A New and Simpler Way to Compute Body's "Maximum Weight Limit"

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ABSTRACT

Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used in screening overweight and obesity in both childhood and adult populations. It is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2) and it is 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, tables, 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, there is no need to calculate or know your BMI, nor 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 a complex serious health risk. 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, weight gain and obesity are posing a growing global threat to human health. To treat obesity, considerable advances have been made in diet, exercise and behavioral approaches. Despite this progress, however, obesity prevalence continues to increase sharply.

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 maintaining healthy weight. In the middle nineteenth century, a Belgian statistician, Adolphe Quetelet, was first to apply advanced statistical analyses to populations. Quetelet was interested in population differences, and how a simple arithmetic index did not fit well in describing differences body weight. Also he found that in general 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 universal accepted term in weight loss.

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

in adult population. Since then BMI is widely used in scientific studies, BMI is usually calculated using the metric system, and the metric BMI is used in discussions of health. But, to convert body weight measured in pounds to metric BMI, weight 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)

Using SAS software's Base, STAT and advanced graphical procedures, I am proposing a much simpler way of calculating a Maximum Weight Limit for adult male and female, which closely corresponds to weight recommendations listed on 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 man, 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 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. More than 100 online sites reported and discussed the usefulness of this calculation[3].

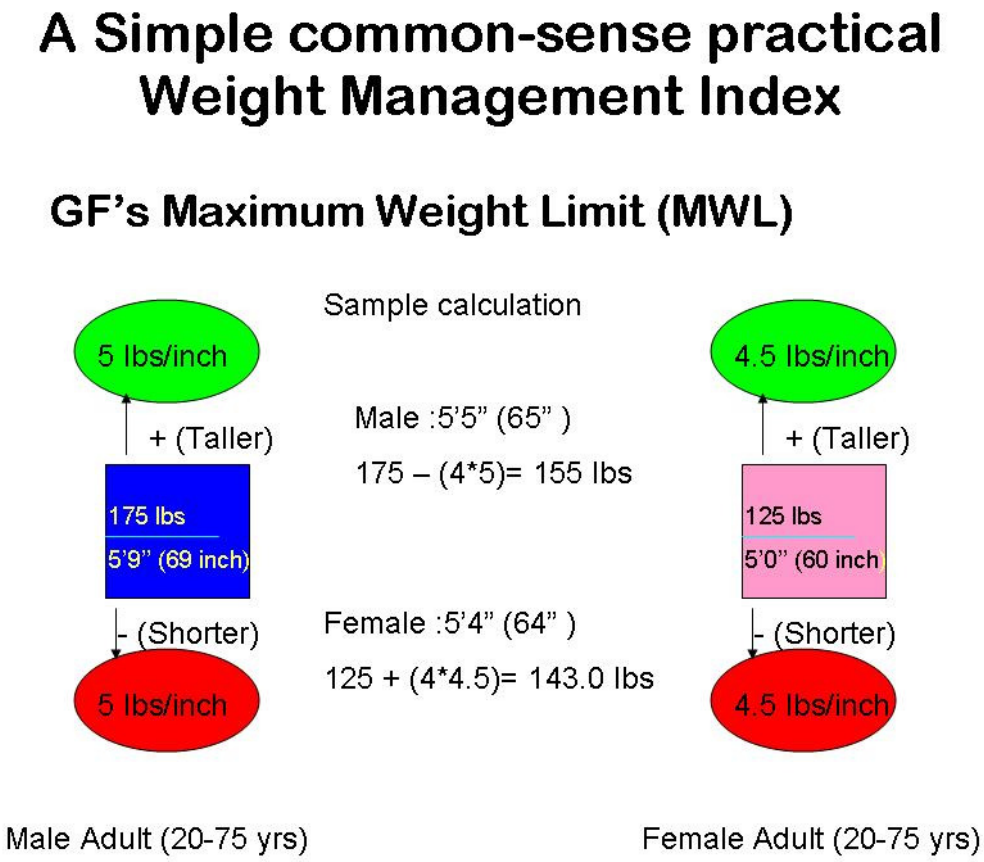


Figure 1 Simple Maximum Weight limit computation for male and female adults

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 and LWL 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 and LWL 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 given 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 value of separating over weight and healthy weight. However, using the user-friendly computation proposed here, MWL can be estimated by simple arithmetic. Therefore, in order to validate the MWL calculation proposed 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 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). Therefore, this analysis clearly confirms that MWL computation using the simple arithmetic based on just height in inches can replace the BMI based calculation.

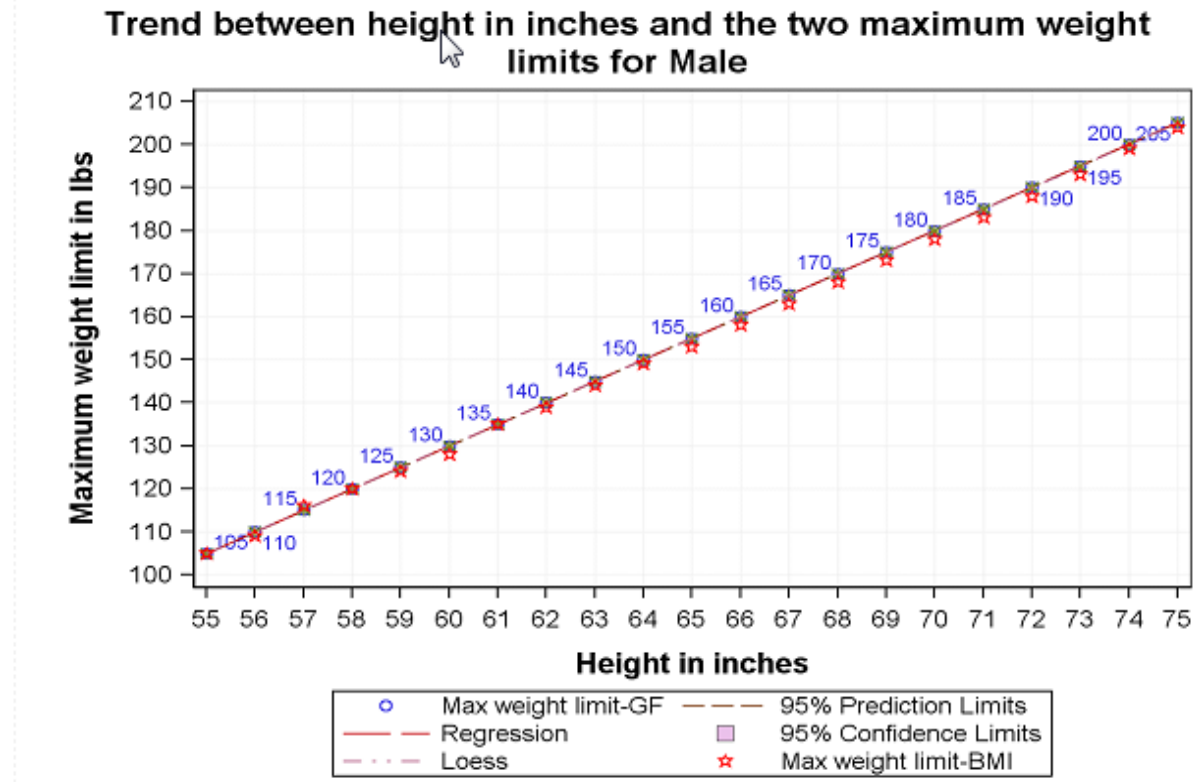
MALE — Lower - Maximum Weight Limits Table (Age 20 – 75 yrs) — FEMALE

HT in Inch	Lower weight limit (LBS)	Max weight limit (LBS)
4' 7": 55	75	105
4' 8" : 56	79	110
4' 9" : 57	83	115
4' 10" : 58	86	120
4' 11": 59	90	125
5' 0": 60	94	130
5' 1": 61	98	135
5' 2": 62	102	140
5' 3": 63	105	145
5' 4": 64	109	150
5' 5": 65	113	155
5' 6": 66	116	160
5' 7": 67	120	165
5' 8": 68	124	170
5' 9": 69	127	175
5' 10": 70	131	180
5'11": 71	135	185
6' 0": 72	138	190
6' 1": 73	142	195
6' 2": 74	145	200
6' 3": 75	149	205

HT in Inch	Lower weight limit (LBS)	Max weight limit (LBS)
4' 5": 53	65.5	93.5
4' 6" : 54	69	98
4' 7" : 55	72.5	102.5
4' 8" : 56	76	107
4' 9": 57	79.5	111.5
4' 10": 58	82	116
4' 11": 59	85.5	120.5
5' 0": 60	89	125
5'1": 61	92.5	129.5
5' 2": 62	96	134
5' 3": 63	98.5	138.5
5' 4": 64	102	143
5' 5": 65	105.5	147.5
5' 6": 66	108	152
5'7": 67	111.5	156.5
5' 8": 68	115	161
5'9": 69	117.5	165.5
5' 10": 70	121	170
5' 11": 71	124.5	174.5
6' 0": 72	127	179
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



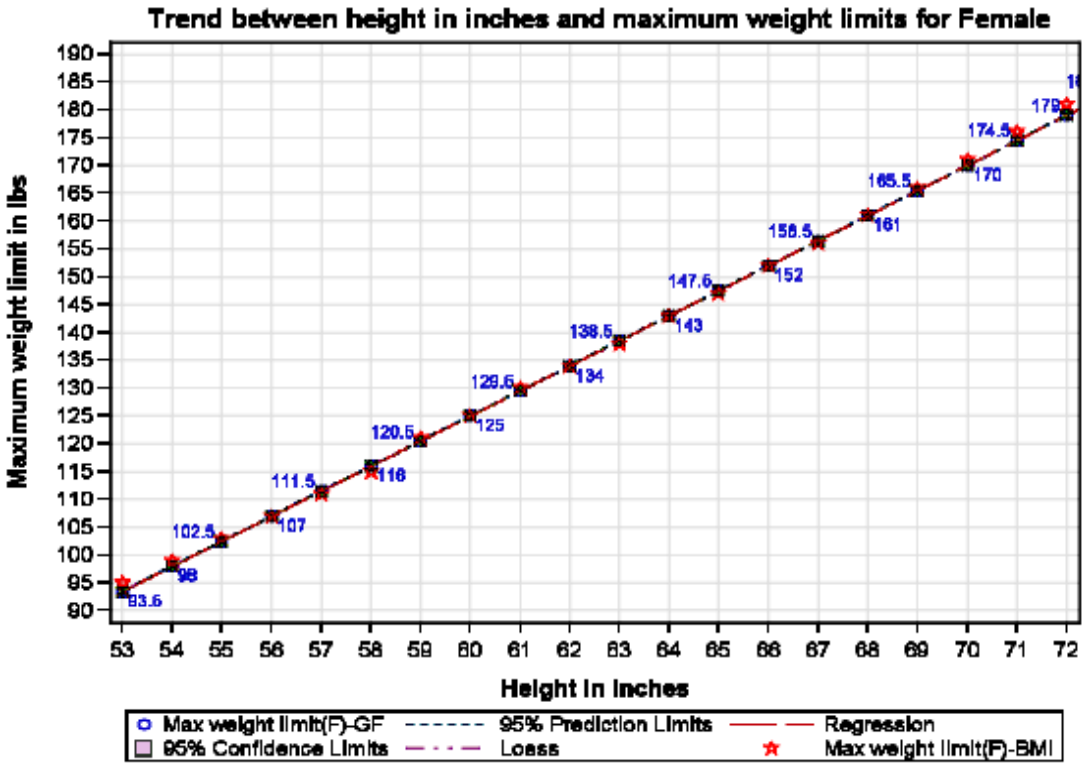


Figure 3 Validating MWL calculations with BMI based calculation using LOESS

LLimitations 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 adult individuals when used in overweight-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 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 risks.

Therefore, a decision tree analysis is proposed here 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 body fitness of individuals who falls in between the healthy and un-healthy categories. Additional studies are currently undergoing to validate the accuracy of the decision tree model.

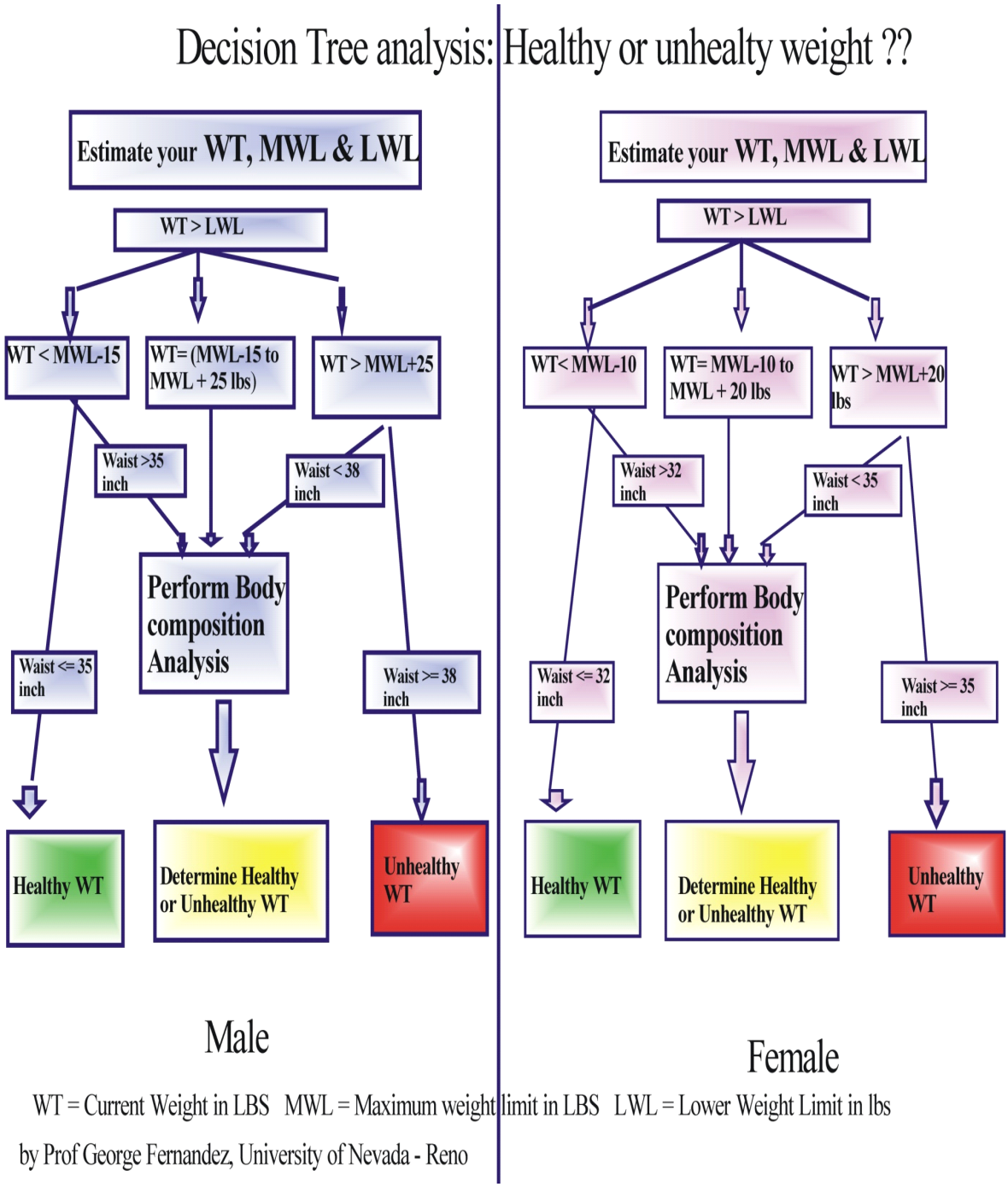


Figure 4 A decision Tree diagram to determine healthy and unhealthy weight

Childhood obesity screening tools

Unlike adults, children grow in height as well as weight, making the norms for BMI in children to vary with age and sex. The 85th and 95th percentile values of BMI are the accepted screening measure for overweight and obesity respectively for children two years of age and older. While having epidemiological and diagnostic value, the BMI is a measurement not readily available to compute and assess for the layperson. More importantly the BMI does not allow parents "to get the feel" of what their children's weight should be for a normal, overweight or obese status. The currently available CDC BMI charts are not user–friendly and are difficult to interpret and use by parents.

The CDC's gender and age specific US population percentile BMI excel data tables can be used as the source to compute the underweight, normal, overweight and obese weight range (in lbs) by converting percentile BMI values to weight limits by (BMI*HT*HT/703) where HT is the child's height in inches. Using SAS/BASE and advanced SAS graphical Procedures such as SGPLOT and SGPANEL, user-friendly and easy-to-read color-coded tables that depict the weight range corresponding to the underweight, normal, overweight and obese BMIs are developed. These user-friendly weight limits tables eliminate the need for BMI calculation, and are very easy to read. They offer parents with a practical tool that allows them to "personalize" their children's BMI limits.

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, LWL, and childhood obesity screening charts can be found at http://www.max-weight-limit.com

REFERENCES

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2. UNR 2009 Professor discovers how to calculate "Maximum Weight Limit" http://www.unr.edu/nevadanews/templates/details.aspx?articleid=5168&zoneid= 8 (Press release)

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

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

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Appendix SAS code:

```
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 ;
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;
```