Weight-height relationships and Body Mass Index. Some observations from the Diverse Populations Collaboration.

The Diverse Populations Collaborative Group

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Abbreviation:

BMI = Body mass index.

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ABSTRACT

Background: Body mass index [BMI, weight (kg)/height (m)^2] is the most widely used weight-height index worldwide. This universal use of BMI assumes the rationale for its use is universally applicable. We examine two possible rationales for using BMI as a universal measure. The first rationale is that BMI is strongly correlated with weight, but is independent of height. The second rationale is that BMI correctly captures the relationship between weight and height, which implies that the slope of log weight regressed on log height is 2.

Design: We examined the weight-height relationship in 25 diverse population samples of men and women from the US, Europe, and Asia. The analysis included 72 subgroups with a total of 385,232 adults aged 25 years and older.

Results: Although BMI was highly correlated with weight in all studies, a significant, negative correlation between BMI and height was found in 31 out of 40 subgroups of men ($r = -0.004$ to -0.133) and 32 of 32 groups of women ($r = -0.016$ to -0.205). When log weight was regressed on log height, the 95% confidence intervals (CI) of the slopes did not include 2 in 25 out of 40 male subgroups. The summary estimate of the slopes across studies of men was 1.92 (95% CI: 1.87 – 1.97). For women, slopes were lower than 2 in 28 of 32 subgroups with a summary estimate of 1.45 (95% CI: 1.39-1.51).

Conclusion: In most of the populations, BMI is not independent of height; and weight does not universally vary with the square of height; and the relationship between weight and height differs significantly between males and females. The use of a single BMI standard for both men and women cannot be justified on the basis of weight-height relationships.

Body mass index or Quetelet's index, (BMI= body weight (kg)/height $(m)^2$), is the most widely used weight-height index. The US Department of Agriculture and the Department of Health and Human Services (1998) and the World Health Organization (2000) have issued recommendations concerning healthy weight levels for adults using BMI. BMIs of 18.5 to 24.9 kg/m^2 are defined as optimal for all adult men and women, at all ages, and of all ethnicities. In this work, we examine two possible rationales for using BMI: that it is strongly correlated with weight, but independent of height; and that it captures the true relationship between weight and height.

To examine these two rationales, we use person-level data from 25 studies from different historical eras and geographical locations. Participants of the studies included both males and females and several ethnic backgrounds.

SUBJECTS AND METHODS

Data

The Diverse Populations Collaboration is examining variation in the results of epidemiological questions in samples from populations from many countries and cultures. The 25 studies reported here included national samples, participants from cohort studies, and participants of clinical trials. A full list of participating studies and investigators is included at the end of this report. The studies analyzed often contained subgroups based on factors such as sex, race/ethnicity (whites, blacks, and Hispanics), area of residence (urban and rural), and other characteristics of the study samples. These subgroups were analyzed separately. Persons in different treatment groups of the clinical trials were analyzed separately. Weight and height were measured in all studies except the National Health Interview Survey where self-reported values were obtained.

Statistical methods

Pearson correlation coefficients were calculated to summarize the strength of the relationship between BMI and height and BMI and weight. Confidence intervals for the estimated correlation coefficients were obtained using Fisher's-z.

BMI is sometimes called Quetelet's Index because Quetelet (1848) suggested that in adult populations, weight varies as the square of height. This implies that for a specific population, the relation between weight and height is such that weight/height^2 = constant. Taking logarithms, we get a linear equation:

$log(\text{weight}) = \alpha + 2*log(\text{height})$

Thus, if we fit the regression equation:

$log(\text{weight}) = \alpha + \beta*log(\text{height})$

we should get an estimated slope of two. If $\beta = 2$ for all samples, we may infer that BMI correctly captures the relationship between weight and height in all samples.

For each summary statistic calculated (mean, correlation, slope) we used standard meta-analytic methods to present the results. The summary statistics are presented in forest plots (Whitehead 2002) and summary estimates obtained using weighted averages. The weight applied to each summary statistics was the estimated inverse variance of the statistic. We first examined heterogeneity of results to determine whether the results vary beyond that that could be attributed to random sampling. To test for heterogeneity we used the chi-square test suggested by DerSimonian and Laird (1986). All of the results exhibited highly significant heterogeneity amongst the groups so we used a random effects model to calculate the summary result for the groups. Thus, our summaries were calculated with weights equal to the inverse of the sum of two variance components, a within group and a between group variance. The between group component of variance was estimated using restricted maximum likelihood (Normand 1999).

After completing the analytic procedures described above, we conducted sensitivity analyses to determine whether the results could have been influenced excessively by the inclusion of a single group. This methodology consisted of reanalyzing the summary statistics, while omitting each of the groups, one by one. We concluded that the summary statistics were not significantly impacted by the inclusion of any particular group.

We examined the summary statistics separately for males and females and tested whether the resultant summary statistics for males differed significantly from the summary statistic for females in two ways. First, we summarized the results for males and females using a random effects model. This procedure results in an estimate of the summary statistic in each group and it's standard error. The hypothesis that these summary statistics are identical in males and females may then be tested in the usual manner: (difference in statistics)/(standard deviation of the difference). Second, since several of our studies contained only male participants, we repeated the analysis including only the 20 studies that had both male and female participants. Additionally, to examine whether the summary slope for males and females differed when log weight was regressed on log height, we fit a linear model in which the logarithm of weight was regressed on the logarithm of height (log(height)) and included in the model dummy variables for group and gender and a term for interaction between gender and log(height). Since all of these methods gave similar results (the male and female summary coefficients differ significantly) we present only the results of the first analysis. One additional sensitivity analysis was conducted to examine the slopes of the regression of log weight on log height. The analyses were repeated by restricting the sample to persons 25 to 75 years of age and also restricting the sample to persons 25 to 60. These results did not differ substantially from those of the full sample, so we present only the results for the full sample.

RESULTS

Table 1 presents the sample sizes, means and standard deviations of weight, height, and BMI for each male sample and Table 2 presents the same information for the female samples. The significant variation amongst the groups is demonstrated in Figures 1-3 that graphically present a summary of the average values for the different groups. In these and the successive figures, the level of the estimated parameter (mean, correlation coefficient, etc.) is marked by a square that is proportional to the inverse of the variance of the estimate and the line on either side of the point estimate notes the 95% confidence interval for the estimated value. The dashed line denotes the random effects average value for the groups. The analyses are presented separately for men and for women.

Figure 1 presents the analysis of height (in meters). The figure demonstrates the well-known fact that women tend to be shorter than men; and also demonstrates the significant variation amongst the groups of either gender. The average heights in the groups vary from 1.63m to 1.78m in the male groups and from 1.53m to 1.63m in the female groups. The random effects average height for the male groups is 1.72m (95% C.I.: 1.71m-1.74m) and for the female groups is 1.60m (95%C.I.: 1.59m-1.61m).

Figure 2 presents the analysis of weight in kilograms for the different groups. The weights amongst the male groups vary from 53.4kg to 86.0kg and from 45.9kg to 81.8kg amongst the female groups. The random effects average for males is 76.6kg (95%C.I.: 74.1kg-

79.0kg) and for the female groups is 67.1kg (95% C.I.: 64.9-69.3).

Figure 3 summarizes the average BMI in the groups. The average BMI varies from 19.8 to 28.2 in the male groups and from 19.6 to 30.8 in the female groups. The random effects average for males is 25.7 (95% C.I.: 25.1-26.2) and for the female groups is 26.1 (95%C.I.: 25.2-26.9).

Figure 4 presents the correlation of BMI with weight. As expected, there is a strong correlation between BMI and weight in all of the groups, male and female. The correlations in the male group vary significantly; the random effects summary for males is 0.868 (95% C.I. 0.861 to 0.875). The correlations in the female group also vary significantly; the random effects summary for females is 0.914 (95% C.I. 0.908 to 0.919). The summary correlation for females is significantly larger than the summary correlation for males.

Figure 5 presents the correlation of BMI with height. The figure demonstrates that for most groups, both male and female, there is a small inverse correlation between height and BMI. The correlations in both males and females vary significantly amongst the groups. The random effects average for males is –0.026 (95% C.I.: -0.041 to -0.012) and for female groups is –0.119 (95% C.I.: -0.132 to -0.106). On this residual correlation is significantly (in absolute value) larger in the female than the male samples.

To examine the relationship between weight and height, log(weight) was regressed on (log(height)) in each group and the results of this analysis are presented in Figure 6. The slopes of the regression lines range from 1.47 to 2.35 in the male groups and from 1.07 to 1.90 in the female groups. The (random effects) average slope in the male groups is 1.92 (95% C.I.=1.87--1.97) and the average slope in the female groups is 1.45 (95% C.I.: 1.39-1.51). The average slope for women is significantly lower than the average slope for men. Among the 40 groups of men, the 95% confidence intervals of the slopes do not include 2 in 25 of the 40 groups and among female groups the 95% confidence intervals of the slope do not contain 2 in 28 of the 32 groups.

DISCUSSION

Among a wide range of weight-height indices, BMI is the most commonly used index in epidemiological and clinical studies. Data from these diverse populations that represent temporal, geographic, ethnic, and gender variation demonstrate that BMI is neither independent of height nor can it be derived from first principals in most populations. A significant inverse correlation between BMI and height was found in most populations; and, squared height was not obtained as the optimal power for describing the weight-height relationships in most populations. There was significant variation in the optimal value obtained amongst the populations studied and the average value for women was significantly lower than that for men.

Previous investigators including Garn (1986), Micozzi (1991), and Smalley (1990) have examined the correlation between BMI and height and reported results consistent with ours in adult populations, and Garn (1986) suggests that the magnitude and sign of the correlation between height and BMI is age dependent. It is positive in children and decreases with age, becoming negative in middle age.

Figure 7 demonstrates the implications of the fact that weight is not proportional to the square of height. The figure presents three lines representing weights associated with particular heights for three different weight height relationships: the line defined by BMI=25, the regression line of log weight on log height estimated as the average regression, gender specific. BMI=25 is the upper limit of present standards for ``healthy'' BMI. The regression line estimates the average weight for people of that height so if the other lines are above the BMI=25 line, it indicates that the average person at that height is overweight. Similarly, if the line is below the BMI=25 line it indicates that the average person at that height is within the "healthy" BMI limit and the further the lines are separated, the higher the proportion of the population at that height who will be classified as overweight or underweight. The exact amount and direction of misclassification will depend on the specific population studied, but the figure demonstrates that this misclassification can be extreme.

An additional rationale for BMI standards might be that BMI is correlated with highly body fat. BMI is influenced to nearly an equal degree by both lean body mass and body fat. Numerous investigators have examined this issue. Micozzi (1986), Smalley (1986), Deurenberg (1991), Long (1998), Florey (1970), Roche (1981), Adbel-Malek (1985), Revick (1986), Heitman (1990), Lean (1996), Gallagher (1996), Luke (1997), and Gallagher (2000) report correlations between body fatness and BMI ranging from .6 to .8. Typically, BMI accounted a little over half the variance in adiposity, but varied by study and method for determining body fat (skinfold thickness, densitometry or bioelectrical impedance analysis). Using isotope dilution and dual energy X-ray absorptiometry methods, Baumgartner (1995) reported a considerable overlap of % body fat and free mass across BMI categories. This entails a potential misclassification of fat content by BMI: a person may be overweight but not overfat, or underweight yet overfat (Roubenoff 1995). Smalley (1990) examined the relationship between percentage body fat determined by densitometry and BMI in 363 middle-aged men and women and concluded that BMIs should be used as indicators of obesity in individuals only with caution since the confidence interval for predicting percent body fat from BMI in individuals were wide.

It is generally understood that women have a greater fat mass as well as % body fat than men at any level of BMI. Deurenberg (1991), Gallagher (1996), and Roubenoff (1995) report that the relationship between BMI and fatness is not the same in men as in women. These same investigators also report that the relationship between fatness and BMI is not the same for all ages. Mazariegos (1994) reports that older adults matched for BMI with young adults, have increased % body fat and reduced free fat mass. Hence, the application of a cut point for BMI based on the distributions and relationships established in younger adults will substantially underestimate the prevalence of excess relative fatness in older adults. Although there are a number of publications in which no differences in the relationship between body fat and BMI of ethnic groups were found (Gallagher 1996), recent studies indicate that these differences may well exist (Luke 1997, Gallagher 2000, Norgan 1994, Deurenberg 1998). Gallagher (2000) reports that Asians have a significantly higher percentage body fat for any given BMI than do whites and African Americans. For the same level of body fat and age, American Blacks had a 1.3 kg/m^2 and Polynesians a 4.5 kg/m^2 higher BMI compared to Caucasians (Deurenberg 1998). Even within the white samples, there appears to be a small difference between Americans and Europeans (Gallagher 2000, Deurenberg 1998), and for populations of the same African ancestry, a BMI of 25 kg/m^2 represented mean body fat levels of 25.8%, 22.2%, and 16.4% among US, Jamaican, and Nigerian men, respectively (Luke 1997). The difference in the relation between BMI and body fat levels across populations is recognized by the WHO in its recent report, in which it is stated that the BMI cut-off values for overweight and obesity may not correspond with the same degree of fatness across different populations (WHO 2000). Although data on direct measures of adiposity were unavailable in the current study, the observed variation of the intercepts and slopes of weight regressed on height across populations and ethnic groups do not support a single BMI standard to define obesity. The use of appropriate cut-off points is of great importance in establishing reliable prevalence figures for obesity and consequent public health policies. Rose (1991) estimated that lowering the cut-off point for obesity from 30 kg/m^2 to 27 kg/m^2 could increase the prevalence of obesity in a population by as much as 14%. The less than perfect correlation of BMI with body fatness may result in a random misclassification among relatively homogenous age, sex and ethnic groups (Manson 1990). However, the application of any fixed BMI cut point across age and ethnic groups is a potential source of systematic, differential misclassification bias when the objective is to compare diverse groups for prevalence of obesity and associated morbidity or mortality risks.

The wide diversity of our studies is both a strength and a weakness. Our collection of studies is not a random sample of any defined population. As in all meta-analyses, we depended on individual investigators from each study to supply the necessary information, in our case, the raw data. Invariably and understandably, not every study requested agrees to collaborate. The studies include a mixture of data collected for both observational and experimental purposes and is a combination of data from studies publicly accessible and data provided to us by individual investigators. However, the collection provides a highly diverse group of studies in terms of geographic origin, gender, race, and baseline risk of mortality.

The popularity of BMI is, in all likelihood, due to the ease with which it may be determined; most studies include determinations of weight and height. BMI is even used in children, for whom the weight height relationships are changing rapidly throughout the developmental years. Quetelet (1848) in his work over one hundred and fifty years ago noted that while weight varied inversely with the square of height in adults, this was not the case in children. In this analysis we have demonstrated that BMI cannot be derived on first principles; and also that the relationship between weight and height vary significantly in the diverse populations included in our database. It appears that weight by height standards, if they are to be used will need to include population specific measures if they are to have the same meaning when applied to all individuals.

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Table 1. Mean and standard deviation (SD) of weight, height, and Body Mass Index (BMI) among men. The Diverse Populations Collaboration.

Cohort	N	Weight (kg) Mean	SD	Height (m) Mean	SD	BMI (kg/m²) Mean	SD	Age Range
ARIC Black Male	1620	85.6	15.8	1.76	0.066	27.6	4.9	45-64
ARIC NonBlack Male	5422	85.0	13.5	1.76	0.065	27.4	4.0	45-65
BIP Male	11820	77.0	11.3	1.70	0.067	26.6	3.3	36-74
Charleston Black Male	326	75.5	13.5	1.73	0.066	25.1	4.4	35-90
Charleston White Male	648	77.4	12.6	1.75	0.070	25.1	3.7	35-90
CHS Black Male	334	79.1	11.8	1.73	0.058	26.5	3.7	65-90
CHS White Male	2124	78.6	11.1	1.73	0.060	26.3	3.4	65-90
Cordis Male	3611	75.2	11.9	1.70	0.071	25.9	3.7	25-80
Framingham Cohort Male	2005	77.4	11.3	1.72	0.069	26.2	3.4	34-69
Framingham OffSpring Male	2184	83.1	12.5	1.75	0.068	27.0	3.6	25-62
Glostrup Male	5078	78.6	12.1	1.76	0.070	25.4	3.5	29-80
GOH Male	2603	70.9	12.3	1.68	0.071	24.9	3.7	29-59
Guanzhou Rural Male	1580	53.4	6.4	1.64	0.060	19.8	1.9	25-64
Guanzhou Urban Male	1748	56.2	7.4	1.65	0.057	20.5	2.4	25-66
HDFP RC-Black Male	1080	81.5	16.2	1.73	0.071	27.1	4.9	30-69
HDFP RC-White Male	1857	85.4	14.2	1.74	0.075	28.2	4.3	30-69
HDFP SC-Black Male	1064	81.6	17.0	1.73	0.074	27.1	5.2	30-69
HDFP SC-White Male	1893	85.1	14.7	1.74	0.077	28.1	4.3	30-69
Honolulu	8006	63.2	9.9	1.63	0.058	23.8	3.2	45-68
Iceland Male (Reykjavik)	9095	80.5	12.1	1.76	0.063	25.8	3.4	33-79
IIHD	10034	71.8	10.8	1.67	0.066	25.7	3.3	39-75
LRC Hyperlipidemic Male	2099	84.1	12.6	1.75	0.067	27.4	3.6	30-91
LRC Random Sample Male	2529	81.2	12.1	1.76	0.067	26.3	3.4	30-89
MRFIT SI	6428	86.0	12.4	1.76	0.067	27.7	3.5	35-58
MRFIT UC	6438	85.8	12.2	1.76	0.066	27.7	3.5	35-58
NHANES I Black Male	766	76.8	16.4	1.73	0.070	25.6	4.9	25-75
NHANES I White Male	4784	78.1	13.6	1.74	0.072	25.7	4.0	25-75
NHANES II Black Male	447	78.2	15.7	1.74	0.068	25.8	4.7	30-74
NHANES II White Male	3809	78.8	13.2	1.74	0.070	25.9	3.9	30-75
NHIS Black Male	6246	81.9	15.6	1.77	0.083	26.2	4.6	25-89
NHIS Hispanic Male	1409	72.6	13.8	1.72	0.076	24.5	3.9	25-87
NHIS White Male	46264	81.8	13.9	1.78	0.073	25.8	3.9	25-90
Norway Male	24028	77.2	10.4	1.75	0.064	25.1	3.0	35-49
Puerto Rico Rural	2973	62.6	10.9	1.64	0.063	23.3	3.5	35-79
Puerto Rico Urban	6821	71.0	12.7	1.65	0.064	25.9	4.1	35-79
Renfrew-Paisley Male	7055	74.6	11.4	1.70	0.068	25.9	3.4	45-64
Scottish Collaborative Male	6001	75.3	10.6	1.73	0.071	25.1	3.1	25-75
Tecumseh Male	1942	77.4	13.0	1.73	0.068	25.7	3.8	25-90
Yugoslavia Rural	2902	65.3	9.0	1.71	0.066	22.2	2.5	34-62
Yugoslavia Urban	3548	71.9	12.3	1.72	0.065	24.3	3.6	35-83

Abbreviations and references are found in the study list at the end of the report.

Table 2. Mean and standard deviation (SD) of weight, height, and Body Mass Index (BMI) among women. The Diverse Populations Collaboration.

Cohort	N	Weight (kg)		Height (m)		BMI (kg/m²)		Age
		Mean	SD	Mean	SD	Mean	SD	Range
ARIC Black Female	2621	81.8	17.5	1.63	0.0597	30.8	6.5	45-64
ARIC NonBlack Female	6044	69.7	14.8	1.62	0.059	26.6	5.5	45-65
BIP Female	2748	68.9	11.5	1.59	0.067	27.2	4.3	43-74
Charleston Black Female	452	70.3	17.0	1.60	0.066	27.3	6.3	35-97
Charleston White Female	738	64.7	12.7	1.63	0.058	24.5	4.6	35-85
CHS Black Female	563	74.6	13.8	1.60	0.059	29.2	5.1	65-90
CHS White Female	2755	66.6	12.0	1.59	0.056	26.3	4.5	65-90
Cordis Female	1412	65.0	12.7	1.58	0.066	26.0	5.1	25-71
Framingham Cohort Female	2521	64.7	11.5	1.59	0.062	25.6	4.5	34-68
Framingham OffSpring Female	2276	63.7	12.6	1.61	0.060	24.4	4.6	25-62
Glostrup Female	5063	64.4	11.7	1.64	0.064	24.3	4.3	29-80
GOH Female	2752	62.8	12.1	1.57	0.068	25.4	4.7	29-59
Guanzhou Rural Female	2023	45.9	5.6	1.53	0.054	19.6	2.0	25-64
Guanzhou Urban Female	1684	51.4	7.7	1.55	0.052	21.4	3.0	25-71
HDFP RC-Black Female	1352	78.7	18.6	1.61	0.068	30.2	7.0	30-69
HDFP RC-White Female	1145	72.0	16.7	1.60	0.069	28.2	6.4	30-69
HDFP SC-Black Female	1339	76.7	18.6	1.61	0.069	29.5	7.0	30-69
HDFP SC-White Female	1178	72.2	16.8	1.60	0.070	28.2	6.3	30-69
Iceland Female (Reykjavik)	9689	67.1	11.8	1.63	0.057	25.2	4.3	33-81
LRC Hyperlipidemic Female	1630	67.3	13.8	1.61	0.065	25.8	5.1	30-89
LRC Random Sample Female	2337	64.8	12.7	1.62	0.064	24.6	4.6	30-97
NHANES I Black Female	1276	72.8	18.2	1.62	0.064	27.9	6.7	25-75
NHANES I White Female	6818	65.6	14.2	1.61	0.064	25.2	5.4	25-75
NHANES II Black Female	549	74.8	17.1	1.61	0.068	28.7	6.4	30-75
NHANES II White Female	4270	66.8	14.6	1.61	0.065	25.9	5.6	30-75
NHIS Black Female	11202	72.7	16.4	1.63	0.073	27.2	6.0	25-89
NHIS Hispanic Female	1753	59.3	13.1	1.59	0.066	23.5	4.7	25-88
NHIS White Female	61521	65.3	13.8	1.63	0.069	24.5	5.1	25-90
Norway Female	23507	65.3	11.1	1.63	0.060	24.7	4.1	35-49
Renfrew-Paisley Female	8339	64.1	11.4	1.58	0.061	25.8	4.5	45-64
Scottish Collaborative Female	1002	62.5	10.3	1.59	0.061	24.7	3.8	27-61
Tecumseh Female	2052	65.1	13.6	1.60	0.062	25.5	5.3	25-91

Abbreviations and references are found in the study list at the end of the report.

List of Figures

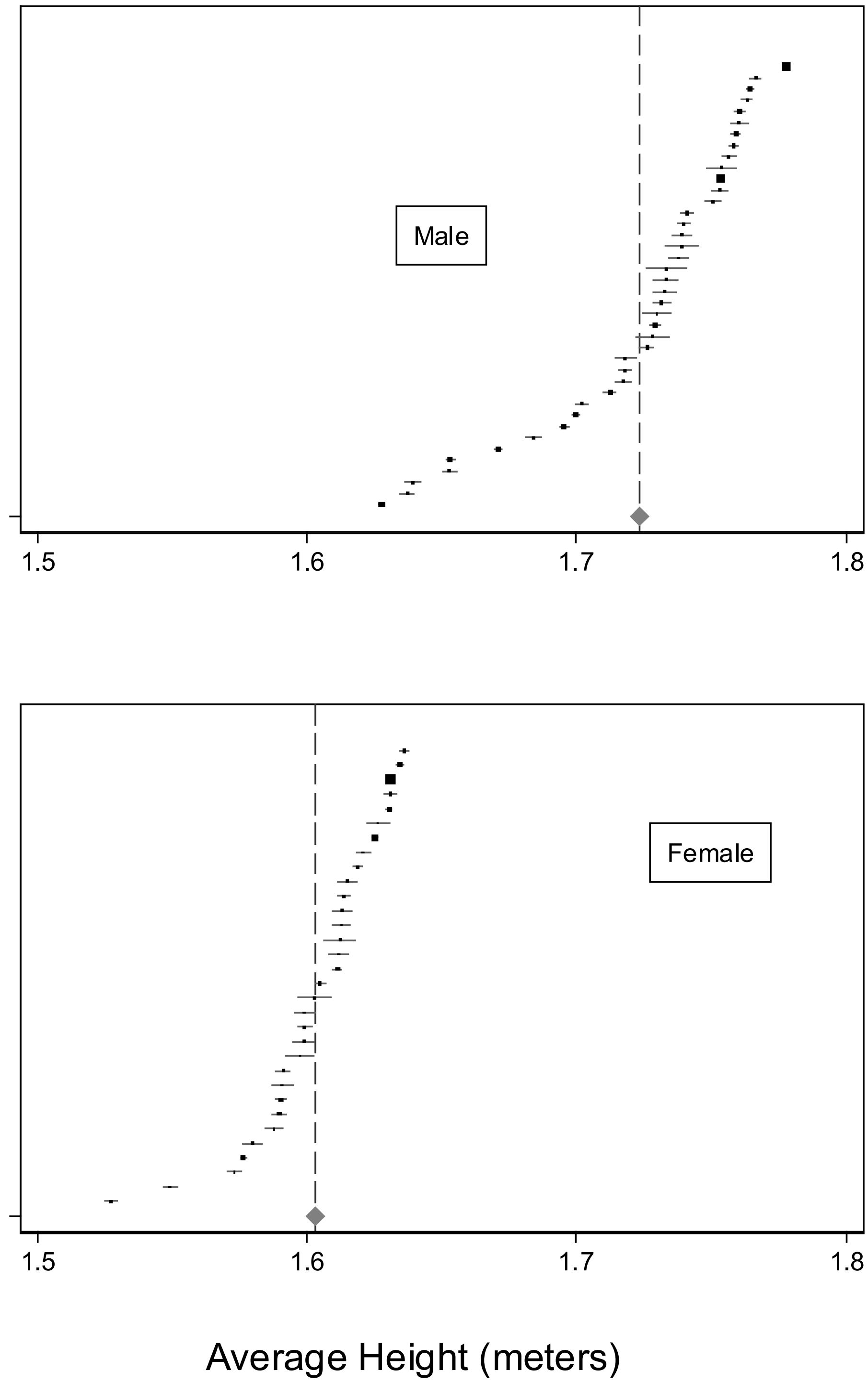


Figure 1

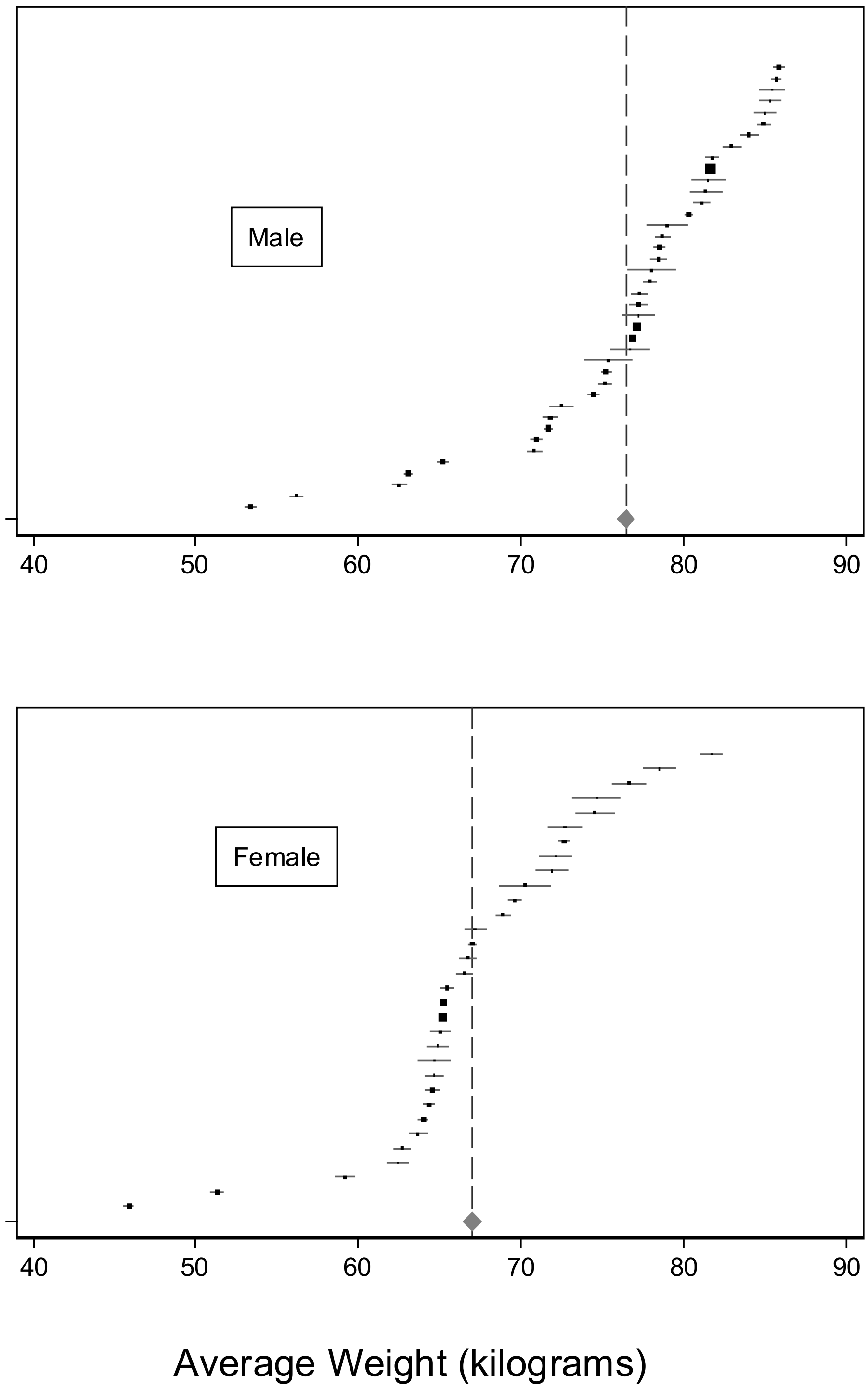
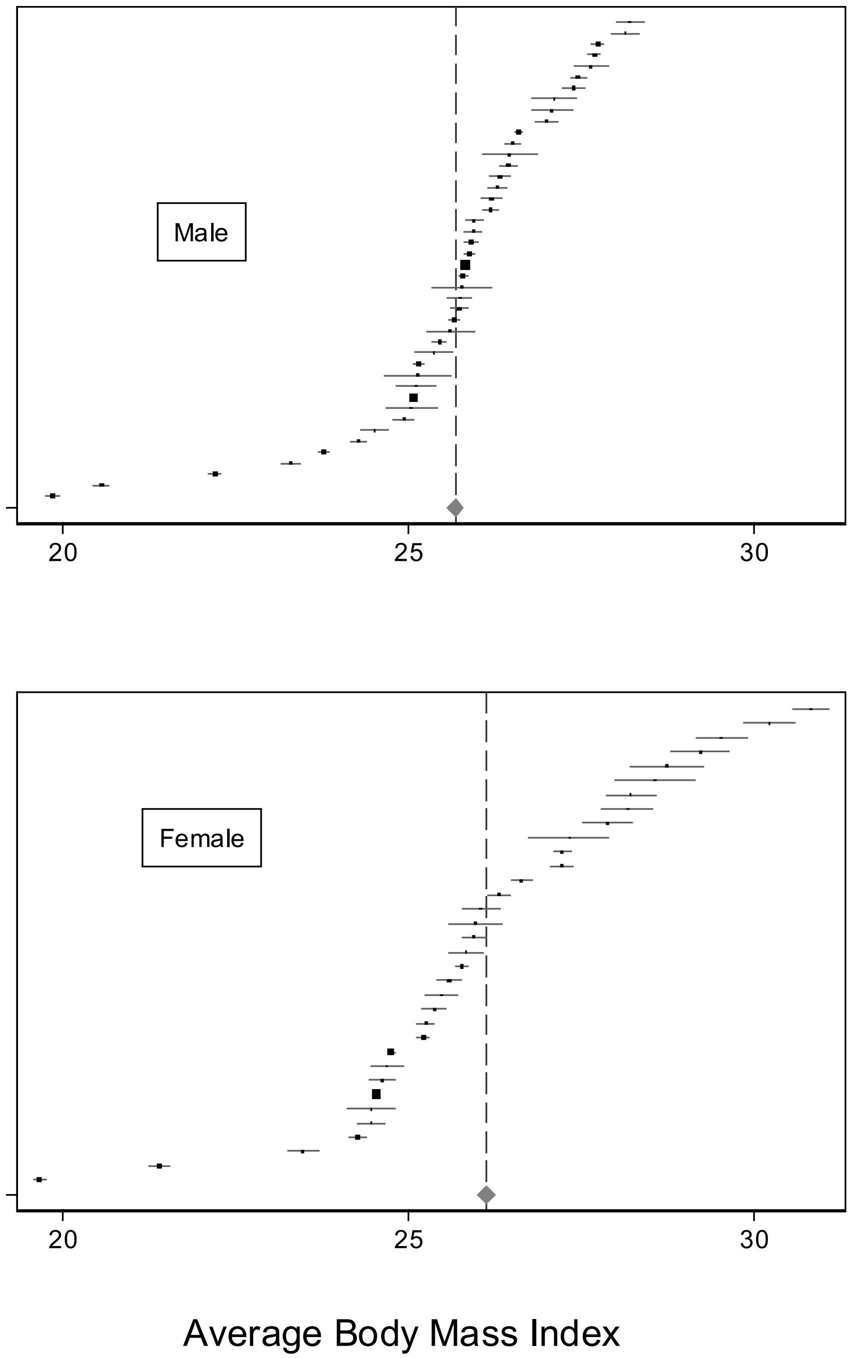

Male
40
50
60
70
80
90
Female
40
50
60
70
80
90
Average Weight (kilograms)

Figure 2



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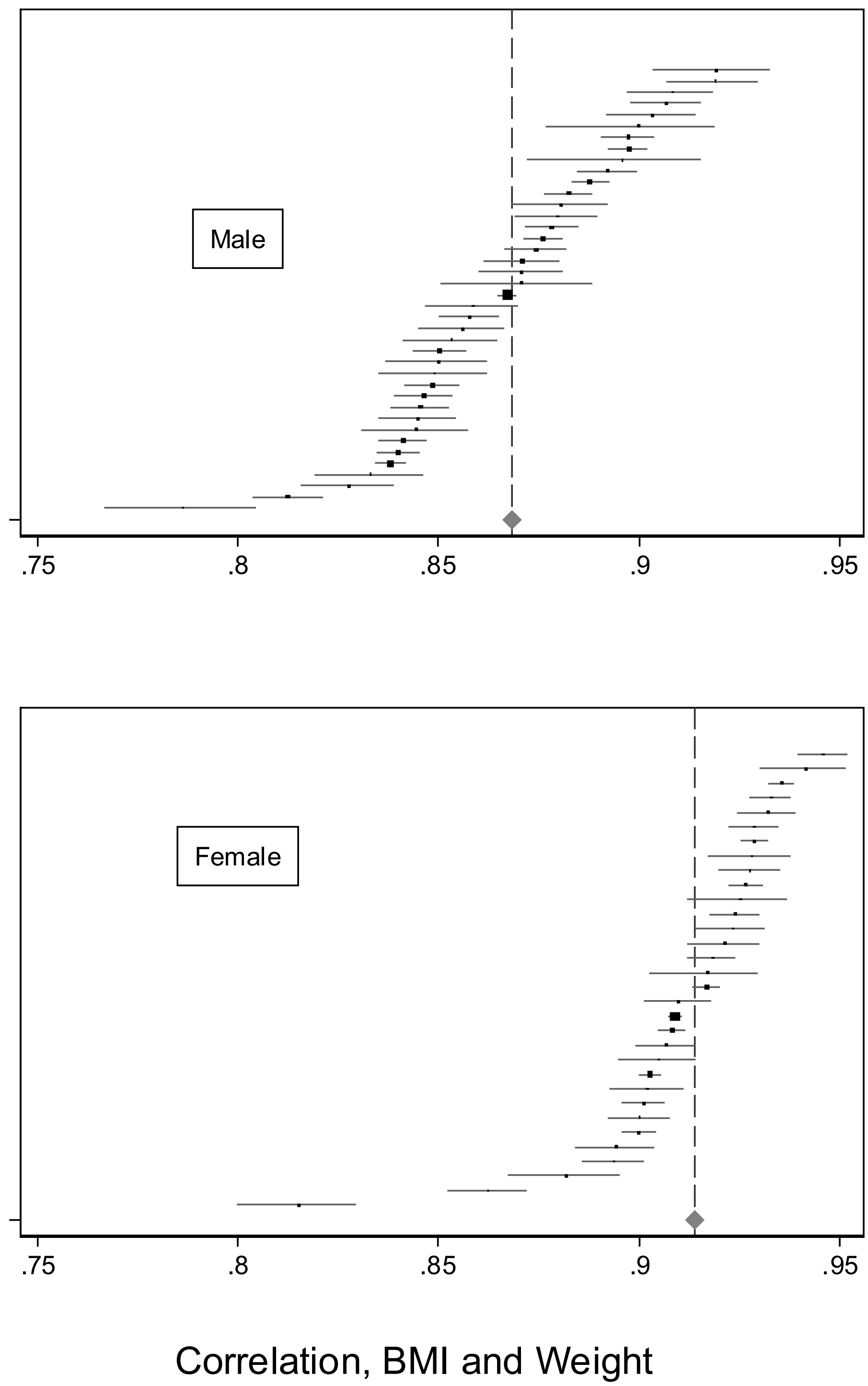

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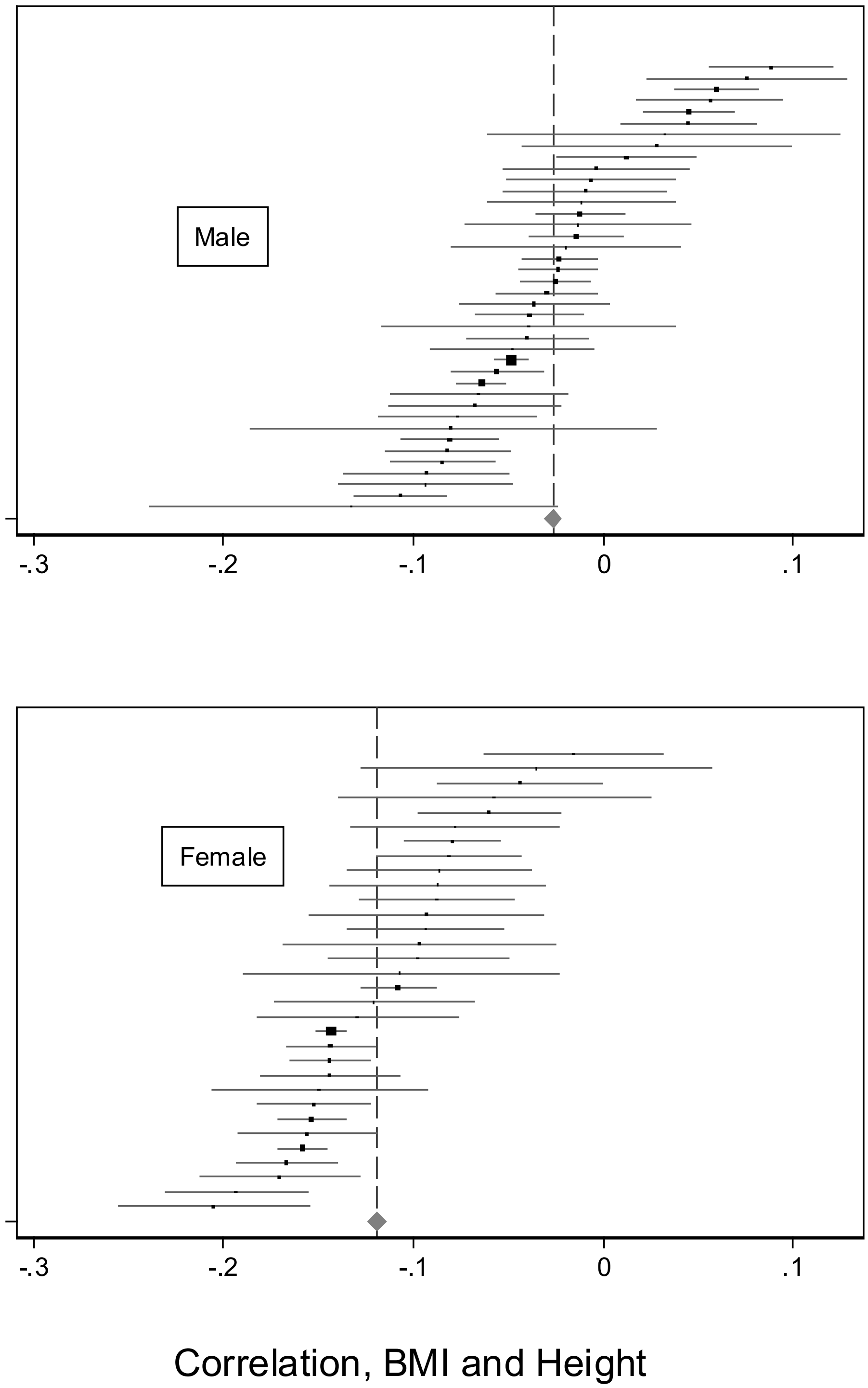

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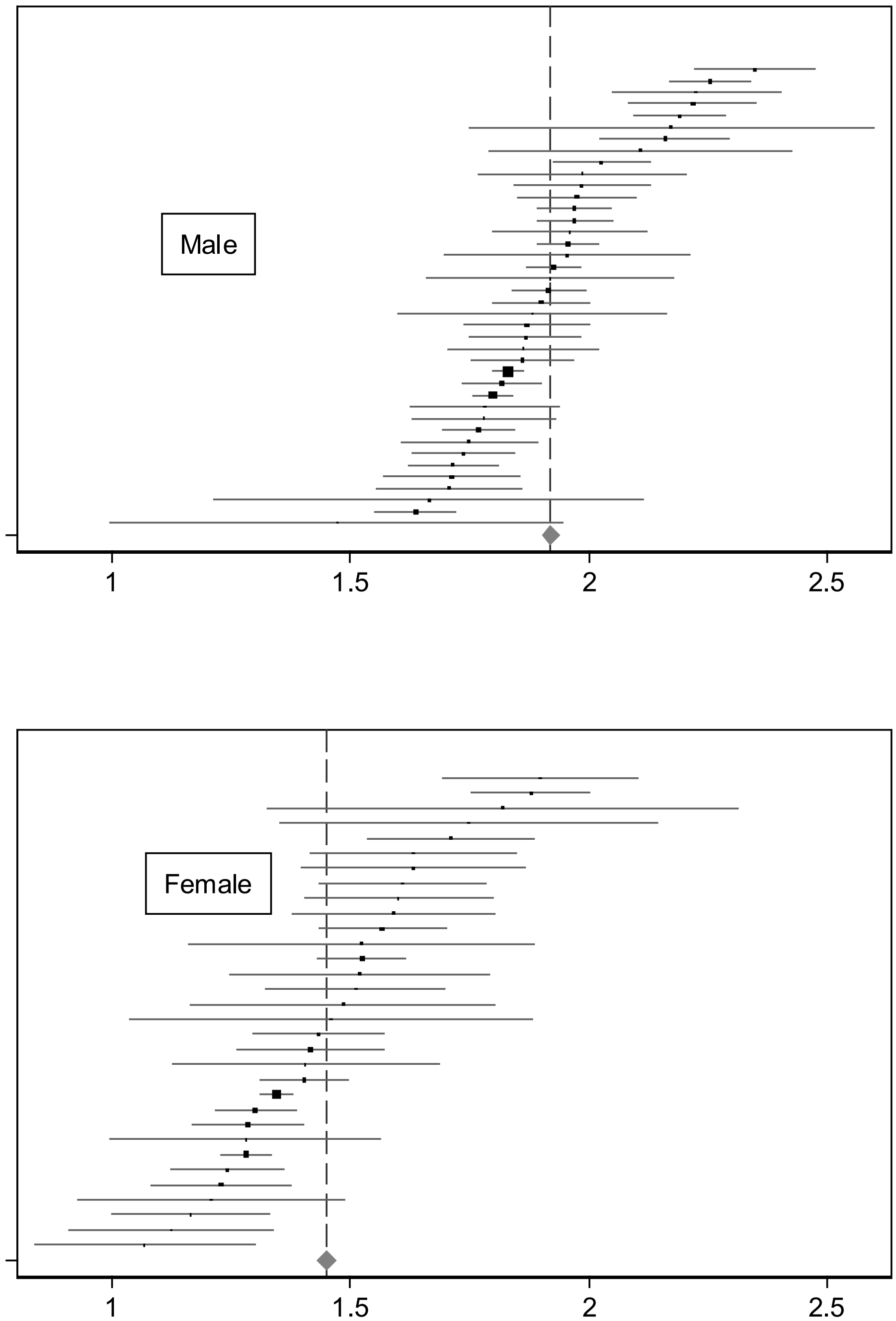
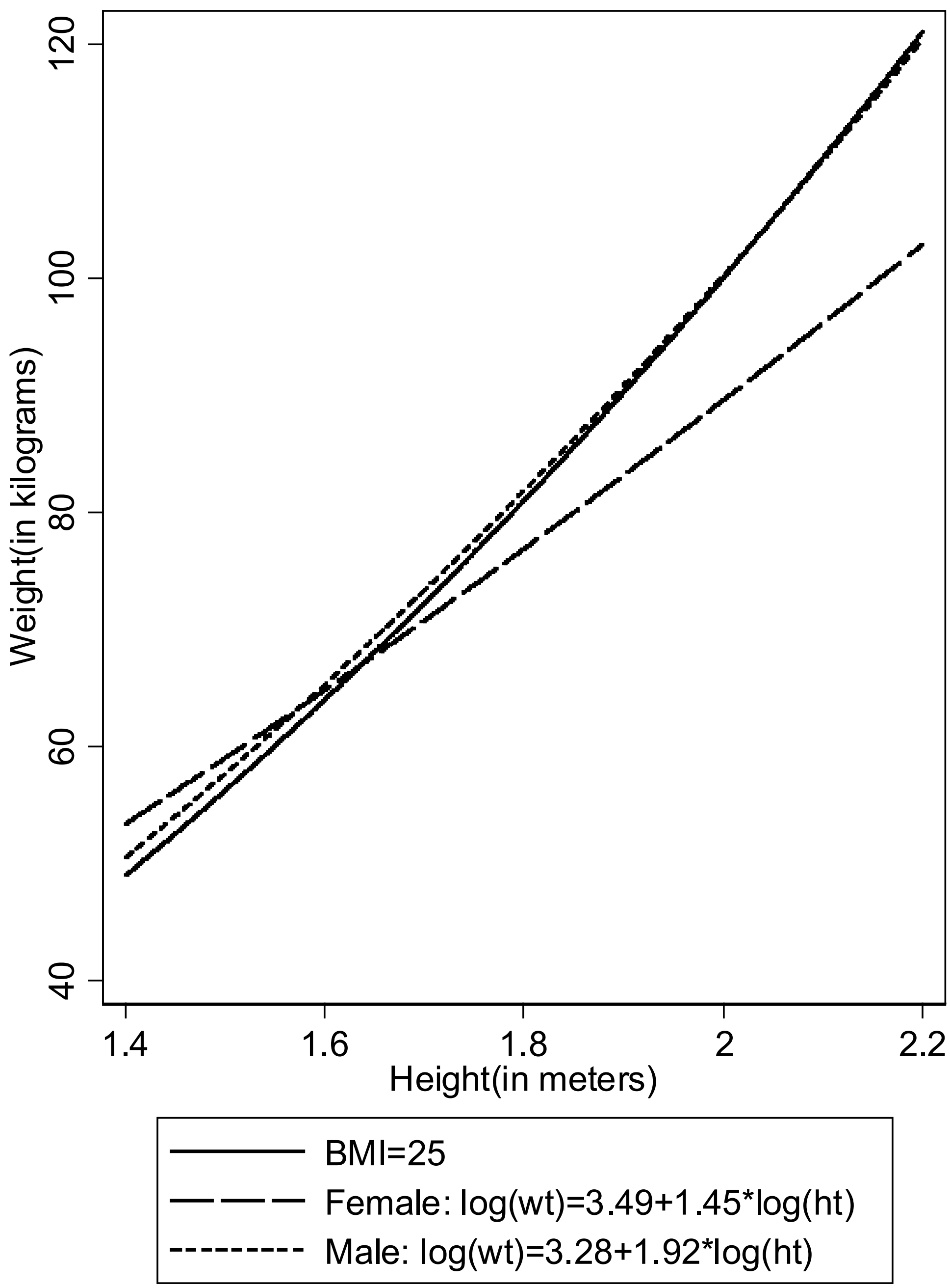


Slope of log weight regressed on log height

Figure 6



120
100
80
60
40
Weight(in kilograms)
1.4
1.6
1.8
2
2.2
Height(in meters)
BMI=25
Female: log(wt)=3.49+1.45*log(ht)
Male: log(wt)=3.28+1.92*log(ht)

Figure 7

Appendix: The Diverse Populations Collaboration Investigators:

The Bezafibrate Infarction Prevention (BIP) Trial screenees (Braun 1996)***:*** Dr. Uri Goldbourt., Dr. Michal Benderly

The Charleston Heart Study (Keil 1989): Dr. Daniel Lackland, Dr. Peter Gazes, Dr. Julian Keil, Dr. Susan Sutherland, Ms. Pamela Ferguson.

The Cardiovascular Occupational Risk factors Determination in Israel Study *(CORDIS)* (Froom 1999)*:* **Dr. Paul Froom;**

The Evans County Study (Hames 1971): Dr. Dan Lackland, Dr. Curtis Hames, Ms. Pamela Ferguson.

The Glostrup Population Studies (Thomsen 2002)***:*** Drs. Torben Jorgensen and Troels Thomsen;

The Glucose Intolerance, Obesity, and Hypertension (GOH) Study (Modan 1991)**:** Dr. Rachel Danker, Flora Lubin, Angela Chetrit and Ayala Lusky;

The Guanzhou Study (People' Republic 1992)**:** Drs. Shuguang Lin, Yihe Li, and Xiaoqing Liu;

The Israeli Ischemic Heart Disease Study (Groen 1968)**:** Dr. Uri Goldbourt and Ms. Shlomit Yaari;

The Norwegian Counties Study (Bjartveit 1979)***:*** Drs. Randi Selmer and Aage Tverdal;

The Puerto Rico Study (Garcia-Palmieri 1970)***:*** Dr. Carlos Crespo, Dr. Mario R. Garcia-Palmieri;

The Reykjavik Study (Olafsson 1969)***:*** Dr. Emil Sigurdsson;

The Scottish Collaborative Study (Smith 1997)***:*** Drs. Charles Gillis, Victor Hawthorne, and

David Hole, and Ms. Carole Hart;

The Tecumseh Community Health Study (Epstein 1965)***:*** Dr. Victor Hawthorne;

The Yugoslavia Cardiovascular Disease Study (Kozarevic 1971)***:*** Drs. Djordje Kozarevic and Nikola Vojvodic;

Consultants: Dr. Zhaohai Li, *George Washington University*; Dr. Ronan Conroy, *Royal College of Surgeons, Dublin, Ireland*; Dr. Youlian Liao, *Centers for Disease Control and Prevention*. Dr. Christopher Sempos, *National Institutes of Health;*

Coordinating Center: *Florida State University*: Dr. Hong Chang, Dr. Somesh Chattopadhay, Dr. Myles Hollander, Dr. Daniel McGee (Principal Investigator), Dr. Xu-Feng Niu, Ms. Jeannette Simino, Mr. Billy Franks, Ms. Mahtab Munshi, Mr. Rob Fowler.

Data from the following studies were obtained from the National Heart, Lung, and Blood Institute: ***The Atherosclerosis Risk in Communities (ARIC) Study*** (Sharrett 1999)***, The Cardiovascular Health Study*** (Fried 1991)***, The Framingham Heart Study*** (Dawber 1951), ***The Framingham Offspring Study*** (Kannel 1979), ***The Honolulu Heart Program*** (Worth 1970), ***The Lipid Research Clinics Prevalence Study*** (Lipid Research 1979), ***The Lipid Research Clinics Primary Prevention Trial*** (Lipid Research 1984), ***The Hypertension Detection and Followup Program (HDFP)*** (Hypertension 1976), ***The Multiple Risk Factor Intervention Trial (MRFIT)*** (Multiple 1986), ***the Puerto Rico Heart Health Study, and the Coronary Artery Risk Development in Young Adults (CARDIA) Study*** (Friedman 1988)***.*** Data from ***The National Health Interview Survey (NHIS)*** (Massey 1989), ***The First National Health and Nutrition Examination Survey Epidemiologic Follow-up Study*** (Plan 1987) and ***The Second National Health and Nutrition Examination Survey Mortality Follow-up Study*** (McDowell 1981) were

obtained from the National Center for Health Statistics. Data from ***the Tecumseh Study*** was obtained from the Inter-University Consortium for Political and Social Research (ICPSR). The views expressed in this paper are those of the authors and do not necessarily reflect those of these agencies.

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