Body frame dimensions can predict obesity: Body mass index, body frame and fatness

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Obesity, a multifactorial phenomenon

- Diet
- Lifestyle
- Metabolic defects
- Normal variation=physiology and anatomy
- Methods of assessment?

Body Mass Index

- A blessing - simple tool of public health
- A curse - poorly constructed, includes lean body weight, assumes wrong mathematical form of height/weight relationship:

  $BMI=W/H^2$ instead of $W=a_*\exp(b_*H)$

  Overestimating BMI of taller people

Use skinfolds if possible !

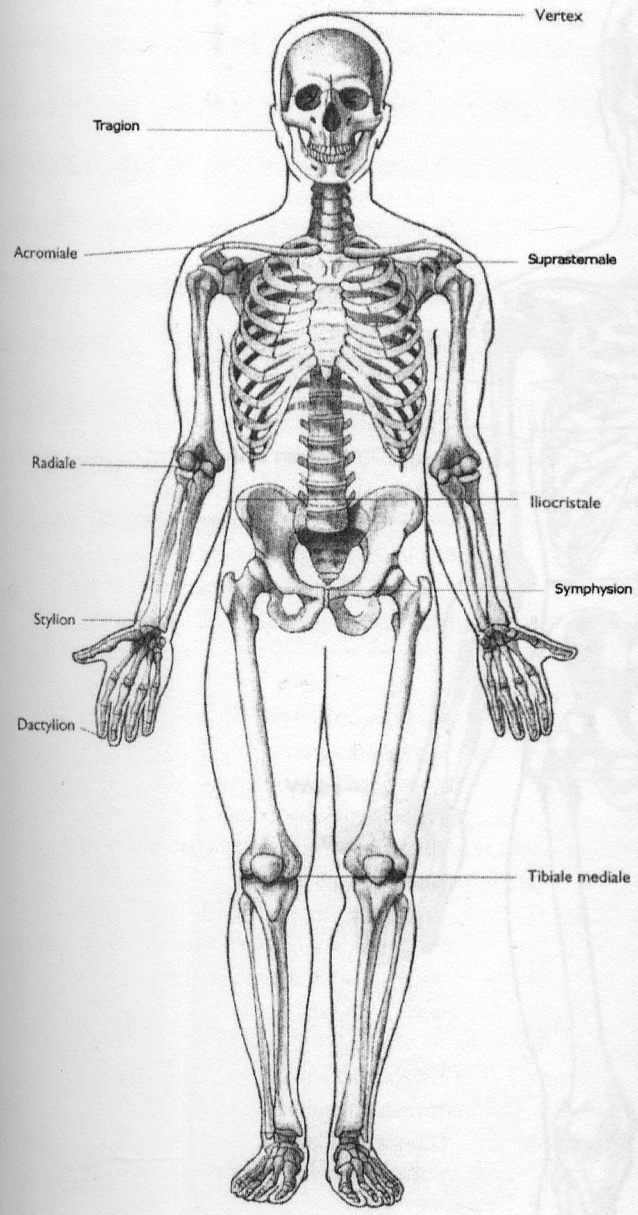
An uncomfortable result

Coefficients of determination (r^2) of BMI and selected metric variables of 1250 Australian adult women. All coefficients, but for body height, significant at $p<0.01$ level. All correlations are positive. (Henneberg and Veitch 2005).

Variable	r^2	type of regression
Body height	0.007	linear
Body mass (weight)	0.856	linear
Waist circumference	0.803	linear
Lean waist circumference	0.732	linear
Abdominal skinfold	0.488	logarithmic
Subscapular skinfold	0.560	logarithmic
Triceps skinfold	0.535	logarithmic
Average skinfold	0.652	logarithmic
Bi-acromial diameter	0.157	linear
Bi-acromial diam./height	0.241	linear
Bi-iliocristal diameter	0.402	linear
Bi-iliocristal diam./height	0.441	linear
Lean arm circumference	0.436	linear

Material: Australian adults

- National Body Size and Shape Survey 2002
- 1300 female and 66 male volunteers, average age ~50 years
- Adelaide, Brisbane, Canberra, Melbourne, Perth, Sydney
- 60 anthropometric dimensions, circumferences and 3 skinfolds
- Thanks to SHARP Dummies Pty Ltd and their Director Daisy Veitch



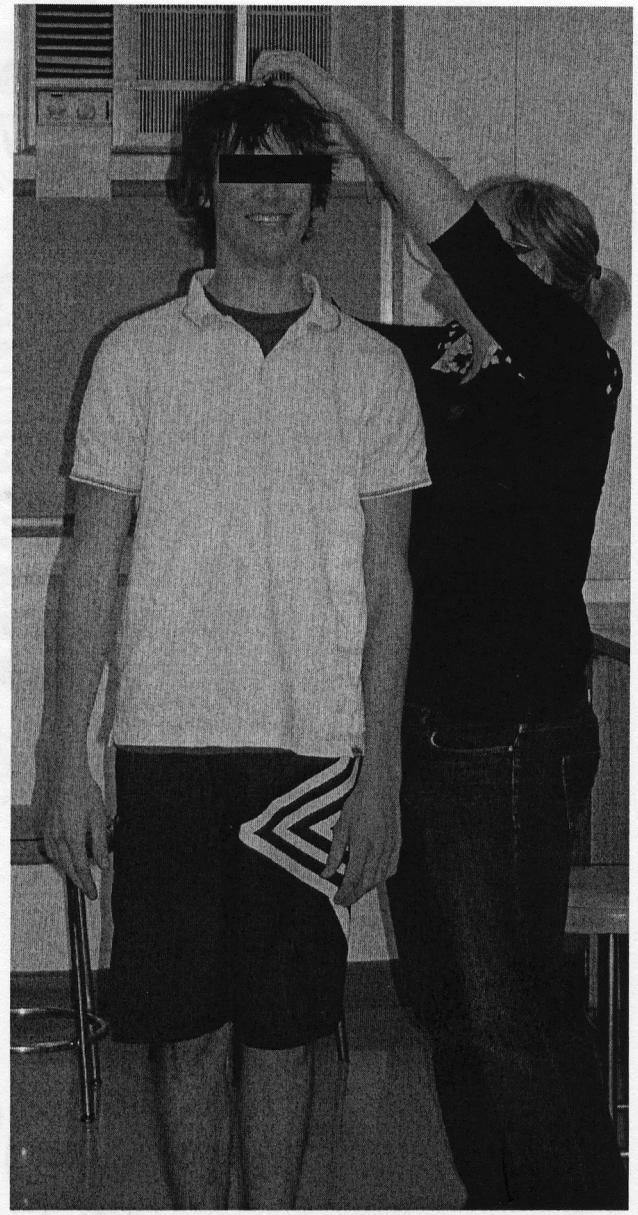


Figure 1. i) Anthropometric points used in measurement of body segment heights adapted from (Norton and Olds, 1996), (ii) measuring base-vertex using the GPM anthropometer.

Age +

30 anthropometric

variables

Basic statistical parameters of variables studied and their correlations with BMI when age and age &skinfolds are kept constant. Only significant (p<0.05) correlation coefficients shown.

Variable	N	Mean	stdev.	Skewness	Kurtosis	Correlation with age	r with BMI age const	r with BMI age &sknf constant
Age	1246	48.8	14.0		-0.33	X	X	X
Weight	1257	74.2	16.6	0.89	0.86	0.08	0.93	0.84
Stature	1263	1625.8	68.1	0.24	0.71	-0.19	-.06	-0.10
Sitting height	1262	860.9	36.1		0.50	-0.30		
Body mass index	1257	28.1	6.0	0.84	0.57	0.16	X	X
Upper limb length	1252	706.3	38.6	0.16	0.41		-.13	-0.11
Lower limb length	1252	837.0	50.3		0.66	-0.18	-.18	-0.17
Knee height	1257	454.5	38.2			-0.06	-0.13	-0.18
Head circumference	1257	551.6	16.2			-0.09	0.30	0.21
Knee circumference	1253	424.0	51.0	0.90	1.18	0.08	0.77	0.63
Ankle circumference	1256	229.5	21.8	0.61	0.58		0.63	0.46
Elbow circumference	1260	293.2	33.1	0.85	1.12	0.21	0.73	0.51
Arm circumference	1256	310.0	44.4	0.73	0.67	0.11	0.86	0.66
Lean arm circumf.	1239	230.1	28.5	0.67	0.72	0.10	0.65	0.64
Wrist circumference	1261	161.4	12.9	0.27	0.98	0.20	0.62	0.47
Chest circumference	1260	984.3	105.1	0.57		0.18	0.86	0.68
Underbust circumf.	1258	886.6	120.9	0.72		0.23	0.90	0.79
Waist circumference	1259	879.6	136.8	0.57		0.24	0.90	0.78
Hip circumference	1260	1100.2	123.8	0.57		0.13	0.91	0.80
Calf circumference	1256	377.3	40.5	0.74	0.93		0.80	0.71
Biacromial width	1252	373.4	21.3		0.17		0.41	0.33
Bi-iliocristal width	1240	304.8	33.9	0.77	0.95	0.18	0.63	0.47
Chest width	825	285.5	29.6	0.66	0.57	0.14	0.73	0.54
Chest depth	828	217.9	35.7	0.62	0.23	0.29	0.77	0.57
Triceps skinfold	1251	25.4	9.8	0.37	0.69	0.08	0.73	X
Subscapular skinfold	1228	25.3	12.0		-0.96	0.13	0.72	X
Abdominal skinfold	1204	27.7	9.8	-0.36	-0.76	0.23	0.67	X
Sum of 3 skinfolds	1182	77.6	24.8		-0.67	0.17	0.78	X
Foot circumference	1225	242.0	17.8	0.38	0.40		0.47	0.33
trunk frame	1239	2.6	0.3	0.74	0.97	0.06	0.56	0.41
Trunk frame index	1233	28.1	4.4	0.57	0.50	0.08	0.84	0.65

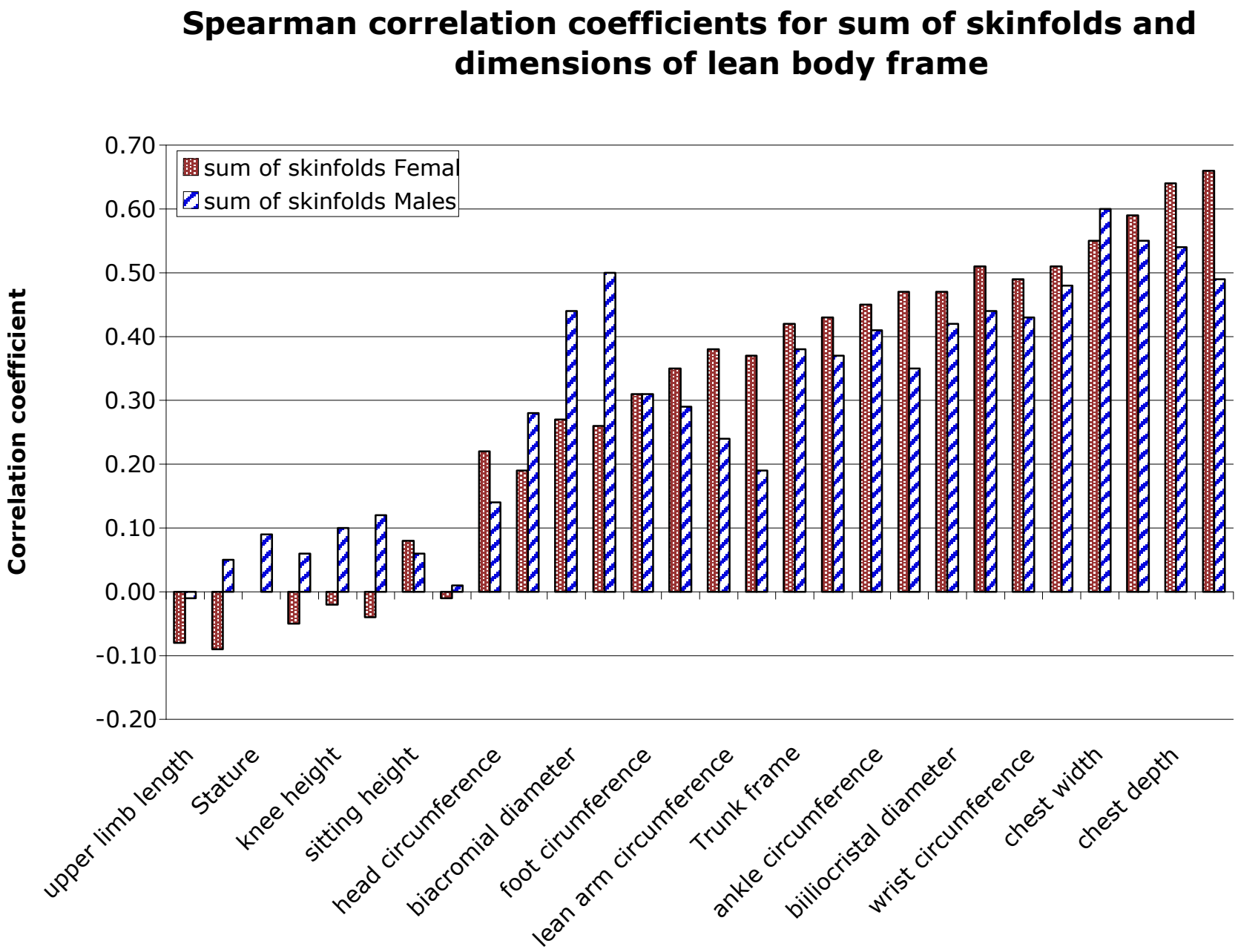
Females: Basic statistical parameters of variables studied and their correlations with BMI when age is kept constant. Only significant ($p<0.05$) correlation coefficients shown.

Variable	N	Mean	stdev.	Correlation with age	r with BMI age const
Weight	1257	74.2	16.6	0.08	**0.93**
Stature	1263	1625.8	68.1	-0.19	**-.06**
Body mass index	1257	28.1	6.0	0.16	**X**
Upper limb length	1252	706.3	38.6		**-.13**
Lower limb length	1252	837.0	50.3	-0.18	**-.18**
Head circumference	1257	551.6	16.2	-0.09	**0.30**
Ankle circumference	1256	229.5	21.8		**0.63**
Lean arm circumf.	1239	230.1	28.5	0.10	**0.65**
Wrist circumference	1261	161.4	12.9	0.20	**0.62**
Chest circumference	1260	984.3	105.1	0.18	**0.86**
Waist circumference	1259	879.6	136.8	0.24	**0.90**
Biacromial width	1252	373.4	21.3		**0.41**
Bi-iliocristal width	1240	304.8	33.9	0.18	**0.63**
Chest width	825	285.5	29.6	0.14	**0.73**
Chest depth	828	217.9	35.7	0.29	**0.77**
Triceps skinfold	1251	25.4	9.8	0.08	**0.73**
Subscapular skinfold	1228	25.3	12.0	0.13	**0.72**
Abdominal skinfold	1204	27.7	9.8	0.23	**0.67**

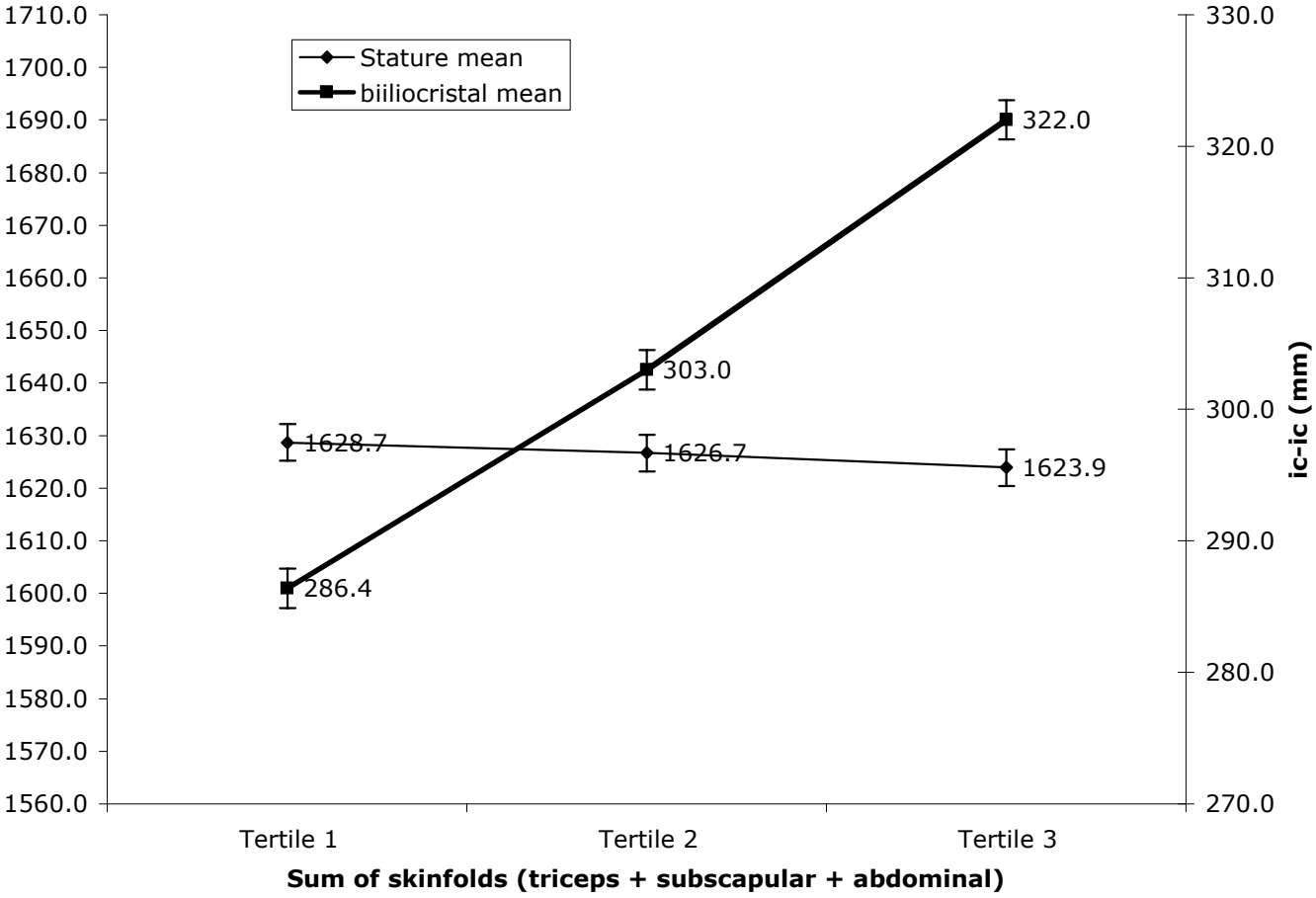
Surprising result

Coefficients of correlation between **lean body frame dimensions and skinfold thickness** when age is kept constant. Females (N=1250), Males (N=61). Significant ($p<0.05$) coefficients in boldface. Spearman's rho in italics. Underlined are coefficients in the cells where rho indicates >10% variance explained.

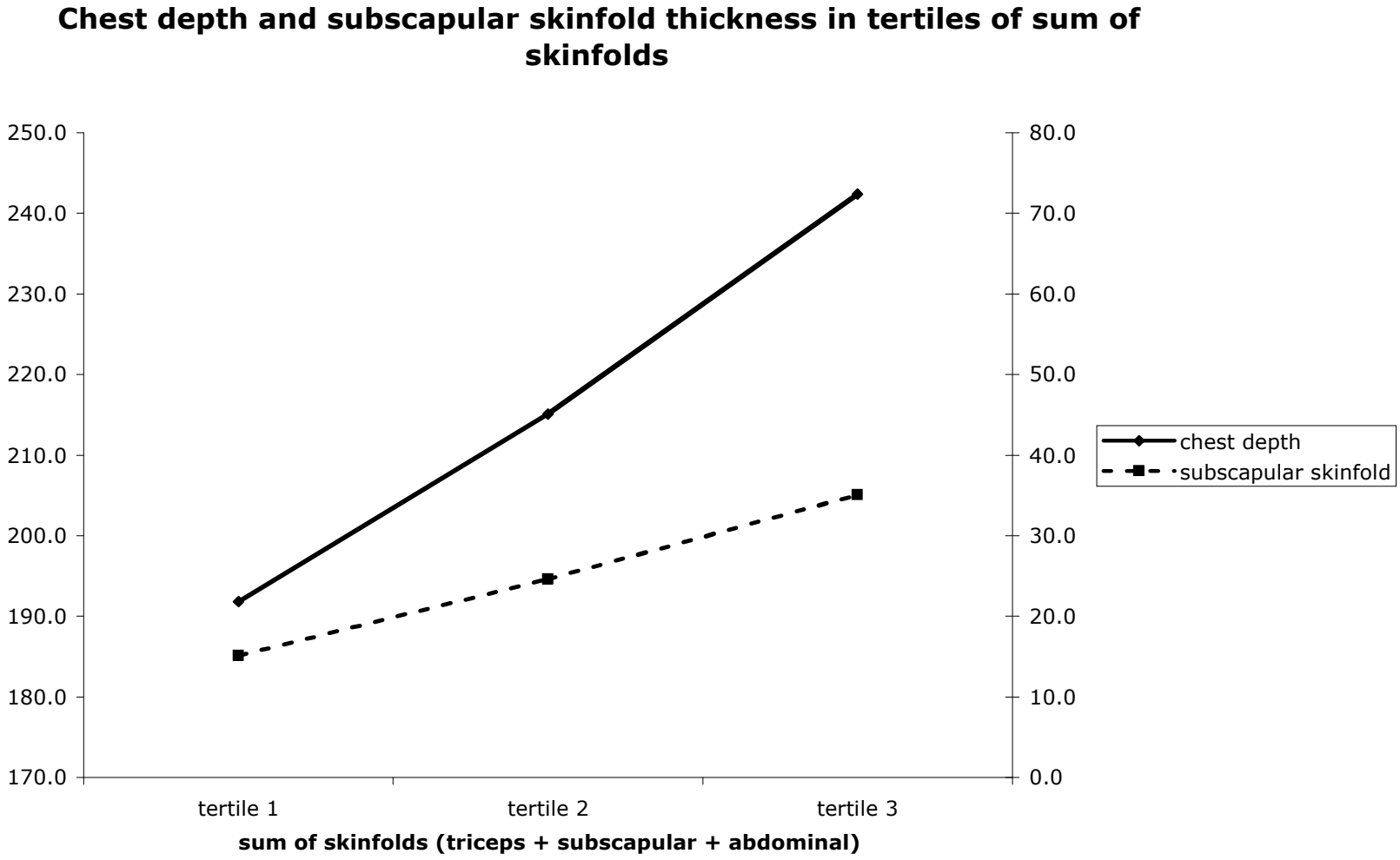
		Females					Males		
variable	triceps skinfold	subscapular skinfold	abdominal skinfold	sum of skinfolds		triceps skinfold	subscapular skinfold	abdominal skinfold	sum of skinfolds
Stature	0.04 *0.00*	-0.01 ***-0.06***	-0.03 ***-0.08***	0.00 *-0.05*		0.08 *0.12*	0.00 *-0.11*	0.15 *0.17*	0.09 *0.06*
ankle circumference	**0.40** ***0.49***	**0.34** ***0.42***	**0.34** ***0.36***	**0.45** **0.47**		**0.39** ***0.31***	**0.38** ***0.26***	**0.41** ***0.37***	**0.41** ***0.35***
wrist circumference	**0.38** ***0.45***	**0.38** ***0.47***	**0.40** ***0.44***	**0.49** ***0.51***		0.17 ***0.30***	**0.39** ***0.42***	**0.49** ***0.53***	**0.43** ***0.48***
biacromial diameter	**0.21** ***0.25***	**0.18** ***0.22***	**0.23** ***0.22***	**0.27** ***0.26***		**0.36** ***0.43***	**0.33** ***0.35***	**0.47** ***0.52***	**0.44** ***0.50***
biiliocristal diameter	**0.37** ***0.45***	**0.35** ***0.45***	**0.42** ***0.47***	**0.47** ***0.51***		**0.36** ***0.26***	**0.43** ***0.47***	**0.43** ***0.44***	**0.42** ***0.44***
chest width	**0.49** ***0.51***	**0.50** ***0.54***	**0.48** ***0.53***	**0.55** ***0.59***		**0.46** ***0.32***	**0.57** ***0.51***	**0.58** ***0.55***	**0.60** ***0.55***
chest depth	**0.55** ***0.55***	**0.60** ***0.63***	**0.55** ***0.60***	**0.64** ***0.66***		**0.36** ***0.28***	**0.56** ***0.51***	**0.51** ***0.50***	**0.54** ***0.49***


Spearman correlation coefficients for sum of skinfolds and dimensions of lean body frame
Correlation coefficient
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
sum of skinfolds Femal
sum of skinfolds Males
upper limb length
Stature
knee height
sitting height
head circumference
biacromial diameter
foot cirumference
lean arm circumference
Trunk frame
ankle circumference
biiliocristal diameter
wrist circumference
chest width
chest depth

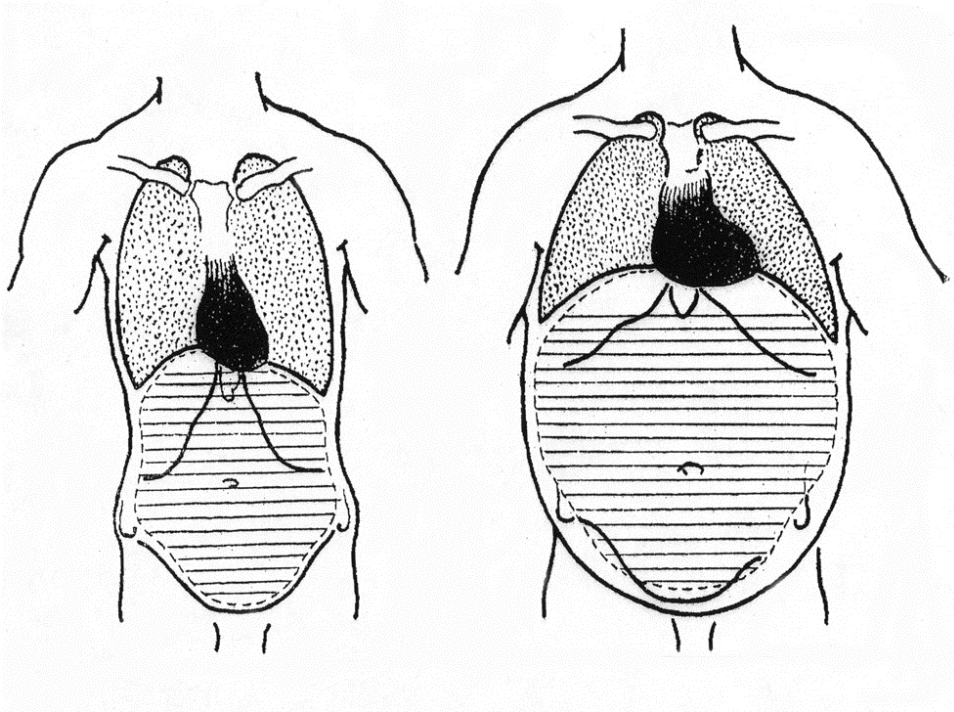
Stature and biilocristal breadth in tertiles of sum of skinfolds, Females

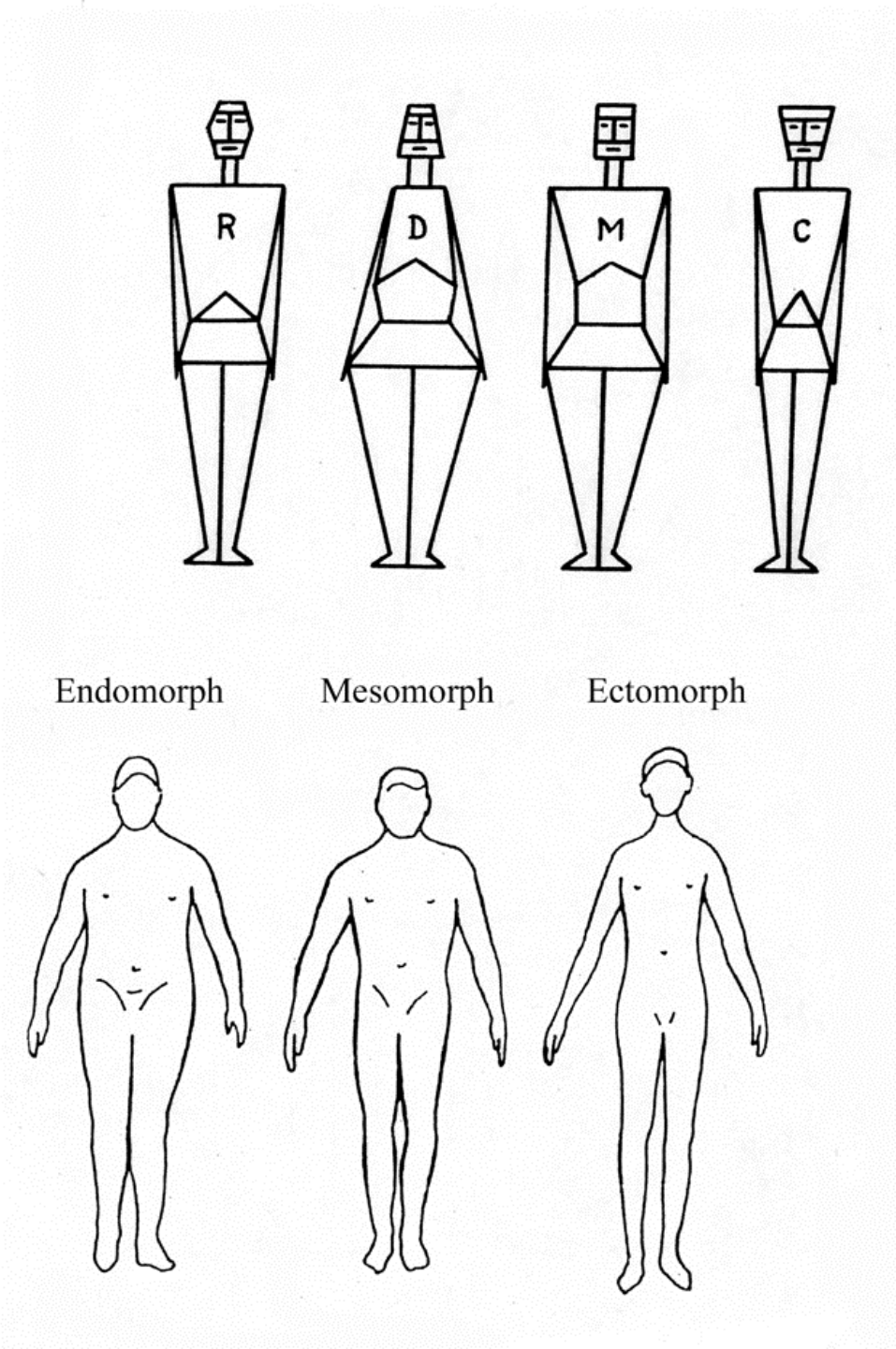


An artefact of measurement?



Body build:





Interpretation (a hypothesis)

- Bigger trunk - larger gastrointestinal tract
- Larger GIT - greater stomach volume
- Ghrelin secretion regulated by stomach extension (antral extension). Ghrelin regulates appetite
- Larger stomach - more food to extend
- Greater food absorption in intestine ???

We have overlooked the answer

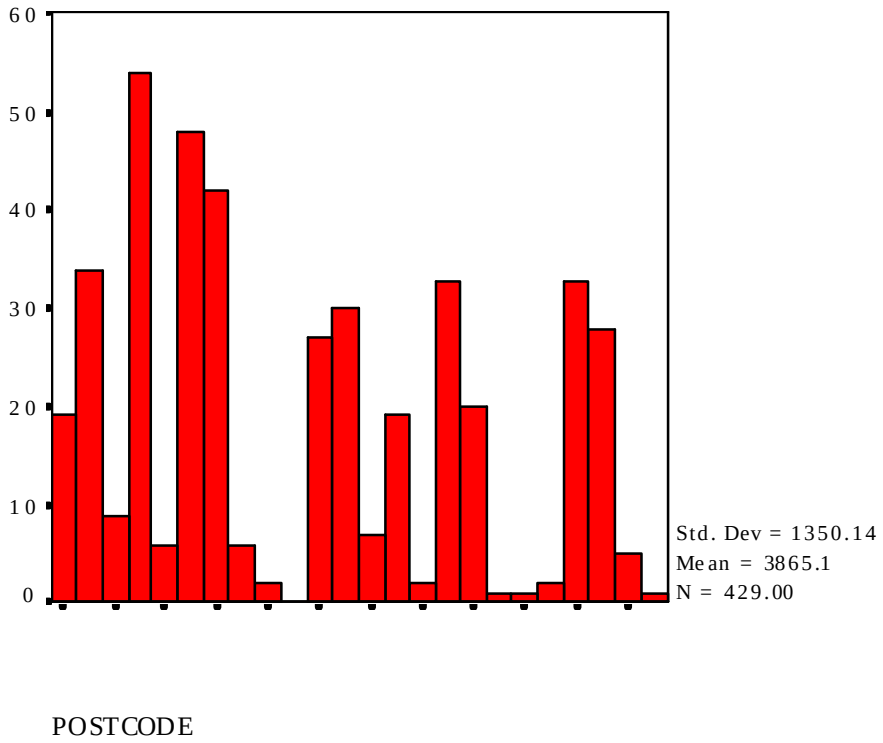
- In “Western” societies everybody is exposed to obesogenic environment
- Yet, some people are non-obese
- They are a walking experiment
- By studying biological, behavioural and socio-economic characteristics of non-obese we can find what to do to avoid obesity.

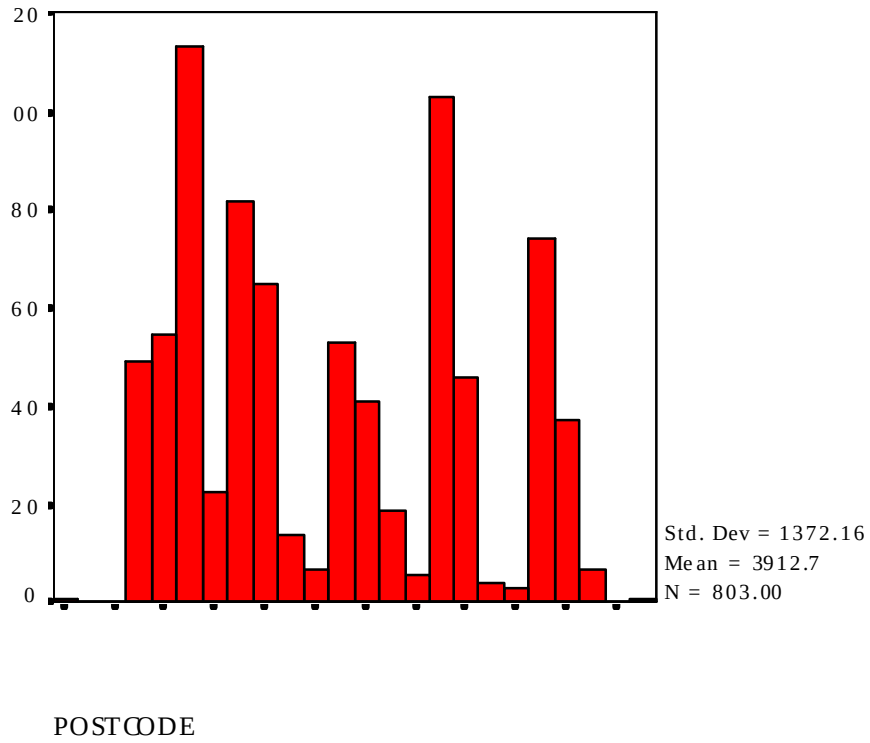
A follow-up: children

Coefficients of Correlation (*r*) between lean body frame dimensions and skinfold thickness for whole data sample (n≈229). Significant coefficients where p≤0.05 indicated by bold type and where p≤0.01 indicated by underlining.

Variable	*Triceps Skinfold*	*Subscapular skinfold*	*Abdominal Skinfold*	*Suprailiac Skinfold*	*Average Skinfold*	*Average Trunk Skinfold*
Body height	0.03	0.05	**0.15**	**0.15**	0.12	**0.14**
Trunk length	0.04	0.08	0.10	0.10	0.07	0.09
Wrist Circumference	**0.33**	**0.36**	**0.39**	**0.38**	**0.39**	**0.40**
Biepicondylar Width	**0.23**	**0.32**	**0.38**	**0.37**	**0.38**	**0.37**
Biacromial width	**0.22**	**0.26**	**0.26**	**0.28**	**0.30**	**0.27**
Chest width	**0.32**	**0.32**	**0.31**	**0.27**	**0.32**	**0.33**
Biiliocristal width	**0.42**	**0.45**	**0.45**	**0.47**	**0.48**	**0.47**
Chest depth	**0.40**	**0.47**	**0.46**	**0.46**	**0.48**	**0.48**
Frame size	**0.30**	**0.33**	**0.35**	**0.36**	**0.35**	**0.36**
Trunk size	**0.39**	**0.42**	**0.43**	**0.43**	**0.45**	**0.44**

BMI<25 POSTCODE BMI>=25





Names and BMI>=25 (Bold)

Marie
Marie
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Marie
Marie
Marilyn
Marina
Marion
Marisa
Marita
Marlene
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Susan
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Susie
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Rachel
Rachel
Rae
Rae
Raja Farida
Rebecca
Rebecca
Rebecca
Regina
Renata
Rhoda
Rhonda
Rhonda
Rita
Roberta

Annette
Annette
Annette
Annette
Annette
Annette
Annette
Annette

Amy
Amy
Amy
Ana
Andrea
Angela
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Angela

Australian Women (N=1250)