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BMI Made Simple - What is your "Maximum Weight Limit ?

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ABSTRACT

BMI is a simple index of weight-for-height that is commonly used in screening overweight and obesity in adult populations. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2) and it the most widely used and universally accepted index. Because BMI measurement is based on metric scale, it is not easy to compute and therefore, special charts, table, special devices such as rotating wheels, and internet tools are used. Therefore, using advanced graphical and statistical procedures available in SAS software and, I am proposing a much simpler way of calculating a new index, Maximum Weight Limit, which closely corresponds to weight recommendations listed on BMI charts. But, you don't need to calculate or know your BMI, nor do you need a chart or online calculator to figure out your Maximum Weight Limit. For men and women, there is a baseline height and weight. For men, the baseline is 5-feet, 9-inches tall and a Maximum Weight Limit of 175 pounds. For women, the baseline is 5-feet tall and a Maximum Weight Limit of 125 pounds. From that starting point, you simply calculate how much taller or shorter you are, in inches. Then, if you are man, you add or subtract 5 pounds for every inch you are taller or shorter than 5 feet, 9 inches. Women add or subtract 4.5 pounds for each inch they differ from the baseline height of 5-feet tall. These Maximum Weight Limits correspond very closely to BMIs of 25.5 for men and 24.5 for women. Anyone, anywhere can calculate their Maximum Weight Limit if they know their height and this simple formula.

INTRODUCTION

The World Health Organization (WHO)'s latest projections indicate that globally approximately 1.6 billion adults (age 15+) were overweight and at least 400 million adults were obese. In US, about 97 million adults are considered over weight and obese. WHO further projects that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese. Two of the *Healthy People 2010* national health objectives are (1) to reduce the prevalence of overweight and obesity among adults to less than 15% and (2) to reduce the prevalence of obesity among children and adolescents to less than 5%. Obesity is considered as a complex serious health risk and large values (>35) of BMI has repeatedly been shown to be associated with health problems. Higher BMI value is usually associated with heart disease, type 2 diabetes, hypertension, dyslipidemia and dementia. As standards of living continue to rise, over weightand obesity are posing a growing global threat to human health. To treat obesity, considerable advances

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have been made in diet, exercise and behavioral approaches. Despite this progress, however, obesity prevalence continues to increase sharply and the challenge to control obesity levels has never been greater.

Setting a weight goal is considered the first step in losing weight to control obesity. How do you determine how much you "should" weigh? Or you could think about how to maintain maintaining healthy weight. In the middle nineteenth century, a Belgian statistician, Adolphe Quetelet, was first to apply advanced statistical analyses to measure population wide obesity. Quetelet was interested in population differences, and noted how a simple arithmetic index did not fit well in describing differences in body weight. Also he found that in general, body weight increases as the square of the height. This association is known as the Quetelet Index. Later Ancel Keyes called it the Body Mass Index (BMI)[1] in 1972 and that name becomes a universally accepted term in weight management program.

World Health Organization recommend using these BMI categorical standards for classification

BMI	Health Category
18.5-24.9	Healthy
25.0-29.9	Overweight
30.0-34.9	Obesity Class I
35.0-39.9	Obesity Class II
=> 40.0	Obesity Class III

Since then BMI is widely used in scientific studies, BMI is usually calculated using the metric system, and the metric BMI is used in health research. But, to convert body weight measured in pounds to metric BMI, weight in pounds is multiplied by 703, and then divided by height in inches squared. Charts or online calculators are then used to show a "healthy weight range" given an individual's height that corresponds to the "healthy range BMI." For example, a BMI chart indicates that a healthy range BMI of 19 to 24 translates to a "healthy weight range" of 120 to 150 pounds for a 5-foot, 6-inch individual. However, the meaning of BMI is difficult to grasp by the common individual and therefore the concept of "ideal weight" and "perfect weight" are introduced in the weight management programs by translating the BMI ranges. However, most of the individuals having weight issues are not considering themselves as "Ideal individuals" and therefore they don't take the ideal weight as serious bench mark. Furthermore, the goal of maintaining the 'healthy weight' is also problematic for individuals less than 50 years old since maintaining health is not usually a major priority for younger adults. Therefore, the purpose of this presentation is to reveal a simple but innovative alternative weight management index[2] where a common adult can easily understand, can manually compute and can be established as a life long goal starting from age 20 so that the weight management programs can become more effective worldwide.

A new weight management index- Maximum Weight Limit (MWL)

After performing several simulation studies using SAS software's BASE STAT and advanced graphical procedures, I am proposing a much simpler way of calculating a Maximum Weight Limit, which closely corresponds to weight recommendations listed in BMI charts (See the SAS codes presented in the Appendix). But, you don't need to calculate or know your BMI, nor do you need a chart or online calculator to figure out your Maximum Weight Limit. It's a very simple calculation that most of us can do in our heads[2].

- For men and women, there is a baseline height and weight.

- For men, the baseline is 5-feet, 9-inches tall and a Maximum Weight Limit of 175 pounds, meaning that a 5-foot, 9-inch tall man should weigh no more than 175 pounds.

- For women, the baseline is 5-feet tall and a Maximum Weight Limit of 125 pounds.

- These are nice round numbers that people can easily remember: 5-feet, 9-inches tall, 175 pounds for man; and 5-feet tall, 125 pounds for a woman.

- From that starting point, you simply calculate how much taller or shorter you are, in inches.

- Then, if you are man, you add or subtract 5 pounds for every inch you are taller or shorter than 5 feet, 9 inches.

- So, if you are 5-feet, 11-inches tall, you are 2 inches taller than the baseline of 5 feet, 9 inches. You add 5 pounds for each of those 2 inches, 10 pounds, to the baseline Maximum Weight Limit of 175. So, your Maximum Weight Limits 185 (175 pounds plus 10 pounds).

- Women add or subtract 4.5 pounds for each inch they differ from the baseline height of 5-feet tall (See Figure 1).

- These Maximum Weight Limits correspond very closely to BMIs of 25.5 for men and 24.5 for women.

A BMI of 18.5 to 25 BMI is diagnosed as the "healthy range." I used a slightly lower BMI base for women and a slightly higher one for men because, on average, women have less muscle mass than men. Although some have debated using BMI as a means for calculating healthy weight because it does not take into account factors such as muscle mass, for example, it has been shown to work as a basis for calculating a healthy weight for more than 90 percent of the population and is the most universally used index in weight management programs. Now people can calculate their own Maximum Weight Limit, based on the BMI index, but without any calculators or charts. And, all they have to remember is that one number, 185 pounds for example, which is easier for most people than retaining a weight range, such as 155 to 185 pounds. But it's far easier to calculate and remember compared to BMI. The MWL does not reflect a person's ideal weight, because people differ in their build and muscle mass. This number is meant to give people a stop sign.

People who reach their limit should change their lifestyle to eat healthier and exercise more or should seek professional guidance to curtail further weight gain. It's time to intervene and take steps immediately. More than 100 online sites reported and discussed the usefulness of this calculation[3].

A Simple common-sense practical Weight Management Index
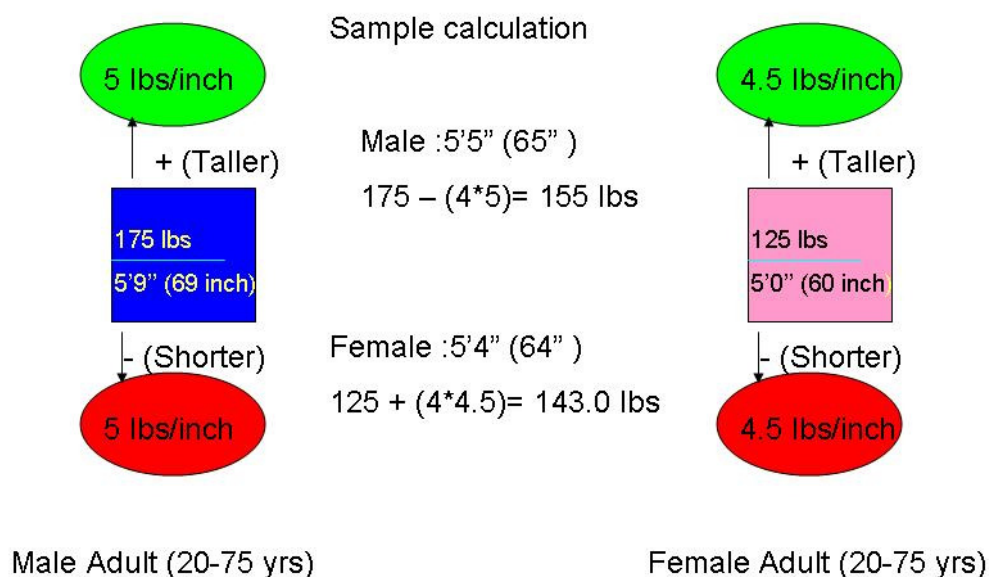
GF's Maximum Weight Limit (MWL)

Figure 1 Simple Maximum Weight limit computation for male and female adults

Similarly, I came out with simple formula for computing the Lower Weight Limit (LWL)corresponding to a BMI of 18.5.

Lower Weight Limit (LWL) computation

For men and women, I am proposing a baseline height and weight.

- **For men**: Baseline height-weight is: 5-feet, 9-inches tall and the Lower Weight Limit of 125 pounds (Eq to a BMI 18.5), meaning that a 5-foot, 9-inch tall man should not weigh less than 125 pounds.

- **For women**: Baseline height-weight is: 5-feet, 2- inch tall and the Lower Weight Limit of 101 pounds (Eq to a BMI 18.5) meaning that a 5-foot, 2-inch tall woman should not weigh less than 101 pounds..

From this base height, you simply calculate how much taller or shorter you are, in inches.

Man: add 4 pounds or subtract 3.5 pounds for every inch you are taller or shorter than 5 feet, 9 inches (from 125 lbs).

- So, if you are 5-feet, 11-inches tall, you are 2 inches taller than the baseline of 5 feet, 9 inches. You add 4 pounds for each of those 2 inches, 8 pounds, to the baseline Lower Weight Limit of 125. So, your Lower Weight Limit is 133 (125 pounds plus 8 pounds).

- **Woman**: Add 3.5 lbs or subtract 3 pounds for each inch you differ from the baseline height of 5-feet 2 inches (62 inches: 101 lbs).

So, if you are 5-feet tall, you are 2 inches shorter than the baseline of 5 feet, 2 inches. You subtract 3 pounds for each of those 2 inches, 6 pounds, to the baseline Lower Weight Limit of 101. So, your Lower Weight Limit is 95 lbs (101 pounds ,minus 6 pounds).

If these MWL and LWL calculations are still difficult to perform, the users can use the simple chart presented in figure 2 to find out the healthy weight limits (maximum and lower weight limits for common heights).

Validating the MWL computations with BMI based values:

MWL can be computed directly from the toggled BMI formula (BMI*HT*HT/703) (at a give height (HT in inches).

 For example the MWL for 70 inches tall male is equal to (25*70*70)/703 where BMI of 25 is the threshold BMI value separating over weight from healthy weight.

However, using my user-friendly computation, MWL can be estimated by simple arithmetic. Therefore, in order to validate the MWL calculation proposed by me and MWL computation using the toggled BMI formula for a range of heights of both male and female adults, a loess regression was fitted using PROC LOESS and the results are displayed using SAS SGPLOT (See Figure 3). The MWL values based on my method are shown using blue circle

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symbols where the MWL values and MWL values based on toggle BMI formula displayed as red star. There is a perfect fit in most of the cases and this is further confirmed by the perfect line fit and the invisible 95% confidence interval lines (Figure 3). Thus this analysis clearly confirms that MWL computation using the simple arithmetic based on just height in inches can replace the BMI based calculation.
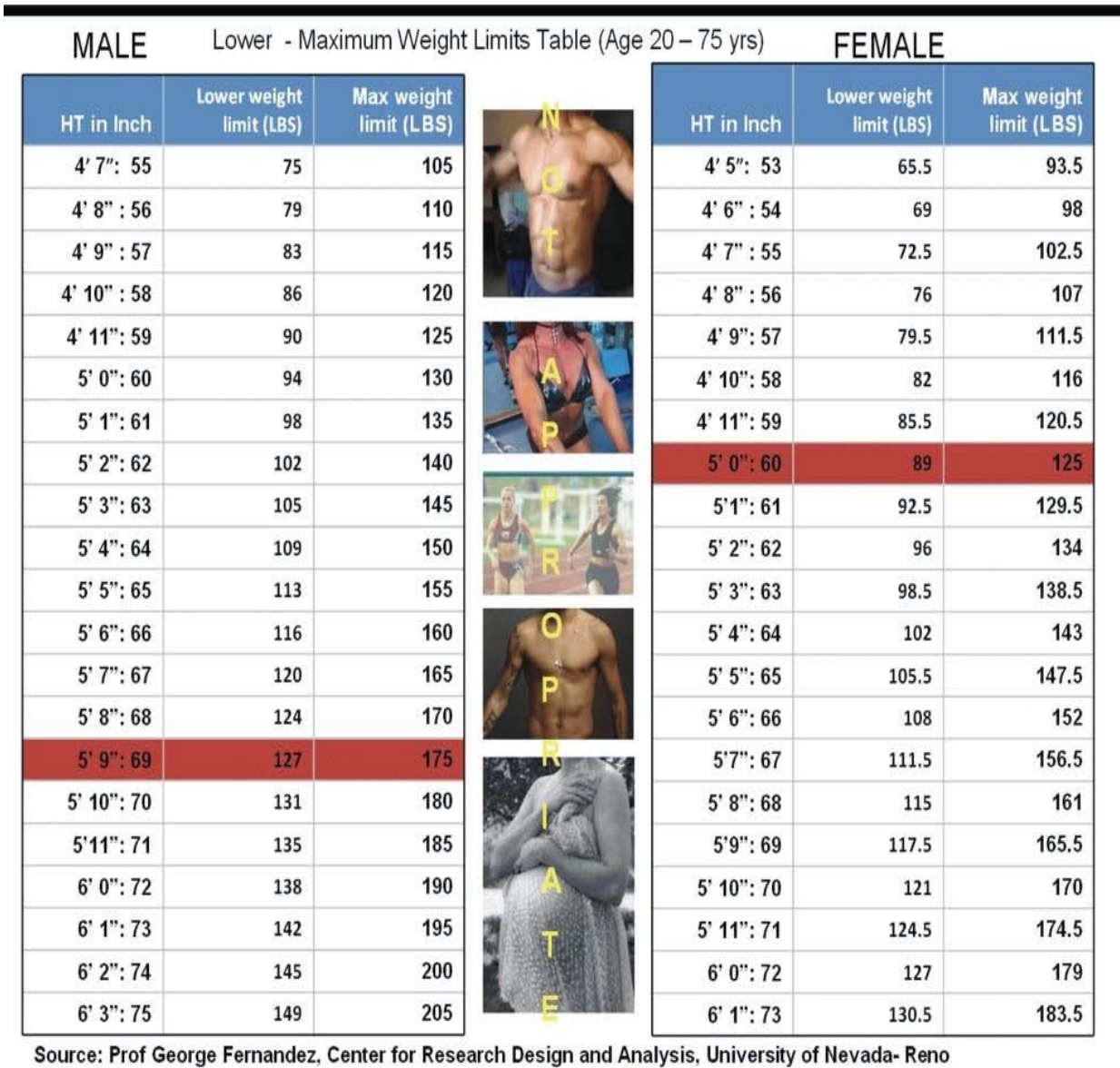
MALE	Lower - Maximum Weight Limits Table (Age 20 – 75 yrs)			FEMALE		
HT in Inch	Lower weight limit (LBS)	Max weight limit (LBS)		HT in Inch	Lower weight limit (LBS)	Max weight limit (LBS)
4' 7": 55	75	105		4' 5": 53	65.5	93.5
4' 8" : 56	79	110		4' 6" : 54	69	98
4' 9" : 57	83	115		4' 7" : 55	72.5	102.5
4' 10" : 58	86	120		4' 8" : 56	76	107
4' 11": 59	90	125		4' 9": 57	79.5	111.5
5' 0": 60	94	130		4' 10": 58	82	116
5' 1": 61	98	135		4' 11": 59	85.5	120.5
5' 2": 62	102	140		5' 0": 60	89	125
5' 3": 63	105	145		5'1": 61	92.5	129.5
5' 4": 64	109	150		5' 2": 62	96	134
5' 5": 65	113	155		5' 3": 63	98.5	138.5
5' 6": 66	116	160		5' 4": 64	102	143
5' 7": 67	120	165		5' 5": 65	105.5	147.5
5' 8": 68	124	170		5' 6": 66	108	152
5' 9": 69	127	175		5'7": 67	111.5	156.5
5' 10": 70	131	180		5' 8": 68	115	161
5'11": 71	135	185		5'9": 69	117.5	165.5
6' 0": 72	138	190		5' 10": 70	121	170
6' 1": 73	142	195		5' 11": 71	124.5	174.5
6' 2": 74	145	200		6' 0": 72	127	179
6' 3": 75	149	205		6' 1": 73	130.5	183.5

Source: Prof George Fernandez, Center for Research Design and Analysis, University of Nevada- Reno

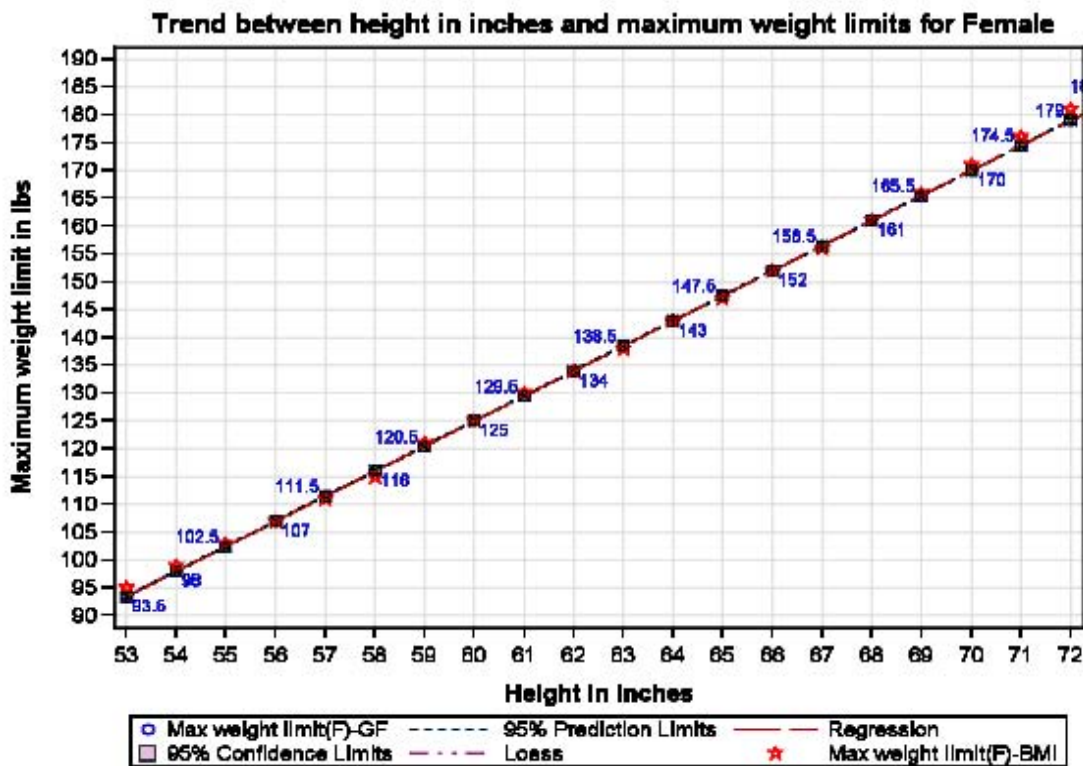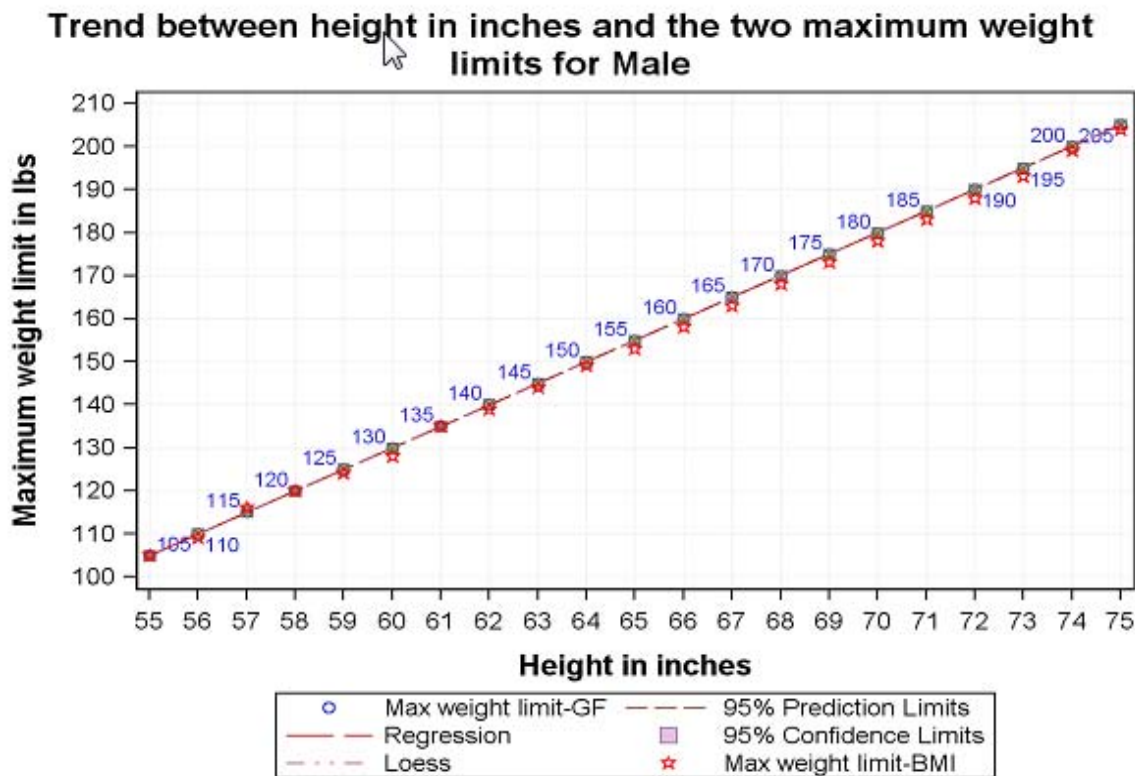**Figure 2** Maximum and Lower weight Limit chart - for adult male and female

Figure 3 Validating MWL calculations with BMI based calculation using LOESS

Limitations of MWL numbers

However, these healthy weights computed based on the threshold BMI values (18.5 and 24-25.5) may not be applicable to very muscular and athletic individuals when used in over weight-obesity classification. Further body composition analysis such as body fat %, muscle mass, fat free mass etc. are required clinically to determine whether a person may have potential health risk. However, performing body composition analysis is expensive and the methodology is not available worldwide. Therefore a need for a simple alternated methods would be very useful.

In population studies, several researchers found that BMI and waist circumference are about equal in predicting health problems. A recent study using both these measurements found an increase in fatal heart disease in obesity was four-fold measured by BMI, and three-fold based on waist circumference[4]. Overweight determined by either measure was also associated with more heart disease.

Therefore, a decision tree analysis is proposed to improve the effectiveness of MWL based over-weight screening by combining waist measurements and MWL (See Figure 4).

- If you are a male and your current body weight is above LWL and 15 lbs below your MWL and your waist measurement is below 34 inches your weight can be classified under healthy group.

- But your weight can be classified under un-healthy group if your current body weight is above LWL and 25 lbs above your MWL and your waist measurement is greater than 37 inches.

- Similarly, If you are a female (non pregnant) and your current body weight is above LWL and 10 lbs below your MWL and your waist measurement is below 30 inches your weight can be classified under healthy group.

- But your weight can be classified under un-healthy group if your current body weight is above LWL and 20 lbs above your MWL and your waist measurement is greater than 33 inches.

Additional body compositional measurements may be required to confirm individual's body fitness who falls in between the healthy and un-healthy categories. Additional studies are currently undergoing to validate the accuracy of the decision tree model.
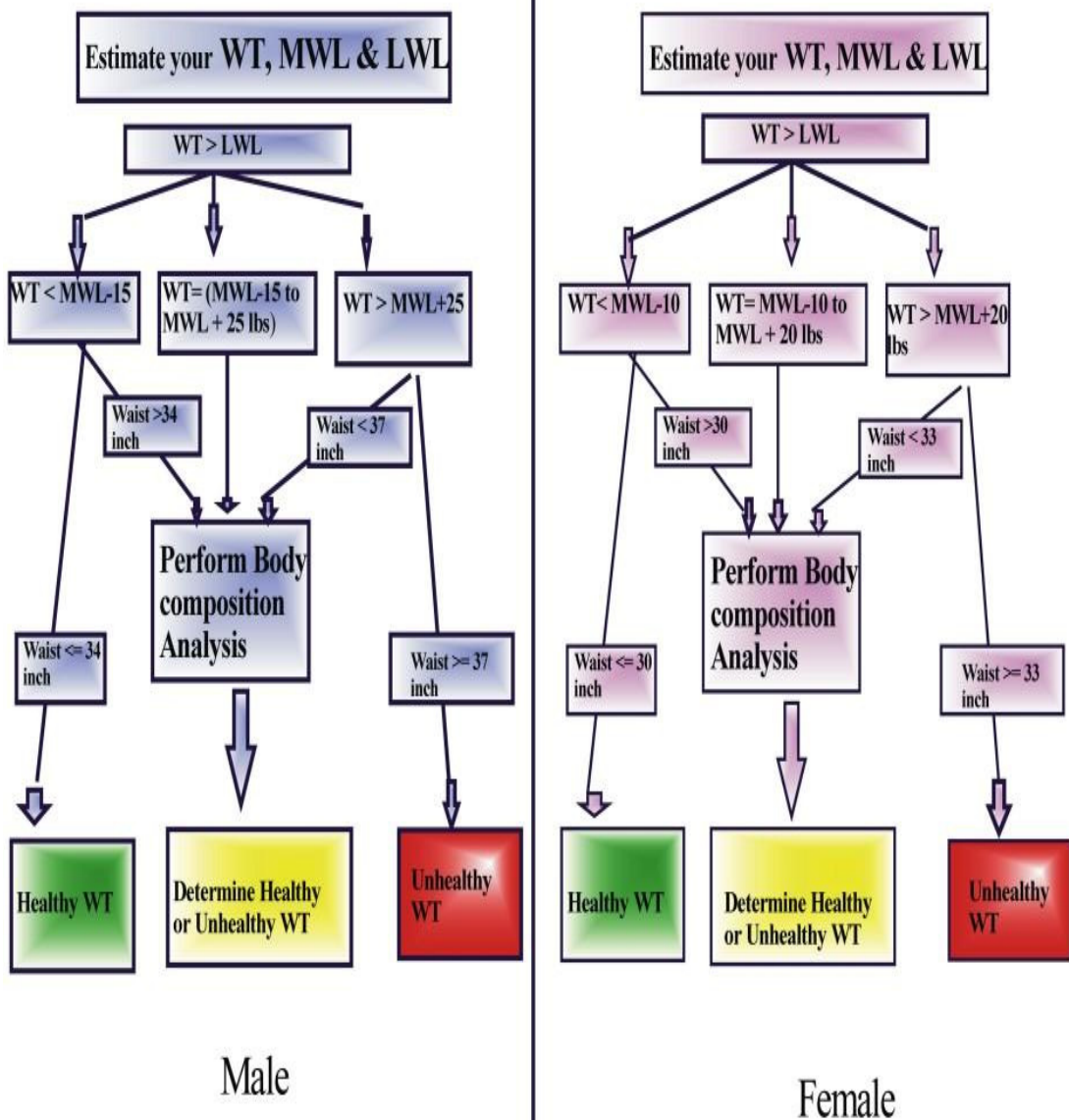
Figure 4 Decision tree diagram to decide your healthy weight status based on MWL, LWL, and waist measurements.

SUMMARY

Obesity is not just an individual problem. It is a population problem and should be tackled as such. Effective prevention and management of obesity will require an integrated approach, involving actions in all sectors of society. It is largely preventable through healthy lifestyle changes. Effective management of obesity cannot be separated from prevention. Knowing an individual adult's maximum and lower weight limits and controlling the weight within the healthy weight limits by healthy lifestyle can reduce the obesity outbreak globally. This simple formula could be also very useful in medically under-served areas of the world, and for individuals without access to technology and charts. Anyone, anywhere can calculate their Maximum Weight Limit if they know their height and this simple formula. People can calculate this in their heads and remember this. More resources and information about the MWL and LWL can be found at http://www.max-weight-limit.com [5]

REFERENCES

1. Eknoyan G. 2008 Nephrology Dialysis Transplantation 23(1):47-51)
2. UNR 2009 Professor discovers how to calculate "Maximum Weight   Limit" http://www.unr.edu/nevadanews/templates/details.aspx?articleid=5168&zone id=8   Press release

3. George Fernandez 2009 MWL online citations http://www.max-weight-limit.com/home/mwl-citations-1

4. European Journal Cardiovascular Prevention and   Rehabilitation   2009; 16: 729-734

5. George Fernandez 2009 MWL resources at http://www.max-weight-limit.com

CONTACT INFORMATION

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Appendix SAS code:

```sas
data maxwtlimit;
do ht = 53 to 73 by 1;
mbmi=25;
if ht >58 then maxwtlimit=round(((mbmi-0.5)/703)*(ht**2));
else if ht < 55 then maxwtlimit=round(((mbmi-1.25)/703)*(ht**2));
else  maxwtlimit=round(((mbmi-1)/703)*(ht**2));
maxwtlimitgf=(ht*2)+((ht-58)*2.5) ;
label maxwtlimit    ="Max weight limit(F)-BMI"
      maxwtlimitgf="Max weight limit(F)-GF";
diff            = maxwtlimit- maxwtlimitgf;
minwtlimit     = maxwtlimitgf - round(ht*ht/100);
 idealwthall     =100 + (ht-60)*5;
 hallbmi          = Round((idealwthall*703)/(ht*ht));
 ideallulu     = 110 + (ht-60)*5.5;
lulubmi        =  Round((ideallulu*703)/(ht*ht));
output; end;
run;
ods listing close;
ods rtf file="c:\temp\bmifemale.rtf" style=sasweb;

Proc print data= maxwtlimit label noobs;
var ht  maxwtlimit minwtlimit maxwtlimitgf idealwthall hallbmi ideallulu lulubmi;
Title "  Max weight limit-BMI and Max weight limit-GF by Height for  Female ";
run;
ods graphics on /noborder;
  proc loess data=maxwtlimit;
    model maxwtlimit=ht/clm alpha=0.1;
  run;

proc sgplot data= maxwtlimit ;
```

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```
Title " Trend between height in inches and maximum weight limits for Female";
yaxis label="Maximum weight limit in lbs"  grid values=(90 to 190 by 5);
xaxis label= "Height in inches" grid values=(53 to 72 by 1);
scatter  x=ht y=maxwtlimitgf/datalabel;
reg  x=ht y=maxwtlimitgf/cli;
loess  x=ht y=maxwtlimitgf/clm   CLMTRANSPARENCY=.5 ;
scatter  x=ht y=maxwtlimit/MARKERATTRS= (color=red  symbol=star) ;
run;


proc sgplot data=maxwtlimit;
Title " Differences between max weight limit-BMI and Max weight limit-GF for female
";
  yaxis label="Maximum weight limit in lbs" min=90;
  xaxis label= "Height in inches";
  vbar ht / response=maxwtlimit FILLATTRS=  (COLOR= cyan) ;
  vbar ht / response=maxwtlimitgf           barwidth=0.5 transparency=0.2;
run;


proc sgplot data= maxwtlimit ;
Title " Trend between height in inches and maximum weight limits for Female";
yaxis label="Maximum weight limit in lbs"  grid values=(70 to 190 by 5);
  xaxis label= "Height in inches" grid values=(53 to 72 by 1);
scatter  x=ht y=maxwtlimitgf/datalabel;
reg  x=ht y=maxwtlimitgf/cli;
loess  x=ht y=maxwtlimitgf/clm   CLMTRANSPARENCY=.5 ;
scatter  x=ht y=maxwtlimit/MARKERATTRS= (color=green  symbol=diamond) ;
scatter  x=ht y=idealwthall/datalabel MARKERATTRS= (color=red  symbol=x) ;
loess x=ht y=idealwthall /MARKERATTRS= ( color=red symbol=x);
scatter  x=ht y=ideallulu/datalabel MARKERATTRS= (color=black  symbol=star) ;
loess x=ht y=ideallulu/MARKERATTRS= (color=black  symbol=star);
run; quit;
ods graphics off;              ods rtf close;           ods listing;
```