ASSESSMENT OF A PROPOSED BMI FORMULA IN PREDICTING BODY FAT PERCENTAGE AMONG FILIPINO YOUNG ADULTS

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BACKGROUND

WHO Global Status Report on Noncommunicable Diseases 2014:

- About 5.1% of the Filipino population is obese, 23.6% overweight

Body Mass Index (BMI) = weight in kg / (height in m)^2

- Developed >150 years ago by Belgian mathematician Adolphe Quetelet
- Used in screening for overweight/obesity and for weight group classification
- Unable to distinguish between fat and lean body mass
- Influenced by factors such as age, sex, ethnicity, muscle mass, activity level

Lloyd Trefethen (University of Oxford) proposed a modified BMI formula:

$$BMI = (1.3 \times \text{weight in kg}) / (\text{height in m})^{2.5}$$

OBJECTIVES

- To assess the performance of the modified BMI formula against the traditional Quetelet formula in predicting percent body fat and in screening for overweight/obesity among a sample of Filipino young adults.
- To assess and compare the diagnostic accuracies of both BMI measures in identifying the overweight-obese state.

METHODS

Study design: Cross-sectional

Study participants: Students enrolled at the DLSMHSI College of Medicine

- Inclusion criteria:
  - Aged 18 to 35 years
  - Of Filipino descent
- Exclusion criteria:
  - Chronic illness (e.g., diabetes mellitus, hypertension, heart failure, malignancy)
  - Acute myocardial infarction or stroke with the past 6 months
  - Pregnancy (for females)
  - Chronic corticosteroid use
  - Conditions affecting posture (kyphosis, scoliosis, kyphoscoliosis)
  - Active engagement in any bodybuilding or exercise program

METHODS

- Direct interview
  - Age, years
  - Sex
  - Smoking history, pack-years
  - Alcohol intake, average number of drinks/week
- Direct measurement
  - Height, cm (standard height rule)
  - Weight, kg (Tanita BC-543 One Size)
  - Percent body fat, %BF (Tanita BC-543 One Size)
  - Waist circumference, cm (standard tape measure)
- Computation
  - BMI_Q and BMI_M

Weight classification	BMI
Underweight	<18.5
Normal	18.5–22.9
Overweight	23.0–24.9
Obese	≥25.0

Weight classification	% Body Fat (%BF)	
	Males	Females
Underweight	<13	<25
Normal	13–23	25–35
Overweight	23.1–28	35.1–40
Obese	>28	>40

STATISTICAL ANALYSIS

- Summary/descriptive statistics
- Pearson's correlation (BMI_Q and BMI_M; BMI values and %BF)
- Cohen's κ coefficient (weight classifications based on BMI_Q and BMI_M)
- Robust polynomial regression analysis (sex-specific models)
  - Bootstrap resampling (1000 replications)
  - Covariates: age, waist circumference, smoking history, alcohol intake
  - Likelihood ratio test (goodness of fit between nested regression models)
  - AIC and BIC (relative quality of the models)
- Measures of diagnostic accuracy
  - Sensitivity, specificity, PPV, NPV, LR+, LR–
  - Receiver operating characteristic (ROC) analysis

RESULTS

Demographic and Anthropometric Characteristics of Participants

Characteristic	Males (n = 74)	Females (n = 116)	*p*-value
Age, median (range)	22 (19–30) years	22 (19–27) years	0.614
Height, mean (SD)	168.9 (5.0) cm	156.1 (5.7) cm	<0.001
Weight, mean (SD)	76.1 (14.8) kg	53.2 (11.5) kg	<0.001
WC, median (range)	88.5 (66.5–125.0) cm	73 (59.5–102) cm	<0.001
%BF, mean (SD)	23.2 (5.5) %	29.6 (5.2) %	<0.001
Smoking history, median (range)	0 (0–20) pack-years	0	0.029
Alcohol intake, median (range)	1 (0–10) drinks/week	0 (0–3) drinks/week	0.002
BMI_Q, mean (SD)	26.6 (5.0)	23.0 (4.3)	<0.001
<18.5 (n, %)	1 (1.3%)	13 (11.2%)	
18.5–22.9 (n, %)	19 (25.7%)	54 (46.6%)	
23.0–24.9 (n, %)	11 (14.9%)	19 (16.4%)	
≥25.0 (n, %)	43 (58.1%)	30 (25.9%)	
BMI_M, mean (SD)	26.7 (5.0)	23.9 (4.5)	<0.001
<18.5 (n, %)	1 (1.3%)	4 (3.4%)	
18.5–22.9 (n, %)	20 (27.0%)	56 (48.3%)	
23.0–24.9 (n, %)	12 (16.2%)	20 (17.2%)	
≥25.0 (n, %)	41 (55.4%)	36 (31.0%)	

WC: waist circumference
%BF: body fat percentage
BMI_Q: BMI computed using the traditional Quetelet formula
BMI_M: BMI computed using the modified BMI formula proposed by Lloyd Trefethen

RESULTS

- There is high correlation between BMI and %BF, and BMI_Q and BMI_M
  - Correlation between BMI and %BF tended to be higher among females

- Agreement between BMI_Q and BMI_M:
  - Females: 81.0% (95% CI 73.9%, 88.2%), κ = 0.7139 (95% CI 0.5969, 0.8309)
  - Males: 96.0% (95% CI 91.5%, 100%), κ = 0.9306 (95% CI 0.7658, 1.0000)

- BMI and WC significant predictors of %BF among females; only BMI significantly predicted %BF among males
- BMI quadratic full models fit the data better than the BMI linear full models

Model	Adjusted R^2		AIC		BIC	
	Males	Females	Males	Females	Males	Females
BMI_Q quadratic full	0.6733	0.8262	302.48	419.40	317.03	434.66
BMI_M quadratic full	0.6694	0.8021	303.19	431.59	317.73	446.85

Regression analysis summary for BMI_Q and BMI_M quadratic full models for both sexes.

BMI_Q quadratic full model (Females)					
Variable	Observed coefficient, B	95% confidence interval	Bootstrap standard error	Z	*p*-value
(Constant)	–49.39	–71.28, –27.49	11.17	–4.42	<0.001
BMI_Q	4.48	2.55, 6.41	0.99	4.54	<0.001
BMI_Q^2	–0.08	–0.11, –0.04	0.02	–3.75	<0.001
Age	0.23	–0.02, 0.47	0.12	1.83	0.067
Smoking	0	Omitted			
Alcohol intake	–0.22	–0.88, 0.44	0.34	–0.65	0.515
WC	0.16	0.03, 0.29	0.07	2.34	0.020

BMI_M quadratic full model (Females)					
Variable	Observed coefficient, B	95% confidence interval	Bootstrap standard error	Z	*p*-value
(Constant)	–46.53	–68.32, –24.73	11.12	–4.18	<0.001
BMI_M	3.70	1.94, 5.46	0.90	4.12	<0.001
BMI_M^2	–0.06	–0.10, –0.03	0.02	–3.48	0.001
Age	0.23	–0.02, 0.48	0.13	1.77	0.076
Smoking	0	Omitted			
Alcohol intake	–0.06	–0.75, 0.63	0.35	–0.17	0.861
WC	0.25	0.13, 0.37	0.06	4.00	<0.001

RESULTS

Summary of measures of accuracy of BMI_Q and BMI_M in diagnosing overweight–obese.* The 95% CIs are indicated in parentheses.

Measure	BMI_Q		BMI_M	
	Males	Females	Males	Females
Sensitivity	97.5% (86.8%,99.9%)	100% (82.4%,100%)	97.5% (86.8%,99.9%)	100% (82.4%,100%)
Specificity	58.8% (40.7%,75.4%)	69.1% (58.9%,78.1%)	61.8% (43.6%,77.8%)	61.9% (51.4%,71.5%)
Positive predictive value (PPV)**	73.6% (59.7%,84.7%)	38.8% (25.2%,53.8%)	75% (61.1%, 86%)	33.9% (21.8%,47.8%)
Negative predictive value (NPV)**	95.2% (76.2%,99.9%)	100% (94.6%,100%)	95.5% (77.2%,99.9%)	100% (94%, 100%)
Likelihood ratio (+)	2.37 (1.58, 3.55)	3.23 (2.4, 4.35)	2.55 (1.66, 3.92)	2.62 (2.03, 3.38)
Likelihood ratio (–)	0.04 (0.01, 0.3)	0 (–)	0.04 (0.01, 0.3)	0 (–)

*Overweight–obesity is defined as ≥23.1% BF in males and ≥35.1% BF in females.

**The PPV and NPV were adjusted for known prevalence of overweight-obese based on %BF.

Females	0.9517 (0.9144, 0.9890)	0.9430 (0.9001, 0.9860)	BMI_Q: 25.1 (Sn = 95%, Sp = 89%) BMI_M: 26.3 (Sn = 89%, Sp = 89%)

CONCLUSION AND RECOMMENDATIONS

- Both BMI_Q and BMI_M significantly predicted %BF, with BMI_Q performing non-significantly better than BMI_M.
- Both BMI_Q and BMI_M are comparable in terms of discriminating between normal and overweight-obese weight classifications.

- We recommend future studies to determine if change in weight classification (based on BMI_M) has long-term health implications.
- We likewise recommend reproducing the study with a larger sample size across different age groups.

THANK YOU VERY MUCH!!


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