

Body Composition and Stature in Middle Aged Women in Quetzaltenango, Guatemala



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Purpose



Stunting and obesity is highly prevalent in the Guatemalan population and presents many health issues. This study aims to quantify certain anthropometric measures in an effort to better understand the effect that the Double Burden of Malnutrition has on health indicators like BMI, WC, WHtR, and Torso/Leg Ratios in Women between the ages of 35-59.

Background Info



- ☞ **Location:** Quetzaltenango
- ☞ **Company:** Center for Studies of Sensory Impairment, Aging and Metabolism (CESSIAM)
- ☞ **People Involved:** Dr. Noel Solomons, Rosario Garcia, Marta Escobar, Alejandra Maldonado, Claudia Arriaga
- ☞ IRB approved by local municipality
 - ☞ Consent Form approved
- ☞ Subjects are kept confidential
 - ☞ Subject ID

Map of Quetzaltenango



Definitions



- ☞ **BMI < 17.0** indicates moderate and severe thinness [Nutrition Landscape Information System 2010]
 - ☞ Ill health, poor physical performance, lethargy and even death
- ☞ **BMI < 18.5** indicates underweight
- ☞ **BMI 18.5–24.9** indicates normal weight
- ☞ **BMI ≥ 25.0** indicates overweight
 - ☞ Non-insulin-dependent diabetes mellitus, coronary heart disease, stroke, several types of cancer, gallbladder disease, musculoskeletal disorders and respiratory symptoms
- ☞ **BMI ≥ 30.0** indicates obesity
 - ☞ Premature death and diminished quality of life (in addition to above)

Cut-off values for public health significance

Indicator	Prevalence cut-off values for public health significance
Adult BMI < 18.5 (underweight)	5-9%: Low prevalence (warning sign, monitoring required) 10-19%: Medium prevalence (poor situation) 20-39%: High prevalence (serious situation) ≥ 40%: Very high prevalence (critical situation)

Reference: WHO, 1995.

Definitions



☞ *How is stunting*

defined?

[World Health Organization: Nutrition Landscape Information System c2016, Alive & Thrive 2010, World Health Organization: Nutrition Landscape Information System c2016]

☞ Stunting: height for age < -2 SD of the WHO Child Growth Standards median

☞ Women: **<145 cm**



Literature Review and Background



Prevalence of Obesity



- ☞ Until 2009, ~67% of Guatemalans aged 15 and above were overweight, of which 29% were obese [The World Bank 2015]
- ☞ In Guatemala, **increase in the prevalence of obesity** in Women of Reproductive Age (WRA) between 1998 and 2008 [Ramirez-Zea et. al. 2014]
- ☞ Nonindigenous WRA prevalence of obesity > indigenous WRA
 - ☞ Adoption of a sedentary lifestyle and more fast-food

TABLE 2. Basic indicators of chronic diseases and risk factors, by gender, Guatemala, 2007.

[Pan American Health Organization 2012]

Indicator	Total	Men	Women
Prevalence (%) of overweight (BMI=25.0–29.9) in adults	38.5	38.8	38.2
Prevalence (%) of obesity (BMI>30) in adults	21.3	16.0	25.8

Prevalence of Stunting



- ☞ Highest prevalence of stunting (49.8 percent) in the Americas [Guatemala (n.d.)]
- ☞ 6th highest stunting among children <5 in the world
- ☞ Mayan communities in the highlands have 70% stunting of children <5
- ☞ (1998-2008) **Reduction in stunting** in both indigenous (0.8%) and nonindigenous (0.6%) children [Ramirez-Zea et. al. 2014]
- ☞ The proportion of indigenous WRA with short stature was >2.5 times that for nonindigenous WRA



Causes of Stunting



- ☞ Inversely related to maternal education levels and wealth [Guatemala (n.d.)]
- ☞ Causes of **under-nutrition**: poverty, food insecurity, inadequate hygienic environments, inequality and exclusion, lack of sufficient child care
- ☞ Causes of **stunting**: [Welse c2014]
 - ☞ Sub-optimal breastfeeding, infectious diseases, subclinical infections, poverty, neglect
- ☞ Stunting during childhood = linear growth retardation → stunting during adulthood
 - ☞ Women stunted in childhood tend to have stunted children
 - ☞ Cycle of poverty and decreased health

Consequences of Stunting



- ☞ Maternal stunting increases the risk of negative fetal, newborn, and child outcomes [Alive & Thrive 2010]
 - ☞ Risks to the survival, health, and development of her offspring
- ☞ Stunting can have long-term effects on **cognitive development, school achievement, economic productivity in adulthood and maternal reproductive outcomes** [Dewey & Begum 2011]
- ☞ For women, stunting in early life was associated with a lower age at first birth and a higher number of pregnancies and children [Hoddinott et al. 2008]

Consequences of Stunting



- ☞ Stunting is related to a **nutrient-poor diet**, **a high incidence and recurrence of infectious diseases during childhood**, **inadequate wastewater disposal** (25% coverage in 2006) and **overcrowded conditions** [Ramirez-Zea et. al. 2014]
- ☞ **Effects:** [Alive & Thrive 2010; Dewey & Begum 2011]
 - ☞ Intrauterine Growth Restriction
 - ☞ Obstructed labor
 - ☞ Maternal and Adult Health
 - ☞ Educational and Economic Performance
 - ☞ Schooling and Cognitive Development
 - ☞ Economic Productivity and Income

Double Burden of Malnutrition



- ☞ Coexistence of under- and over- nutrition [Ramirez-Zea et. al. 2014]
- ☞ DBM is **more prevalent in indigenous** than in nonindigenous populations at the household and individual levels
- ☞ Guatemalan households had the highest prevalence of DBM in the world, with a prevalence of 16–18% stunted child-overweight mother (SCOM) pairs

Significance of DBM



- ☞ Hypertension, hyper- glycaemia, low HDL cholesterol prevalence metabolic syndrome present with DBM can widen the socio-economic and gender health gap [Zeba et. al. 2012]
- ☞ Obesity/overweight was found to be more prevalent in women than in men
- ☞ Offspring of obese women or women with diabetes are at greater risk for developing metabolic disorders themselves, even during childhood [Gluckman et. al. 2008]

BMI as a Health Indicator



- ☞ Body mass index (BMI = kg/m^2) is standard and valid measure for monitoring fatness [Schroeder & Martorell 1999]
- ☞ In Guatemalans, fatness is highly centralized
- ☞ In stunted populations in developing countries, BMI alone should be interpreted with caution
- ☞ Measures in addition to BMI are needed for a more complete assessment



BMI as Health Indicator



- ❧ Considerations [Center for Disease Control]:
 - ❧ Older people and women tend to have more body fat for a similar BMI
 - ❧ No differentiation between muscle weight and fat weight (ex. Athletes)
 - ❧ Decrease in height with advancing age [Karadag et al. 2012], greater in women starting from 30 years of age [Sorkin, Muller & Andres 1999]

Alternative Height Measures



- ☞ Long-bones do not change because there is minimal compression throughout life [Karadag et al. 2012]
- ☞ Armspan instead of height to calculate BMI [Rabe et al. 1996] – Body Mass Armspan (BMA)
 - ☞ Consistent in adulthood, no deterioration with age – ‘maximal height’
- ☞ Knee-Height (KH) to calculate BMI (BM-KH)[Chumlea, Guo & Steinbaugh 1994; Cerada, Bertoli & Battezzati 2010]

White women: Height = 70.25 + (1.87 x knee height) – (0.06 x age)

Black women: Height = 68.1 + (1.86 x knee height) – (0.06 x age)

White men: Height = 71.85 + (1.88 x knee height)

Black men: Height = 73.42 + (1.79 x knee height)

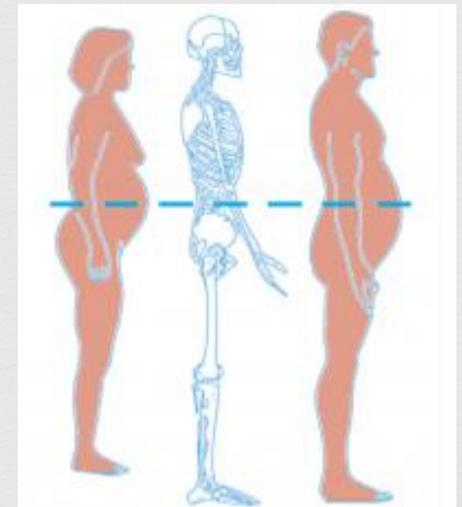
Height = 60.76 + (2.16 knee height) – (0.06 x age) + (2.76 x sex**)

- ☞ Seems to be more specific to the population – ‘current height’ [Hickson et al. 2003]

Waist Circumference Alternative to BMI



- ☞ Large waist circumference is a measure of fatness and central fat distribution [Han et al. 1996]
 - ☞ Potentially more important than BMI in assessing cardiometabolic risk
- ☞ Indicative of hypercholesterolemia ($>6.5\text{mm/L}$), low HDL ($<0.9\text{mm/L}$), hypertension (>95 diastolic or medication)
- ☞ Identified:
 - ☞ Action Level 1: $>80\text{ cm}$
 - ☞ Most predictive when correlated with $>25\text{ BMI}$
 - ☞ Should be aware of risks
 - ☞ Alert Zone
 - ☞ Don't gain more weight, start exercising
 - ☞ Action Level 2: $>88\text{ cm}$
 - ☞ Correlates best with $>30\text{ BMI}$



Waist Circumference Alternative to BMI



- ✎ In older subject, high BMI did not necessarily correlate with more cardiometabolic risk
 - ✎ Suggested that Action Level 1 cutoff for younger women be $>76\text{cm}$
- ✎ Data should be applied to white populations only and further research needs to be done in other ethnic groups
- ✎ Based on specificity and sensitivity, WC is good at identifying people at risk without incorrectly identifying too many people [Molarius et al. 1999]

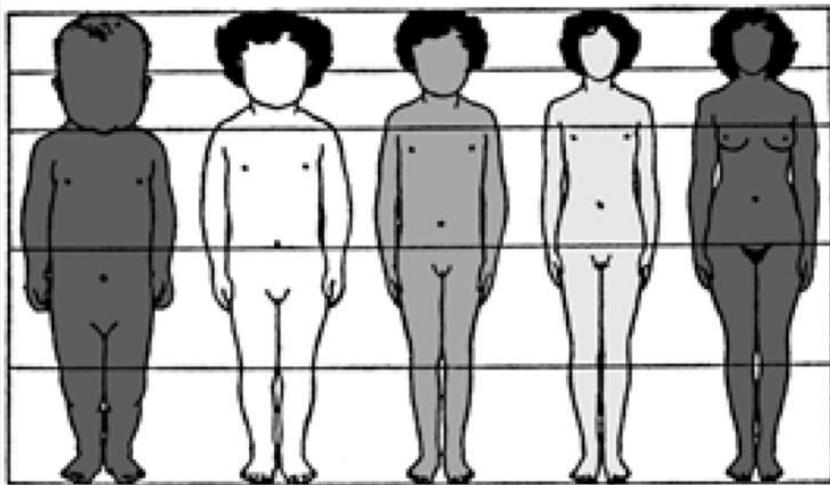


Waist-To-Height Ratio (WHtR)



- ☞ Waist/Height Ratio (WHtR) seemed to be a better predictor of cardiometabolic risk factors [Karadag et al. 2012]
- ☞ Estimated WHtR (EWHtR) from KH emerged to be a better cardiometabolic risk index (esp. in the elderly group)
- ☞ WHtR significantly better indicator than BMI or WC alone [Ashwell, Gunn & Gibson 2012]
- ☞ Discrimination of hypertension, DMII, dyslipaemia, metabolic syndrome, cardiovascular outcomes
- ☞ First-cut off level proposed at >0.5

Body Proportions and Health



- ❧ Leg-Length as an indicator of childhood environment [Bogin & Varela-Silva 2010]
 - ❧ Defined as Iliac Height (IH)
- ❧ Between birth and puberty, legs grow the fastest (cephalocaudal development)
- ❧ High leg/torso ratio or leg/total height ratio is indicative of favorable growth
 - ❧ Low ratios correspond with higher risk of CAD, liver disease, cancers
- ❧ Role of both environment and genes
 - ❧ Short-stature homeobox containing gene (SHOX) – Turner's
 - ❧ Environment is the bigger influence

Body Proportions and Health

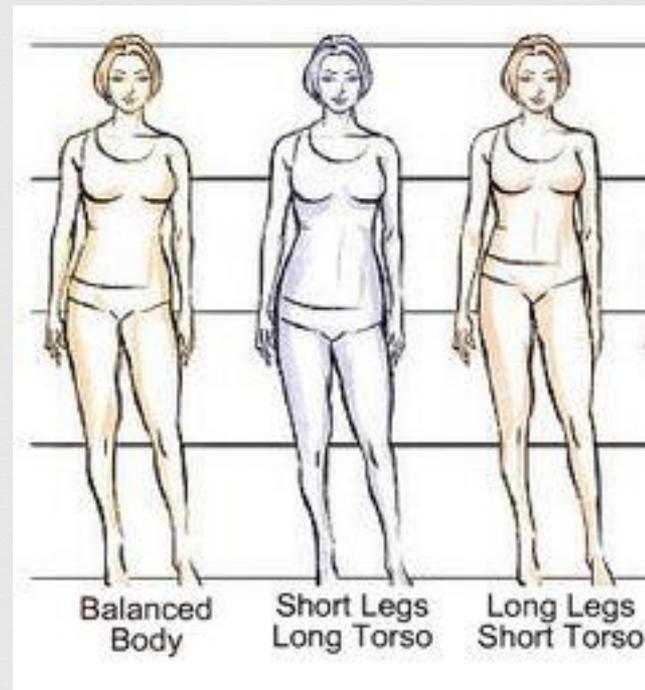


- ☞ -50% of overall stature to achieve optimal bipedal capacity (in humans, occurs at 7 years old)
 - ☞ Typically measures are taken using sitting height to represent the torso [Fredriks et al. 2005]
- ☞ Colder climates – shorter limbs to conserve heat [Bogin & Varela-Silva 2010]
 - ☞ Higher latitude corresponds to higher body mass
- ☞ Food intake during development in Guatemalan Mayans is lower (80% of necessary w/ 20.4% having iodine deficiency)
 - ☞ Iodine deficiency associated with reduced leg-length
- ☞ In women, earlier onset of menarche causes earlier stop in growth

Photography as a Alternate Method



- Body posture photographs can be used as a measurement tool and have been shown to be accurate [Van Maanen et al. 1996]
- Very few flaws in inter-rater reliability
- Potential source of torso:leg ratios



Objectives



Objectives



In Women between the ages of 35-59 in Quetzaltenango, Guatemala:

1. How valid are the alternative measures of BMI (Knee Height and Armspan)?
2. What are the differences in anthropometric measurements between stunted/non-stunted individuals and
3. Are there differences in individuals sampled from different areas?
4. How do the action levels for WC and WC/Height correlate?
5. How do the measurements between elderly and middle-aged population compare?

Methods



Informed Consent and Preparation



- ☞ Marta gave an introductory seminar explaining the research project
- ☞ Eligible participants were consented:
 - ☞ Women
 - ☞ Ages 35-59
 - ☞ Living in Quetzaltenango (poor regions targeted)
- ☞ Exclude: pregnant, physically unable to participate, mentally unable to consent
- ☞ Participants asked to:
 - ☞ Remove shoes, roll up pants/lift skirt to view feet, remove jackets and keys/wallet, remove belt



130-D



Knee-Height



- ❧ Participants were instructed to sit in a chair
- ❧ Measured using the right leg w/ the thigh and leg @ 90 degrees
 - ❧ Participant was asked to lift their leg to achieve this
- ❧ Knee Anthropometric Caliper (MediForm) was used
- ❧ Measured to the nearest cm



Total Standing Height



- Scale was placed against the wall and a level was used to ensure it was straight
- Participants were instructed to keep their feet together and against the wall, and look in forward in Frankfort Plane
- Carpenter's Square was used to measure at the top of the head
- Measured to the nearest cm

Weight



- ☞ Participants instructed to stand on the scale (Rosthal)
- ☞ Instructed to look forward in Frankfort Plane
- ☞ Weight adjusted for W, P, E (Western, Heavy Skirt, Light Skirt)
- ☞ Measured to the nearest 0.1 kg



Armspan



- ❧ Participants were instructed to stand up on a box and extend their arms w/ their palms facing forward
- ❧ Marta assisted in aligning the armspan ruler with their left hand
- ❧ Measures were taken from their extended right hand to the nearest cm

Photograph



- ❧ Participants were instructed to stand on a box
 - ❧ Stood with their right side facing the camera with their right arm crossed over their chest
 - ❧ Feet were together and horizontal w/ the plane of the box
- ❧ Subject ID # was marked in the scope of the photo
- ❧ Top of the Iliac Crest (after palpating) was marked with tape
- ❧ Photographs were printed out and torso/leg ratios were calculated to the nearest mm



Waist Circumference



- ❧ For privacy, a screen was used
- ❧ Lowest rib and Iliac crest were palpated and the halfway point was identified
- ❧ WC was measured at this level using soft tape
- ❧ Measured to the nearest cm

Data Analysis



Summary of Data: Mean/SD



		Knee-Height (cm)	BMI-KH	Adjusted Weight (kg)	BMI-H	Armspan (cm)	Height (cm)
Total	Mean	44.46	30.305641	66.295	30.100	150.56	148.31
	N	80	80	80	80	80	80
	Std. Deviation	2.444	4.8848562	11.7064	4.9232	6.141	5.884

		BMI-A	Armspan/Height	Waist Circum. (cm)	WC/Total Height
Total	Mean	29.260	1.01543	93.44	.63027
	N	80	80	80	80
	Std. Deviation	5.0851	.023874	10.814	.072656

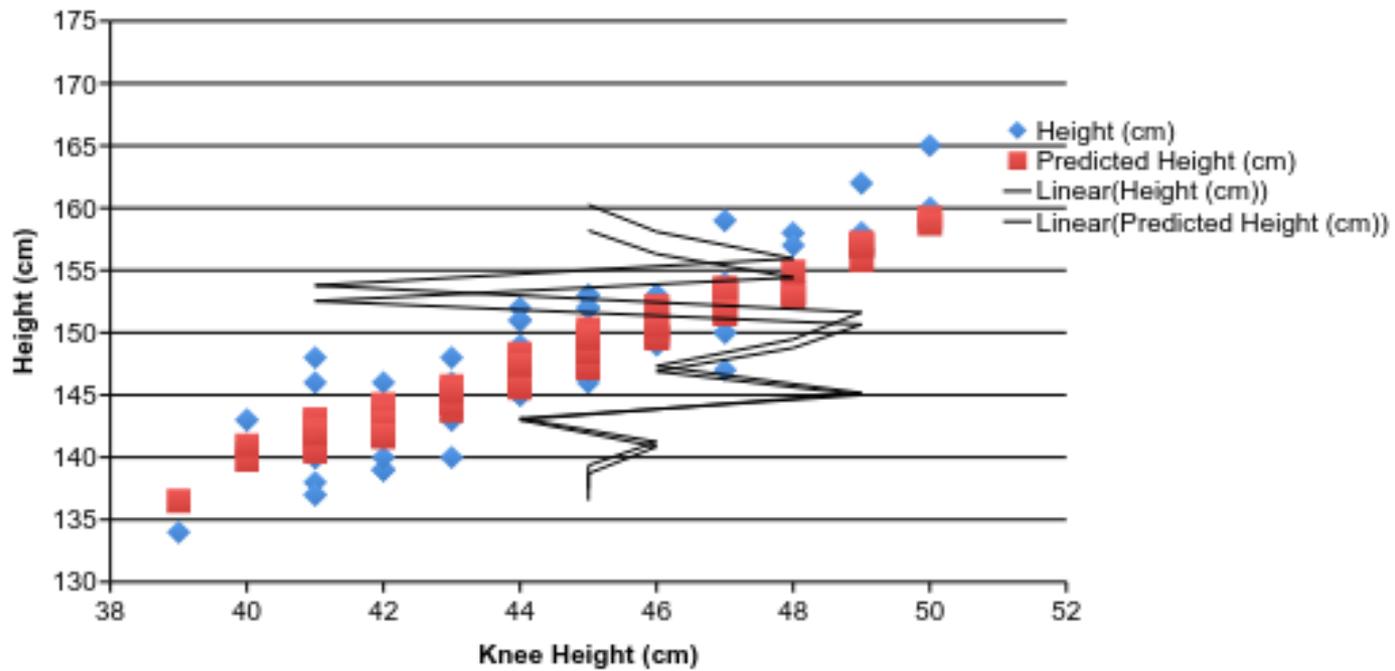
		Total Height (mm)	Torso Height (mm)	Leg Height (mm)	Torso:Total Ratio	Torso:Leg Ratio
Total	Mean	203.07	82.50	120.57	.50847	.68553
	N	72	72	72	72	72
	Std. Deviation	13.141	7.525	8.091	.096490	.060892

Differing Height Values

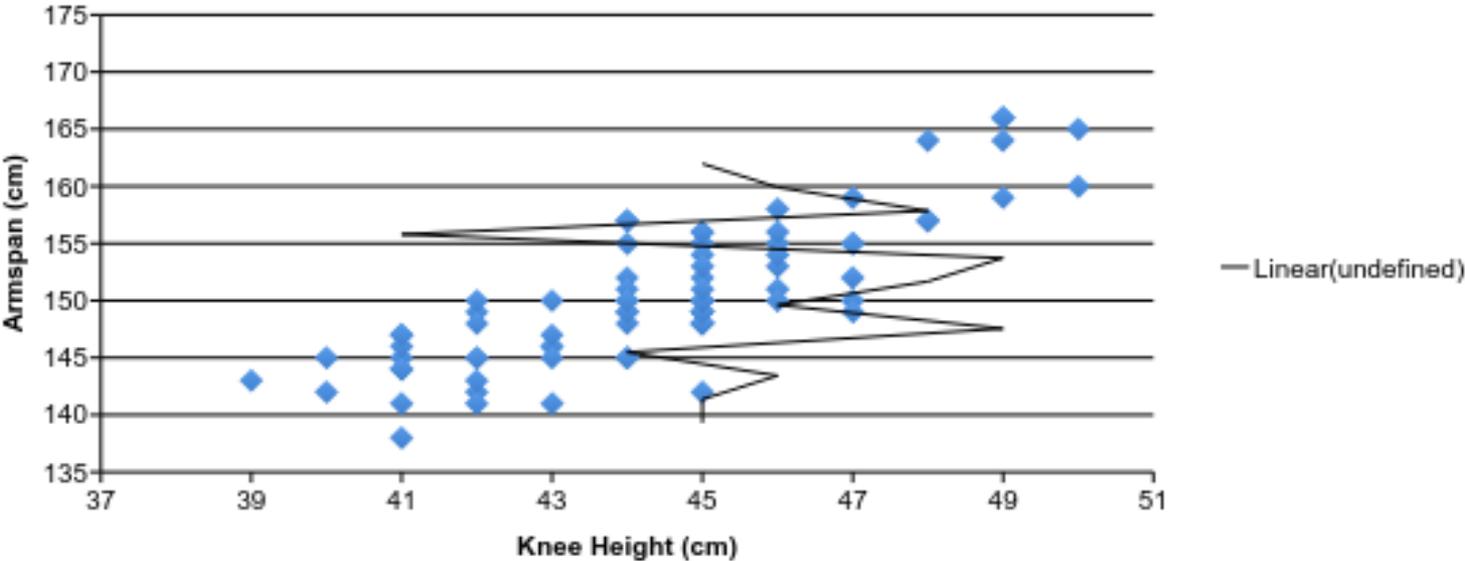


		KH-Adjusted Total Height (cm)	Height (cm)	Armspan (cm)
Total	Mean	147.76	148.31	150.56
	N	8	80	80
	Std. Deviation	4.70	5.884	6.141
		AS - KH (cm)	AS - Ht (cm)	KH - Ht (cm)
Total	Mean	2.81	2.25	-0.56
	N	8	8	8
	Std. Deviation	3.49	3.55	2.69

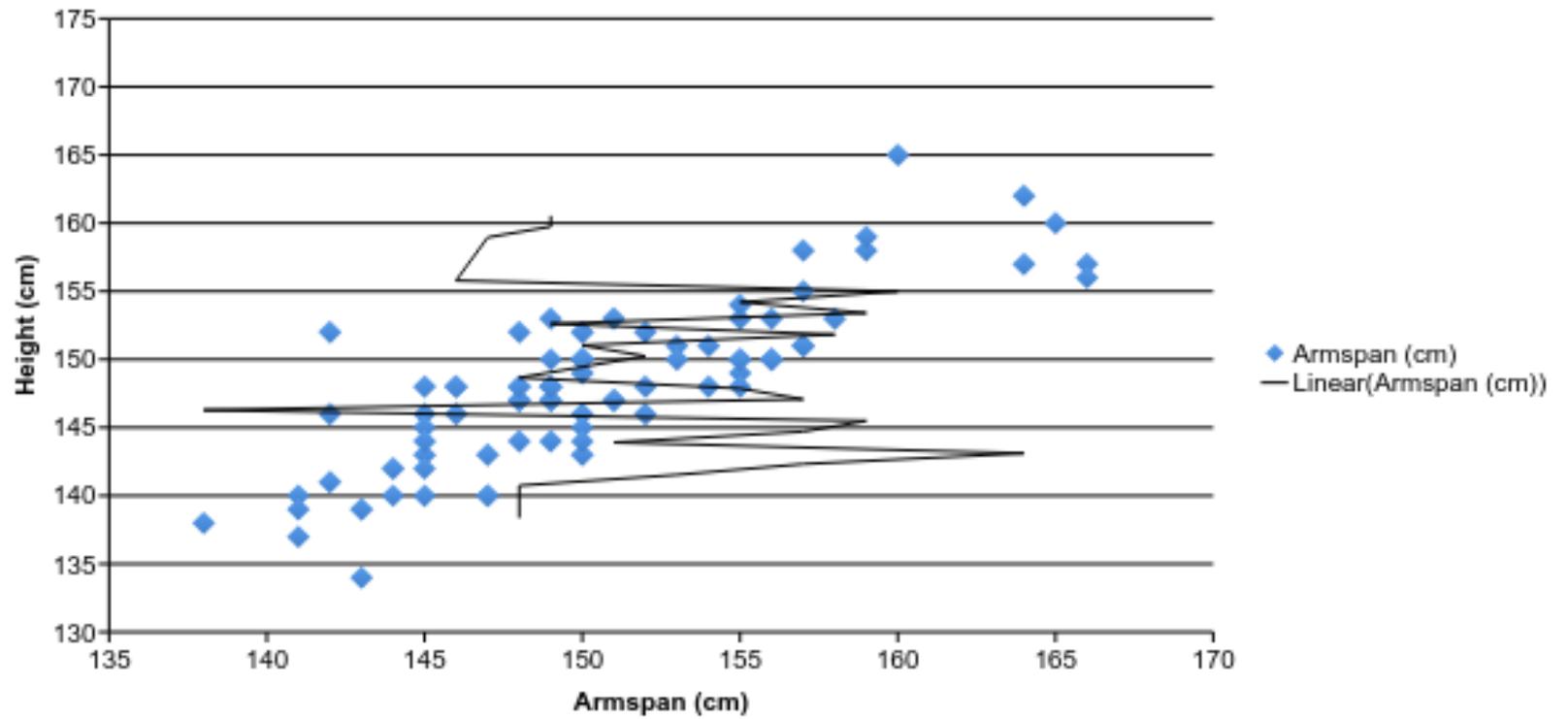
Height (cm) v. Knee Height (cm)



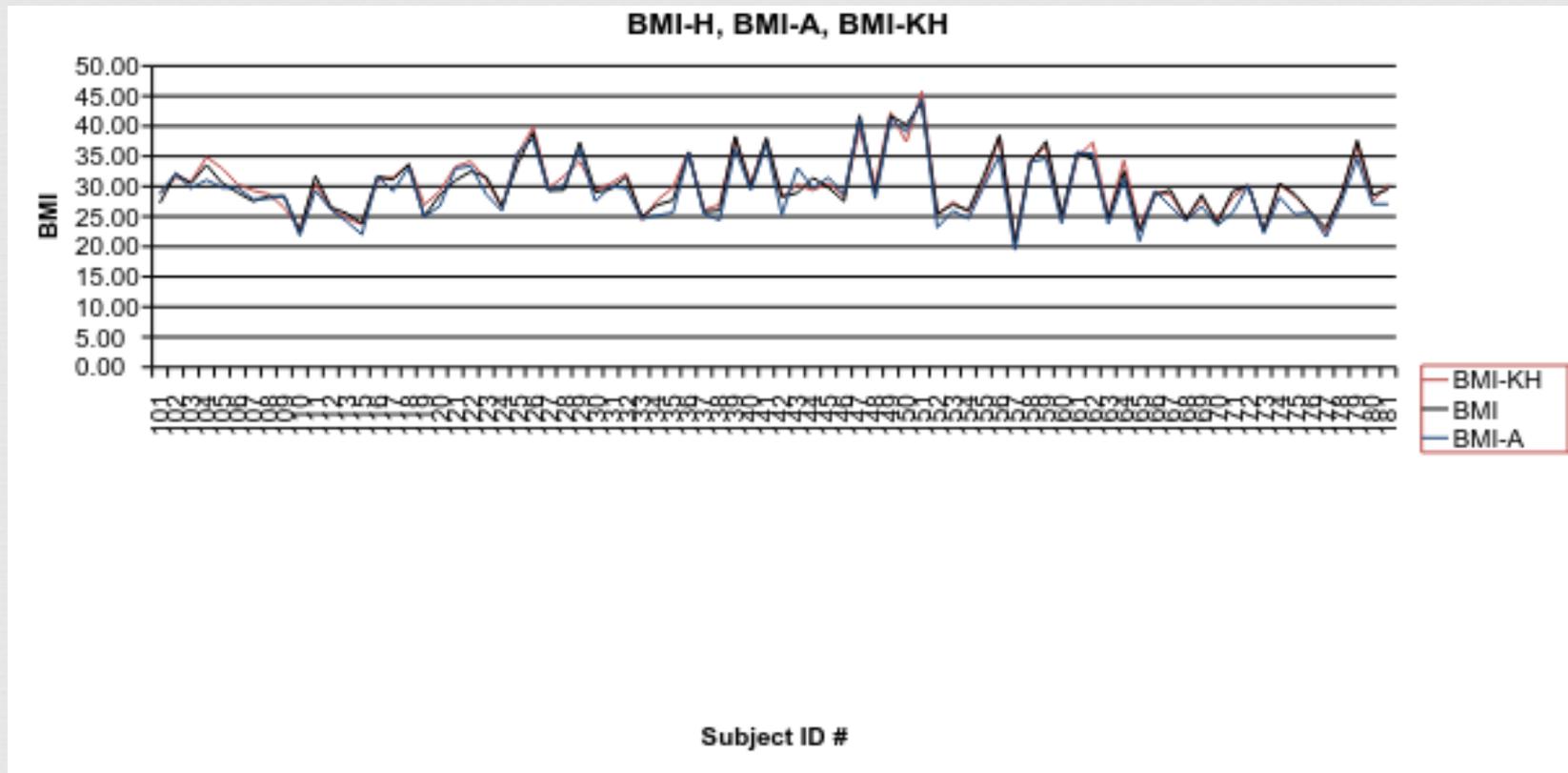
Armspan (cm) v. Knee Height (cm)



Height (cm) v. Armspan (cm)



Distribution of BMIs



Correlations

			BMI-KH	BMI-A	BMI-H
Spearman's rho	BMI-KH	Correlation Coefficient	1.000	.954 ^{**}	.969 ^{**}
		Sig. (2-tailed)	.	.000	.000
		N	80	80	80
	BMI-A	Correlation Coefficient	.954 ^{**}	1.000	.944 ^{**}
		Sig. (2-tailed)	.000	.	.000
		N	80	80	80
	BMI-H	Correlation Coefficient	.969 ^{**}	.944 ^{**}	1.000
		Sig. (2-tailed)	.000	.000	.
		N	80	80	80

Comparison of Means



Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between BMI-H and BMI-KH equals 0.	Related-Samples Wilcoxon Signed Rank Test	.083	Retain the null hypothesis.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between BMI-H and BMI-A equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	BMI-KH - BMI-A	6.780	79	.000

Sensitivity and Specificity



BMI-Height

BMI-KH

	Normal/Underweight	Overweight/Obese
Normal/Underweight	10	2
Overweight/Obese	0	68

Sensitivity: 100% Specificity: 97.1%

BMI-Height

BMI-A

	Normal/Underweight	Overweight/Obese
Normal/Underweight	10	5
Overweight/Obese	0	65

Sensitivity: 100% Specificity: 92.9%

Stunted v. Non-stunted



Height (cm)	KH-Adjusted (cm)	Armspan (cm)
Stunted = 22	Stunted = 22	Stunted = 18
Non-Stunted = 58	Non-Stunted = 58	Non-Stunted = 62
27.5% stunted	27.5% stunted	22.5% stunted

Stunted v. Non-Stunted



		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Adjusted Weight (kg)	Equal variances assumed	.000	-9.9241	2.7275
	Equal variances not assumed	.001	-9.9241	2.8746
Knee-Height (cm)	Equal variances assumed	.000	-3.710	.450
	Equal variances not assumed	.000	-3.710	.373
Armspan/Height	Equal variances assumed	.008	.015715	.005747
	Equal variances not assumed	.003	.015715	.005004
BMI-KH	Equal variances assumed	.158	-1.7333872	1.2151946
	Equal variances not assumed	.201	-1.7333872	1.3287345
BMI-A	Equal variances assumed	.251	-1.4683	1.2706
	Equal variances not assumed	.309	-1.4683	1.4188
Waist Circum. (cm)	Equal variances assumed	.061	-5.055	2.664
	Equal variances not assumed	.113	-5.055	3.098

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of BMI-H is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.398	Retain the null hypothesis.
2	The distribution of Armspan (cm) is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
3	The distribution of WC/Total Height is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.783	Retain the null hypothesis.

	Stunted (1/0)	N	Mean	Std. Deviation	Std. Error Mean
Adjusted Weight (kg)	1	22	59.100	11.8210	2.5203
	0	58	69.024	10.5304	1.3827
Knee-Height (cm)	1	22	41.77	1.270	.271
	0	58	45.48	1.958	.257
Armspan (cm)	1	22	145.00	3.295	.703
	0	58	152.67	5.639	.740
Armspan/Height	1	22	1.02682	.017962	.003830
	0	58	1.01110	.024535	.003222
BMI-KH	1	22	29.048935	5.5623751	1.1859024
	0	58	30.782322	4.5642001	.5993088
BMI-H	1	22	29.659	5.9426	1.2670
	0	58	30.267	4.5253	.5942
BMI-A	1	22	28.195	5.9952	1.2782
	0	58	29.664	4.6897	.6158
WC/Total Height	1	22	.63609	.096526	.020579
	0	58	.62807	.062175	.008164
Waist Circum. (cm)	1	22	89.77	13.309	2.838
	0	58	94.83	9.469	1.243

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Total Height (mm) is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.001	Reject the null hypothesis.
2	The distribution of Torso Height (mm) is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.004	Reject the null hypothesis.
3	The distribution of Leg Height (mm) is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
4	The distribution of Torso:Total Ratio is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.013	Reject the null hypothesis.
5	The distribution of Torso:Leg Ratio is the same across categories of Stunted (1/0).	Independent-Samples Mann-Whitney U Test	.766	Retain the null hypothesis.

Stunted (1/0)		Total Height (mm)	Torso Height (mm)	Leg Height (mm)	Torso:Total Ratio	Torso:Leg Ratio
0	Mean	207.10	84.10	123.00	.48461	.68516
	N	51	51	51	51	51
	Std. Deviation	10.854	7.311	6.809	.096507	.065718
1	Mean	193.29	78.62	114.67	.56643	.68643
	N	21	21	21	21	21
	Std. Deviation	13.290	6.712	8.052	.069199	.048624
Total	Mean	203.07	82.50	120.57	.50847	.68553
	N	72	72	72	72	72
	Std. Deviation	13.141	7.525	8.091	.096490	.060892

Locations



Letter	Location
A	Colonia La Democracia Zona 8
B	Colonio San Antonio Zona 7
C	Colonia Diaz Zona 3
D	Colonia Minerva Zona 3
E	Centro de Salud de Quetzaltenango
F	Cantón Choquí Bajo Zona 2
G	Centro de Salud

Difference Between Locations



	Null Hypothesis	Test	Sig.	Decision
1	The medians of BMI-H are the same across categories of Location.	Independent-Samples Median Test	.398	Retain the null hypothesis.
2	The medians of Armspan (cm) are the same across categories of Location.	Independent-Samples Median Test	.107	Retain the null hypothesis.
3	The medians of WC/Total Height are the same across categories of Location.	Independent-Samples Median Test	.710	Retain the null hypothesis.
4	The medians of Total Height (mm) are the same across categories of Location.	Independent-Samples Median Test	.000	Reject the null hypothesis.
5	The medians of Torso Height (mm) are the same across categories of Location.	Independent-Samples Median Test	.000	Reject the null hypothesis.
6	The medians of Leg Height (mm) are the same across categories of Location.	Independent-Samples Median Test	.001	Reject the null hypothesis.
7	The medians of Torso:Total Ratio are the same across categories of Location.	Independent-Samples Median Test	.000	Reject the null hypothesis.
8	The medians of Torso:Leg Ratio are the same across categories of Location.	Independent-Samples Median Test	.228	Retain the null hypothesis.
9	The medians of Knee-Height (cm) are the same across categories of Location.	Independent-Samples Median Test	.016	Reject the null hypothesis.

10	The medians of BMI-KH are the same across categories of Location.	Independent-Samples Median Test	.692	Retain the null hypothesis.
11	The medians of Adjusted Weight (kg) are the same across categories of Location.	Independent-Samples Median Test	.565	Retain the null hypothesis.
12	The medians of Height (cm) are the same across categories of Location.	Independent-Samples Median Test	.023	Reject the null hypothesis.
13	The medians of BMI-A are the same across categories of Location.	Independent-Samples Median Test	.462	Retain the null hypothesis.
14	The medians of Armspan/Height are the same across categories of Location.	Independent-Samples Median Test	.134	Retain the null hypothesis.
15	The medians of Waist Circum. (cm) are the same across categories of Location.	Independent-Samples Median Test	.283	Retain the null hypothesis.

Location		Knee-Height (cm)	BMI-KH	Adjusted Weight (kg)	Height (cm)	BMI-H	Armspan (cm)	BMI-A	Armspan/Height	Total Height (mm)	Torso Height (mm)	Leg Height (mm)	Torso:Total Ratio	Torso:Leg Ratio	Waist Circum. (cm)	WC/Total Height
A	Mean	46.00	29.471108	66.883	151.83	28.975	152.92	28.558	1.00717	201.00	84.80	116.20	.42200	.72980	96.08	.63308
	N	12	12	12	12	12	12	12	12	5	5	5	5	5	12	12
	Std. Deviation	2.296	3.1677559	8.3651	6.250	2.9955	6.829	2.6363	.019145	6.325	3.271	3.962	.008456	.025577	7.038	.041925
B	Mean	45.67	28.602086	64.367	150.33	28.483	153.00	27.550	1.01800	210.33	88.00	122.33	.41883	.72283	90.00	.59933
	N	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Std. Deviation	1.211	4.0370951	9.9152	5.007	4.1581	4.382	4.4810	.017911	5.317	5.404	7.005	.026596	.083159	10.218	.072401
C	Mean	44.30	32.459675	70.780	149.00	31.890	149.50	31.680	1.00420	212.40	87.10	125.30	.40920	.69670	96.50	.64830
	N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Std. Deviation	2.710	3.7139754	9.3280	6.912	3.8829	4.743	4.1553	.025694	14.508	10.525	7.959	.029295	.089209	10.014	.071346
D	Mean	45.43	30.524448	68.107	150.43	30.036	152.71	29.221	1.01507	211.23	84.62	126.62	.40062	.66954	93.36	.62007
	N	14	14	14	14	14	14	14	14	13	13	13	13	13	14	14
	Std. Deviation	2.065	4.1567450	11.0528	4.146	4.3468	6.521	4.6112	.029251	10.779	5.059	7.687	.015338	.042479	10.616	.065515
E	Mean	42.96	31.210923	65.896	145.04	31.238	147.42	30.331	1.01669	191.96	76.50	115.46	.60135	.66385	92.27	.63650
	N	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
	Std. Deviation	1.800	6.3586208	14.7971	4.737	6.3940	4.859	6.6132	.021766	7.225	4.130	5.551	.016546	.046120	13.838	.096015
F	Mean	44.25	26.523007	57.925	147.00	26.700	151.00	25.263	1.02738	204.75	83.63	121.13	.59163	.69250	89.38	.60813
	N	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Std. Deviation	3.370	3.1839755	9.8317	6.908	3.2872	7.578	2.8824	.027887	13.360	7.405	9.094	.023482	.067426	8.210	.051159
G	Mean	45.25	30.894598	69.200	149.50	31.050	154.50	29.050	1.03350	213.75	89.75	124.00	.57975	.72525	99.00	.66275
	N	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	Std. Deviation	2.062	4.1905469	7.5542	5.568	4.3898	6.455	3.7740	.011958	10.874	5.252	7.528	.015086	.045228	1.155	.021515
Total	Mean	44.46	30.305641	66.295	148.31	30.100	150.56	29.260	1.01543	203.07	82.50	120.57	.50847	.68553	93.44	.63027
	N	80	80	80	80	80	80	80	80	72	72	72	72	72	80	80
	Std. Deviation	2.444	4.8848562	11.7064	5.884	4.9232	6.141	5.0851	.023874	13.141	7.525	8.091	.096490	.060892	10.814	.072656

Action Level Segregation (WC)



		Sig.
Knee-Height (cm)	Between Groups	.001
	Within Groups	
	Total	
BMI-KH	Between Groups	.000
	Within Groups	
	Total	
Adjusted Weight (kg)	Between Groups	.000
	Within Groups	
	Total	
Height (cm)	Between Groups	.005
	Within Groups	
	Total	
BMI-A	Between Groups	.000
	Within Groups	
	Total	
Armspan/Height	Between Groups	.611
	Within Groups	
	Total	
Waist Circum. (cm)	Between Groups	.000
	Within Groups	
	Total	

	Null Hypothesis	Test	Sig.	Decision
1	The medians of Total Height (mm) are the same across categories of Action Level.	Independent-Samples Median Test	.045	Reject the null hypothesis.
2	The medians of Torso Height (mm) are the same across categories of Action Level.	Independent-Samples Median Test	.124	Retain the null hypothesis.
3	The medians of Leg Height (mm) are the same across categories of Action Level.	Independent-Samples Median Test	.037	Reject the null hypothesis.
4	The medians of Torso:Total Ratio are the same across categories of Action Level.	Independent-Samples Median Test	.233	Retain the null hypothesis.
5	The medians of Torso:Leg Ratio are the same across categories of Action Level.	Independent-Samples Median Test	.964	Retain the null hypothesis.

	Null Hypothesis	Test	Sig.	Decision
1	The medians of BMI-H are the same across categories of Action Level.	Independent-Samples Median Test	.001	Reject the null hypothesis.
2	The medians of Armspan (cm) are the same across categories of Action Level.	Independent-Samples Median Test	.020	Reject the null hypothesis.
3	The medians of WC/Total Height are the same across categories of Action Level.	Independent-Samples Median Test	.000	Reject the null hypothesis.

**All individuals had a WHtR of 0.5 or greater

Action Level		Leg Height (mm)	Torso:Total Ratio	Torso:Leg Ratio	Knee-Height (cm)	BMI-KH	Adjusted Weight (kg)	Height (cm)	BMI-A
0	Mean	112.33	.59117	.69333	42.67	22.962832	47.783	143.83	22.050
	N	6	6	6	6	6	6	6	6
	Std. Deviation	3.670	.020074	.059068	1.751	1.3456583	3.3920	3.764	1.8469
1	Mean	120.95	.49842	.67442	43.24	27.798139	58.767	145.90	26.805
	N	19	19	19	21	21	21	21	21
	Std. Deviation	7.494	.100886	.036708	1.841	2.4113193	5.2394	5.078	2.6867
2	Mean	121.47	.50198	.68902	45.15	32.130441	71.374	149.77	31.049
	N	47	47	47	53	53	53	53	53
	Std. Deviation	8.238	.096784	.068884	2.453	4.6569144	10.3833	5.872	4.9482
Total	Mean	120.57	.50847	.68553	44.46	30.305641	66.295	148.31	29.260
	N	72	72	72	80	80	80	80	80
	Std. Deviation	8.091	.096490	.060892	2.444	4.8848562	11.7064	5.884	5.0851

Action Level		BMI-H	Armspan (cm)	WC/Total Height	Total Height (mm)	Torso Height (mm)	Armspan/Height	Waist Circum. (cm)
0	Mean	23.117	147.33	.53233	190.17	77.83	1.02417	76.50
	N	6	6	6	6	6	6	6
	Std. Deviation	1.6940	5.203	.028911	7.494	6.306	.013963	2.739
1	Mean	27.643	148.24	.57305	202.53	81.58	1.01633	83.52
	N	21	21	21	19	19	21	21
	Std. Deviation	2.4606	5.049	.027453	13.318	6.736	.022112	2.421
2	Mean	31.864	151.85	.66404	204.94	83.47	1.01408	99.28
	N	53	53	53	47	47	53	53
	Std. Deviation	4.7938	6.311	.063705	12.870	7.821	.025458	8.189
Total	Mean	30.100	150.56	.63027	203.07	82.50	1.01543	93.44
	N	80	80	80	72	72	80	80
	Std. Deviation	4.9232	6.141	.072656	13.141	7.525	.023874	10.814

WC/Height v. WC v. BMI Correlation



			BMI-H	Waist Circum. (cm)	WC/Total Height
Spearman's rho	BMI-H	Correlation Coefficient	1.000	.795**	.818**
		Sig. (2-tailed)	.	.000	.000
		N	80	80	80
	Waist Circum. (cm)	Correlation Coefficient	.795**	1.000	.925**
		Sig. (2-tailed)	.000	.	.000
		N	80	80	80
	WC/Total Height	Correlation Coefficient	.818**	.925**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	80	80	80

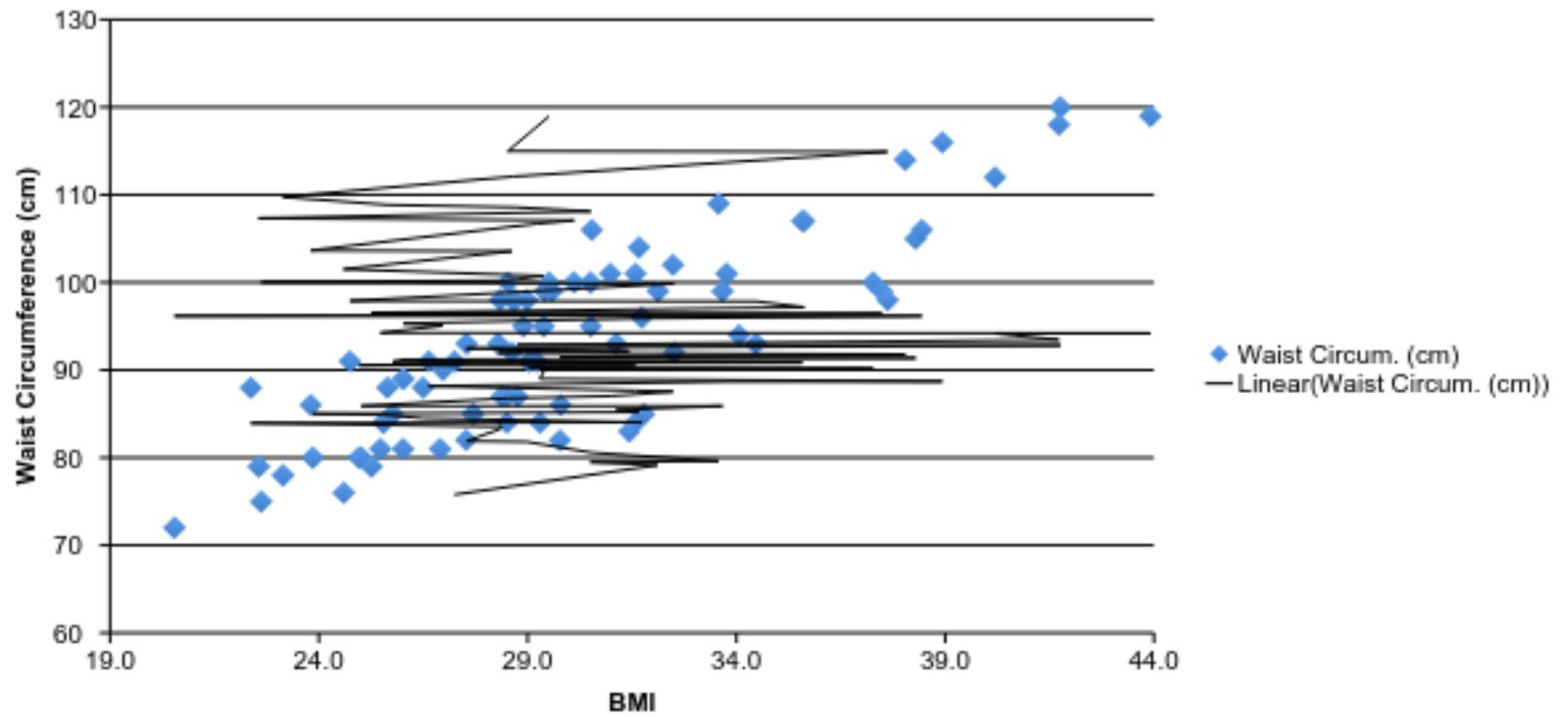
Contingency Table



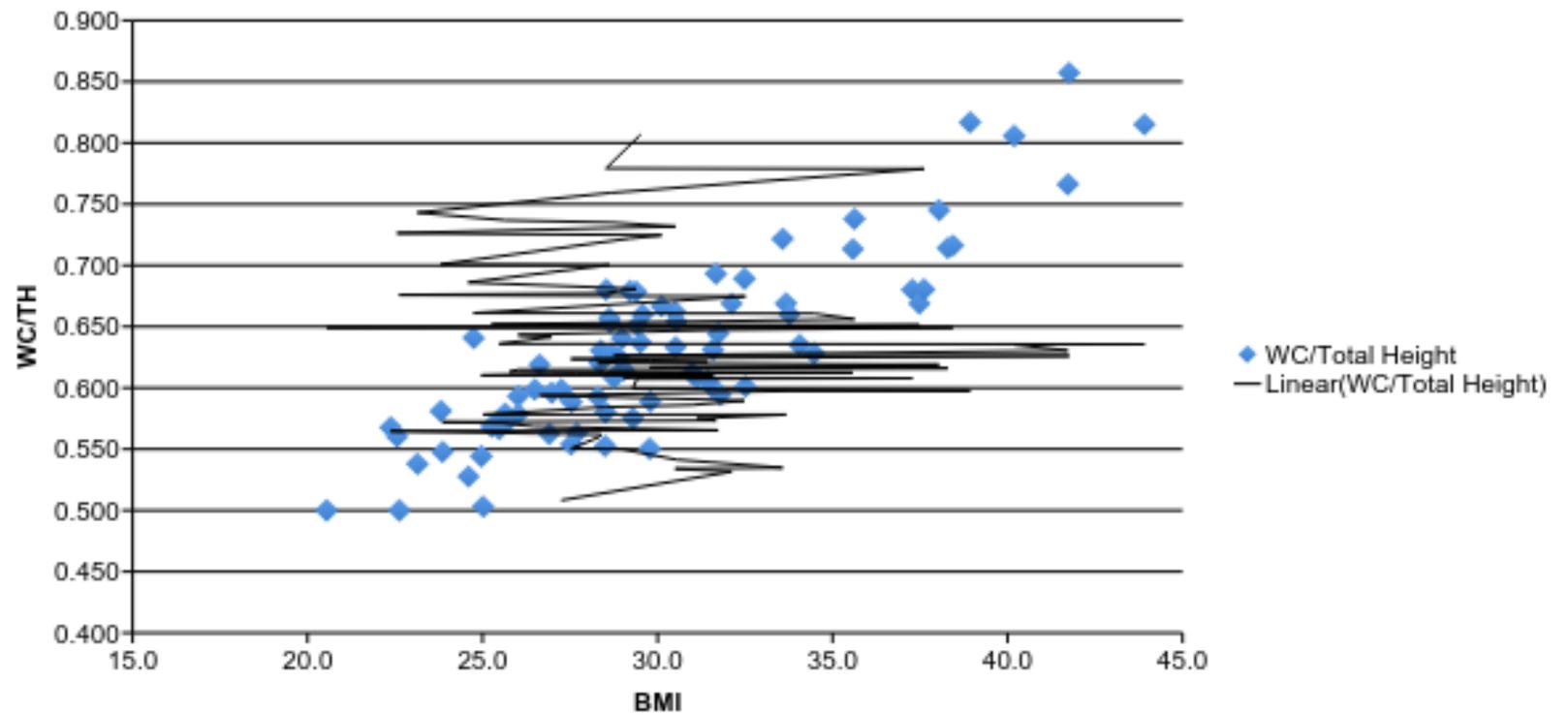
	Normal Weight	Overweight	Obese
Action Level 2 (53)	2	21	30
Action Level 1 (21)	3	15	3
Action Level 0 (6)	5	1	0

Percent Concordant = $50/80 = 62.5\%$

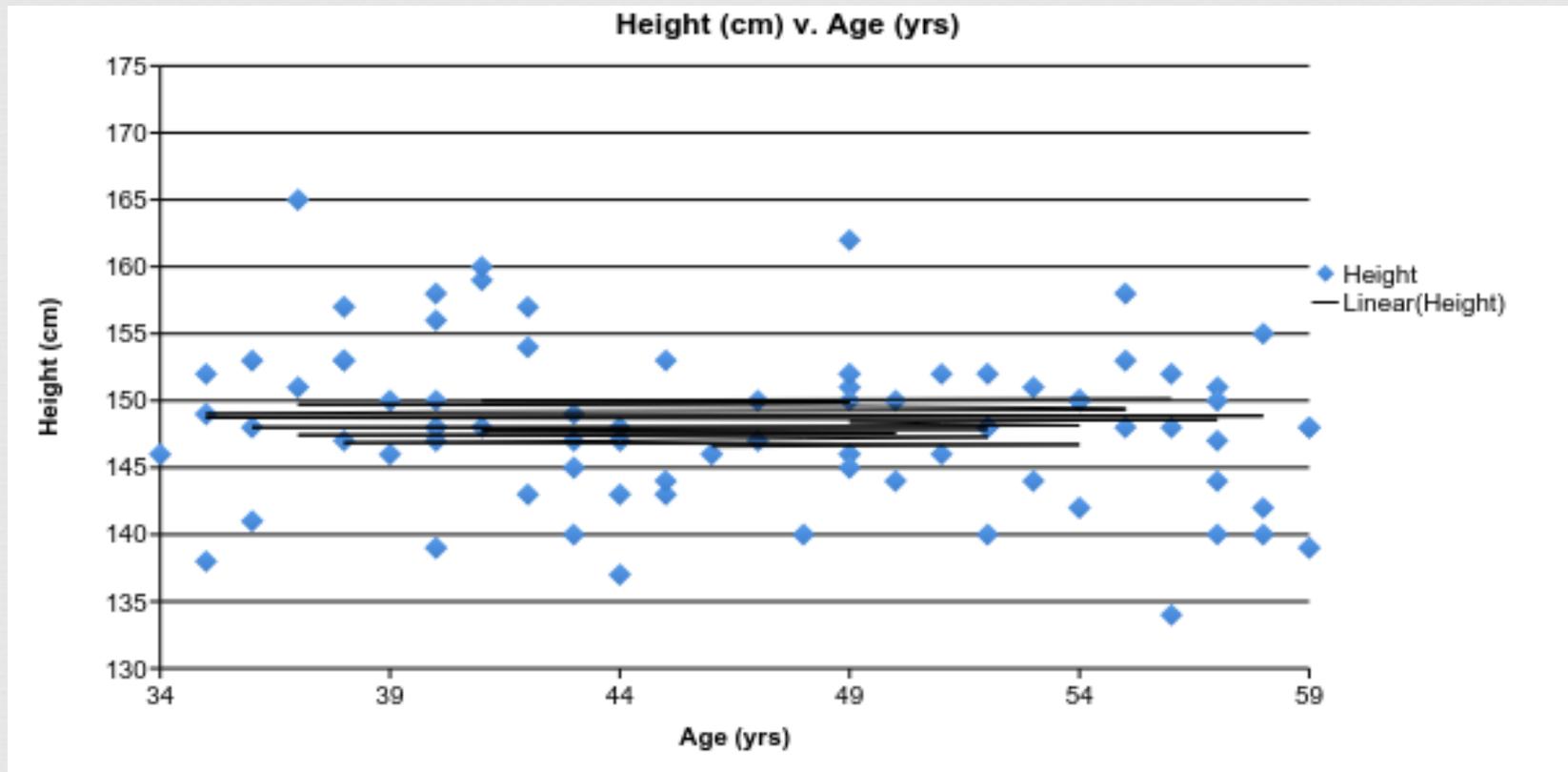
Waist Circum. (cm) v. BMI



WC/Total Height v. BMI



Decline in Height/Time



Middle-Age v. Elderly Compare and Contrast



	MvJ	N	Mean	Std. Deviation	Std. Error Mean
Knee-Height (cm)	M	80	44.46	2.444	.273
	J	73	43.68	5.607	.656
Adjusted Weight (kg)	M	80	66.295	11.7064	1.3088
	J	72	55.442	14.7103	1.7336
Height (cm)	M	80	148.31	5.884	.658
	J	72	139.89	24.651	2.905
BMI-H	M	80	30.100	4.9232	.5504
	J	72	25.190	7.2358	.8528
Armspan/Height	M	80	1.01543	.023874	.002669
	J	0 ^a	.	.	.
Waist Circum. (cm)	M	80	93.44	10.814	1.209
	J	72	88.84	19.270	2.271

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Knee-Height (cm)	Equal variances assumed	.257	.784	.689
	Equal variances not assumed	.273	.784	.711
Adjusted Weight (kg)	Equal variances assumed	.000	10.8533	2.1465
	Equal variances not assumed	.000	10.8533	2.1722
Height (cm)	Equal variances assumed	.004	8.421	2.841
	Equal variances not assumed	.006	8.421	2.979
BMI-H	Equal variances assumed	.000	4.9096	.9954
	Equal variances not assumed	.000	4.9096	1.0150
Waist Circum. (cm)	Equal variances assumed	.068	4.593	2.503
	Equal variances not assumed	.077	4.593	2.573

Conclusions



BMI, Stunting, and WC



- ✂ BMI-H, BMI-KH, and BMI-A all significantly correlate with one another
- ✂ Only BMI-KH and BMI-H do not significantly differ from one another
- ✂ Stunted individuals are significantly lower in weight and height and significantly higher in armspan/height
- ✂ They also have significantly higher torso:total height ratios

BMI, Stunting, and WC



- ✿ WC Action Levels have significantly different values of BMI and WHtR
- ✿ BMI, WC, and WHtR all correlate significantly with each other

Age Groups



- ✿ Poor, but present negative correlation present between age and overall height
- ✿ Elderly population was significantly lower in weight, height, and BMI
- ✿ Elderly had a higher percentage of stunting (27.5% v.

Internal and External Validity



- Inter-rater reliability for photographic measurements
- Difficult in palpating for landmarks because of obesity
- Low-income areas in Quetzaltenango
- Women 35-59

Future Directions



Future Directions



- ❧ Location of Study
- ❧ Cut-offs based on health of participants
 - ❧ Other factors: hygiene practices, medical history, family history
- ❧ Develop KH equation and WC action levels specific for this population
- ❧ Bland-Altman analysis for BMI, WC, and WHtR

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