group	<145 cm						145–159 cm						160–200 cm						
	Quetelet BMI			*De facto* BMI			Quetelet BMI			*De facto* BMI			Quetelet BMI			*De facto* BMI			
Mortality rate (/000)	Low	Normal	High	<−2SD	Normal	2+SD	Low	Normal	High	<−2SD	Normal	2+SD	Low	Normal	High	<−2SD	Normal	2+SD	*n*
Neonatal	66	36	30	65	35	24	37	31	26	37	30	25	35	29	26	35	29	24	220 761
Infant	114	70	61	106	68	58	82	71	53	81	68	51	79	74	57	79	71	45	220 761
Under 5	149	108	85	141	102	95	146	121	77	144	114	70	158	144	91	164	134	63	220 761
Size at birth (%)																			
Larger than average	23.8	20.9	21.4	24.8	20.4	30.9	25.1	24.0	26.9	24.3	25.3	25.1	25.6	30.2	32.9	24.8	29.1	28.4	49 103
Average	43.6	49.1	53.1	46.3	50.4	50.7	48.0	54.0	54.7	49.2	53.1	58.0	45.9	49.1	51.5	45.6	50.7	56.9	97 707
Smaller than average	32.7	30.0	25.5	28.9	29.3	18.3	26.9	22.0	18.4	26.6	21.5	17.0	28.5	20.7	15.5	29.5	20.3	14.8	40 751
Birth weight (%)																			
<2.5 kg	21.4	14.3	9.6	19.1	12.8	8.0	14.0	11.5	7.5	13.6	10.3	6.9	13.9	9.8	6.9	15.1	9.4	6.1	8269
⩾2.5 kg	78.6	85.7	90.4	80.9	87.2	92.0	86.0	88.6	92.5	86.4	89.7	93.1	86.1	90.2	93.1	84.9	90.6	93.9	72 726
Had a terminated pregnancy (%)																			
Yes	19.6	16.5	20.9	21.9	17.7	22.3	17.2	19.1	26.1	20.6	20.2	30.7	19.7	20.9	29.8	24.1	22.6	32.5	22 920
No	80.4	83.5	79.1	78.1	82.3	77.7	82.8	80.9	73.9	79.4	79.8	69.3	80.3	79.1	70.2	75.9	77.4	67.5	84 852

a small sized baby or one with a low birth weight than one with either a normal or high BMI. Again, the *de facto* standard gave a slightly better distinction in terms of difference in small size by level of BMI but not in birth weight.

Pregnancies that did not terminate in a live birth were more likely to have occurred to low and to high BMI women in each of the height groups using the *de facto* index. Using the Quetelet BMI, the percentage with a non-live birth termination was greater the higher the index among women 145–200 cm.

Discussion

A feature of the age-based curves of NHANES I & II is that weight increases linearly with height. The different age-based curves tend to be parallel to each other, with older women being heavier for a given height. The exception is the curve for those 18–24 years old, which is flatter than for the older age groups. Using the same dataset, but on a frame-size basis, a different pattern emerges. For large framed women, the trend is for weight to decline with increasing height, for medium framed women the trend is concave from below in shape, and for small framed women the curve is slightly concave. The *de facto* DHS curve for elite women shows that the 'ideal' weight for a given height is convex in shape, i.e. 'ideal' weight increases faster than height for shorter women but the opposite is true for taller women. Because elite women in the *de facto* DHS reference are thinner than those in the NHANES I & II reference, fewer women are defined as undernourished and slightly more as overnourished using this reference compared with the NHANES I & II references.

The standard definition for an appropriate weight-for-height (Quetelet BMI) is based on the association between BMI and optimal life expectancy of US adults over 25 years old who had taken out life insurance policies with the Metropolitan Life Insurance Company in the early 1940s[13,14]. The relationship between BMI and mortality at both ends of the BMI distribution, however, is unknown for developing countries[16]. Cut-off points have been established to define chronic energy deficiency for the Quetelet BMI[16] and applied in studies on mortality[17], risk of premature births[18], prenatal supplementary feeding[19], and worker efficiency, morbidity and mortality[20]. However, these values depart from the desired constant when 'ideal' weights from the references are used. This is reflected in the difference in the proportion of elite mothers defined as having a low and high BMI. In other words, the NHANES I & II references define more women as having a high BMI, i.e. as being overnourished, than the *de facto* curve but the opposite is true for having a low BMI, i.e. being undernourished.

The Quetelet BMI is based on a quadratic relationship between weight and height. Our results indicate that, for women of reproductive age, a more appropriate exponent for height is 1.63 rather than 2.0. In an investigation of the Benn index using data from NHANES II[21], the calculated Benn index was 1.62 for women 18–34 years old, which compared with a coefficient of log height of 1.64. However, the Benn index and coefficient of log height for 35–54-year-old women were 1.21 and 1.27, respectively. We did not run separate log regressions for each age group but rather included age in the single log regression as an adjustment to the log constant term. The adjustments were found to be less than 2% (about 1.1 kg) between ages 20–24 and ages 35–39 and 40–49 years.

In 14 of the 35 countries surveyed, the predicted values of weight given height and age were significantly different to those for the Dominican Republic. Higher average weights of the elite women occurred in Egypt, Morocco and Turkey in the Near East/North Africa region, in Guatemala, Nicaragua and Peru in Latin America, and in Ghana, Niger, Tanzania and Zimbabwe in sub-Saharan Africa. Four countries had significantly lower average weights: Bangladesh, Nepal, Kyrgyz Republic and Uzbekistan. These differences were controlled for in the estimation of the *de facto* standard.

Among children, greater height-for-age implies a better nutritional status. For women this is not the case. Tables 2 and 5 show that being tall does not necessarily indicate a woman is well-nourished. Nine of the 10 surveys with the tallest women were from sub-Saharan Africa, but these surveys ranked within the first 14 highest levels of prevalence of women with low BMI. In contrast, many of the countries whose women were the shortest, e.g. Guatemala, Peru and Bolivia, had women with the least prevalence of low BMI. In a third group of countries, notably Nepal and Bangladesh, most women are both short and of low BMI. However, a rank correlation test gave a Spearman's rho of 0.53 ($P = 0.000$), indicating that there was a moderate level of correlation between low height and low BMI (wt/ht^2).

In a healthy adult population, 3–5% of adults have a Quetelet BMI <18.5[11]. WHO also proposed a somewhat arbitrary classification for nutritional status that endeavours to take into consideration functional impairments such as work capacity, work productivity, and adult mortality and morbidity. If 5–9% of the population has a BMI <18.5, nutritional monitoring is required; if 10–19% are in this category, the nutritional situation is poor; if 20–39%, the situation is serious; and if >40%, the situation is critical. Among the 46 surveys included here, only 12 fell within the range for a healthy population; 13 required nutritional monitoring; in 17 the nutritional status was classified as poor; in three it was serious; and in one it was critical.

The strengths of this analysis are that it is based on a large number of non-pregnant women of reproductive age from various ethnic groups, thus it is not biased by genetic selection; the data are nationally representative and from a large number of developing countries; the sample size allowed estimation of neonatal, infant and under-five mortality within nutritional status groups without being subject to large sampling variability; and the constructed dataset allowed estimation of both under- and overnutrition.

The limitations are that the data are based on women with children under 5 years old rather than on all women of reproductive age (15–49 years old); a selection bias exists for younger women who are not yet married, especially those under 20 years old; and the women identified as being elite were unequally distributed by country because the data were based on nationally representative samples and some countries are more developed than others. An important caveat in the analyses relating functional outcomes to nutritional status is that nutritional status was taken at the time of the survey, while the functional outcomes pertained to the five-year period preceding the survey. Unless a prospective study is done, the latter is unavoidable.

This analysis, based on national level data from 46 surveys, supports the use of the Quetelet BMI in developing countries, despite the fact that it was developed from data on the US population. The *de facto* standard developed here has somewhat higher discriminatory power in identifying differences in functional outcomes, namely neonatal, infant and under-five mortality, birth weight and birth size, and adverse pregnancy outcomes. However, the convenience of using 2 as an exponent in the Quetelet BMI, rather than 1.6 in the *de facto* index, outweighs the advantage of the *de facto* index in classifying nutritional status of women. In his 1971 study of a power-type weight-for-height index as a measure of adiposity, Benn came to a similar conclusion[22].

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Appendix A: Values for country (C) and their t-values

Country	C	t-value
Bangladesh	−0.042	−8.467
Benin	0.014	1.051
Bolivia	0.002	0.492
Brazil	−0.006	−1.726
Burkina Faso	0.014	1.848
Central African Republic	−0.021	−1.295
Chad	0.004	0.251
Colombia	0.003	0.592
Comoros	−0.009	−0.367
Cote d'Ivoire	−0.001	−0.060
Egypt	0.062	21.066
Ghana	0.037	2.408
Guatemala	0.030	6.490
Haiti	−0.005	−0.410
Kazakstan	0.002	0.597
Kenya	0.002	0.225
Kyrgyz Republic	−0.018	−5.697
Madagascar	−0.052	−1.503
Mali	0.002	0.213
Malawi	0.017	1.026
Morocco	0.013	2.110
Mozambique	0.008	0.509
Namibia	0.010	1.692
Nepal	−0.048	−4.055
Nicaragua	0.008	2.306
Niger	0.031	3.997
Peru	0.010	3.377
Senegal	0.021	1.885
Tanzania	0.035	2.902
Togo	0.002	0.207
Turkey	0.015	2.683
Uganda	0.033	1.639
Uzbekistan	−0.018	−6.261
Zambia	−0.005	−0.707
Zimbabwe	0.033	4.522

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