

## Chapter 4

### Results

Our study proposed New-HWDI and compared to Prior-HWDI and BMI. This study also showed the association between HWDI and BF%. The results of this study are presented in three sections include:

- 4.1 Participants characteristics
- 4.2 New criterion of HWDI (New-HWDI) for screening obesity status
- 4.3 Relationship between HWDI and BF%

The seal of Chiang Mai University is a circular emblem. It features a central figure of an elephant standing and facing left. Above the elephant is a sunburst or flame-like symbol. The entire emblem is encircled by a border containing the university's name in Thai script at the top and 'CHIANG MAI UNIVERSITY 1964' in English at the bottom.

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่  
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#### 4.1 Participants characteristics

All participants enrolled healthy Thai volunteers by way of invitation at the Faculty of Medicine, Chiang Mai University via public information posters and the hospital web site, between May 2010 and May 2011. Volunteers were people from the general community. We excluded volunteers whose age was less than 18 years old. The final analytical sample was composed by 2,771 participants.

Table 4.1 Population characteristics

Characteristics	Men		Women		<i>P</i> *
	n (%) or Median( IQR)		n (%) or Median( IQR)		
Overall	999	(36.1)	1,772	(64.0)	
Age, years	60	(47-68)	52	(43-60)	<0.001
18-39	148	(14.8)	311	(17.6)	
40-59	351	(35.1)	959	(54.1)	
≥60	500	(50.1)	502	(28.3)	
Weight, kg	63	(55-71)	56	(50-62)	<0.001
Height, cm	165	(160-170)	155	(150-158)	<0.001
BMI, kg/m <sup>2</sup>	23	(21-26)	24	(21-26)	0.310
Thin	67	(6.7)	115	(6.5)	
Normal	385	(38.5)	676	(38.2)	
Overweight	233	(23.3)	397	(22.4)	
Obese	314	(31.4)	584	(33.0)	
Body-fat percentage, %	27	(24-31)	34	(31-38)	<0.001
Thin	0	(0.0)	71	(4.0)	
Normal	250	(25.0)	973	(54.9)	
Overweight	376	(37.6)	549	(31.0)	
Obese	373	(37.3)	179	(10.1)	
Prior-HWDL,	101	(95-107)	98	(92-104)	<0.001
Thin	124	(12.4)	70	(4.0)	
Normal	594	(59.5)	1042	(58.8)	
Overweight	238	(23.8)	543	(30.6)	
Obese	43	(4.3)	117	(6.6)	

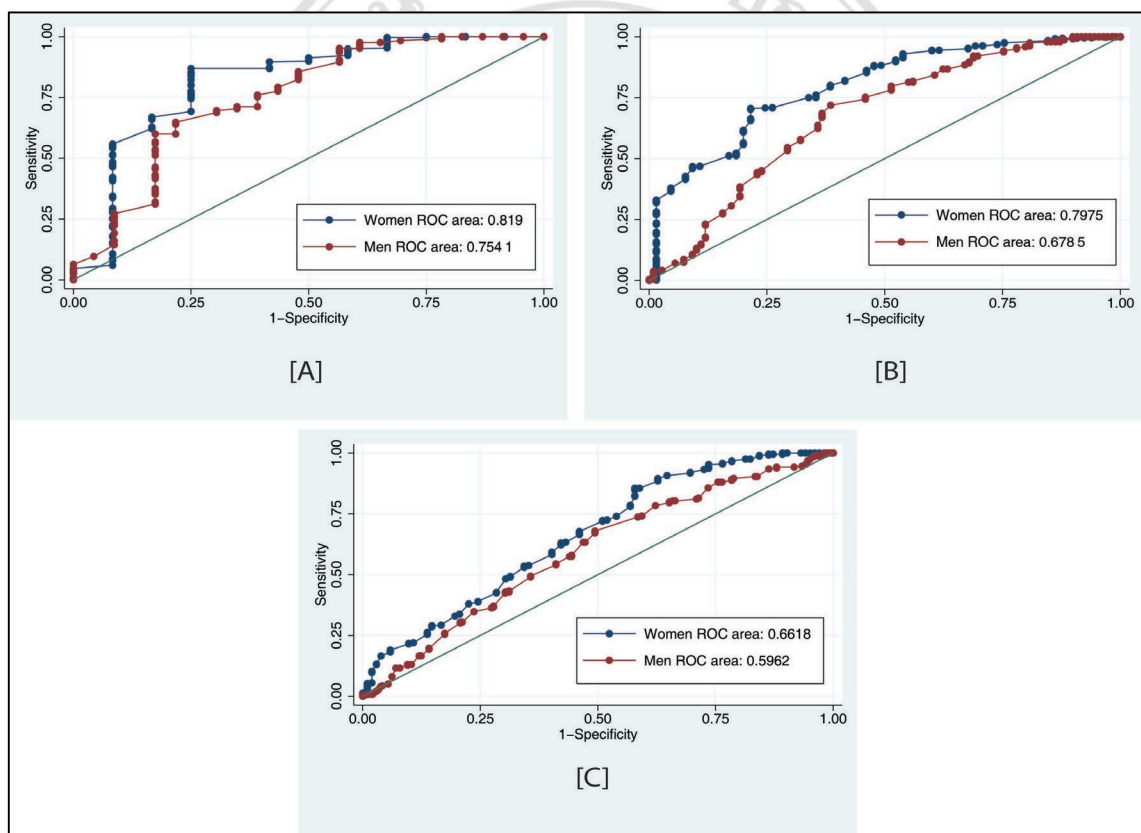
\*Wilcoxon rank-sum test

Of the 2,771 participants, 1,772 (64%) were women, and their characteristics were summarized in Table 1. The median age was 60 years (Interquartile range [IQR], 47-68)

in men and 52 years (IQR, 43-60) in women. Most of men were heavier and taller than women. Men had a median of BF% lower than women (27% and 34% respectively,  $P < 0.001$ ). The obese prevalence as defined by BMI, by BF% and by Prior-HWDI were 31%, 37% and 4% in men and 33%, 10% and 7% in women, respectively.

#### 4.2 New criterion of HWDI (New-HWDI) for screening obesity status

Sensitivity, specificity and area under the receiver operating characteristic curve (AUROC) were compared among markers to find new criterion of HWDI (New-HWDI) for screening obesity status, considering percent body fat as gold standard.



**Figure 4.1** Sensitivity and 1-specificity of New-HWDI cut-off [A] 18-39 years, [B] 40-59 years and [C]  $\geq 60$  years.

Figure 4.1 AUROC graph on the values of Sensitivity and 1-specificity of New-HWDI cut-off in three age groups as: [A] 18-39 years, [B] 40-59 years and [C]  $\geq 60$  years shows that women (blue line) occupies the area below AUROC graph which is higher than men (red line) in all three age groups. In age group 18-39 years the highest AUROC value of

0.819 is from women while from men the AUROC value is 0.754. For the age group  $\geq 60$  years the lowest AUROC value of 0.662 is from women while from men the AUROC value is 0.596.

Table 4.2 Sensitivity (Se), specificity (Sp), area under the receiver operating characteristic curve (AUROC) and Youden's Index for the selection of an optimal threshold value for the new criterion of HWDI for screening obesity status

Age	Men					Women				
	Se	Sp	AUROC	Youden's Index	New-HWDI cut-off	Se	Sp	AUROC	Youden's Index	New-HWDI cut-off
18-39	0.71	0.61		0.32	96	0.90	0.58		0.48	88
	0.70	0.70		0.39	97	0.87	0.58		0.45	89
	<b>0.65</b>	<b>0.78</b>	0.754	<b>0.43</b>	<b>98</b>	<b>0.87</b>	<b>0.75</b>	0.819	<b>0.62</b>	<b>90</b>
	0.64	0.78		0.42	99	0.85	0.75		0.60	91
	0.57	0.83		0.39	100	0.84	0.75		0.59	92
40-59	0.75	0.54		0.29	94	0.76	0.65		0.41	92
	0.75	0.54		0.29	95	0.71	0.75		0.46	93
	<b>0.72</b>	<b>0.61</b>	0.679	<b>0.33</b>	<b>96</b>	<b>0.71</b>	<b>0.78</b>	0.797	<b>0.49</b>	<b>94</b>
	0.67	0.63		0.31	97	0.66	0.78		0.44	95
	0.62	0.64		0.27	98	0.61	0.80		0.41	96
$\geq 60$	0.80	0.35		0.15	98	0.90	0.37		0.27	89
	0.78	0.38		0.16	99	0.89	0.37		0.27	89
	<b>0.68</b>	<b>0.51</b>	0.596	<b>0.19</b>	<b>100</b>	<b>0.86</b>	<b>0.42</b>	0.662	<b>0.28</b>	<b>90</b>
	0.68	0.51		0.18	101	0.85	0.42		0.27	91
	0.63	0.53		0.16	102	0.82	0.42		0.24	92

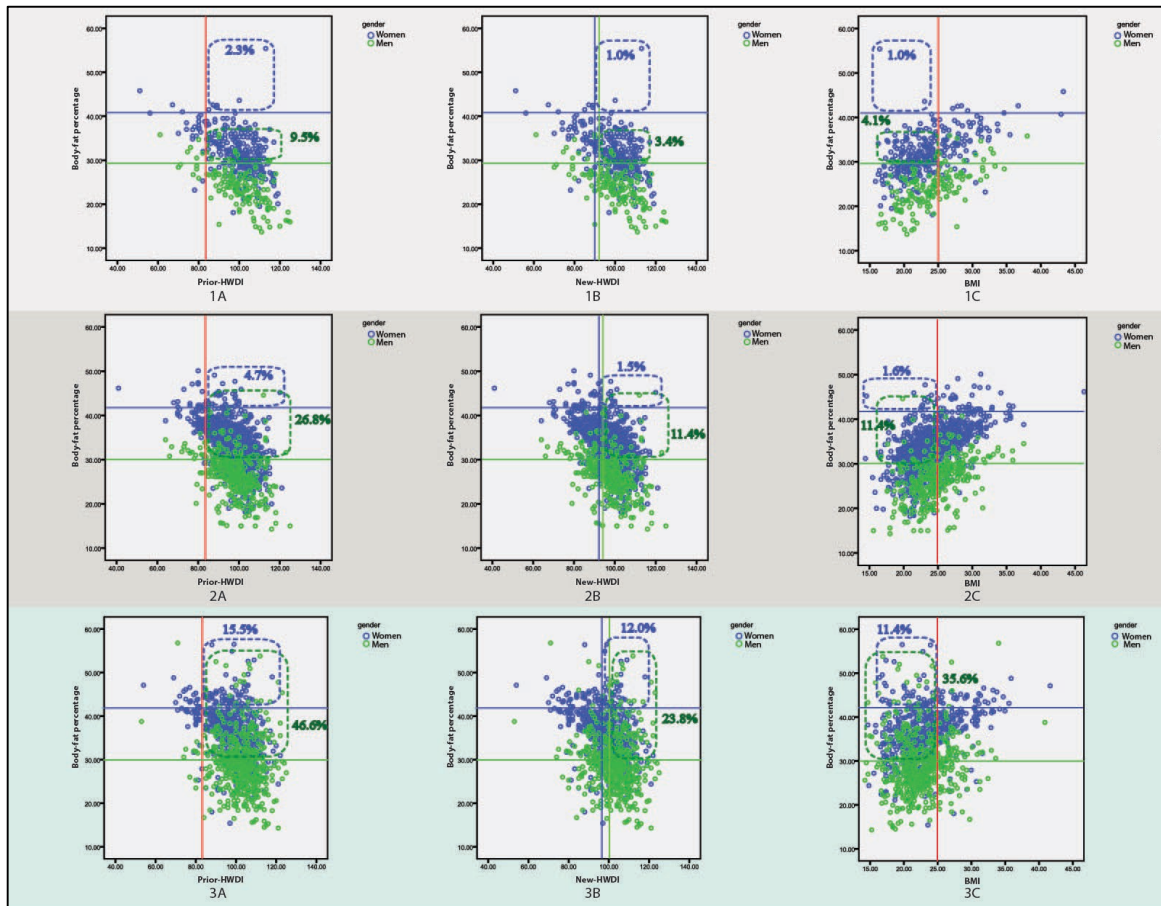
Table 4.2 demonstrates an optimal threshold value for the new criterion of HWDI for screening obesity status for each age group by gender. For men aged 18-39 years based on the Youden's index method, New-HWDI was 98. The sensitivity results demonstrated that 65% of those classified as obese by their measured New-HWDI were also classified as obese by BF% (Se=0.65). Specificity demonstrated that 78% of those not classified as obese by their measured New-HWDI were also not considered obese by their BF% (Sp=0.78). The New-HWDI for screening obesity status are  $<98$  in men and  $<90$  in women age between 18-39;  $<96$  in men and  $<94$  in women age between 40-59; and  $<100$  in men and  $<90$  in women age  $\geq 60$ .

Table 4.3 Evaluation consistency and Kappa statistics for obesity status among percent body fat vs. Prior-HWDI and vs. New-HWDI stratified by age and gender.

		Concordant n (%)		Discordant n (%)		Kappa
	Age (years)	Obese, Obese	Non-obese, Non-obese	Obese, Non-obese	Non- obese, Obese	
BF% vs BMI		253 (9.1%)	1574 (56.8%)	299 (10.8%)	645 (23.3%)	0.136
Men	18-39	17(11.5)	88(59.5)	6(4.0)	37(25.0)	0.286
	40-59	69(19.7)	159(45.3)	40(11.4)	83(23.6)	0.262
	≥60	63(12.6)	214(42.8)	178(35.6)	45(9.0)	0.089
Women	18-39	9(2.9)	232(74.6)	3(1.0)	67(21.5)	0.148
	40-59	50(5.2)	590(61.5)	15(1.6)	304(31.7)	0.140
	≥60	45(9.0)	291(58.0)	57(11.4)	109(21.7)	0.142
BF% vs Prior-HWDI		81 (2.9%)	2140 (77.2%)	471 (17.0%)	79 (2.9%)	0.152
	18-39	14(3.0)	404(88.0)	21(4.6)	20(4.4)	0.358
	40-59	35(2.7)	1097(83.7)	139(10.6)	39(2.3)	0.221
	≥60	32(3.2)	639(63.8)	311(31.0)	20(2.0)	0.079
BF% vs New-HWDI		311 (11.2)	1613 (58.2)	241 (8.7)	606 (21.9)	0.233
Men	18-39	18 (12.2)	81 (54.7)	5 (3.4)	44 (29.7)	0.255
	40-59	69 (19.7)	166 (47.3)	40 (11.4)	76 (21.7)	0.292
	≥60	122 (24.4)	176 (35.2)	119 (23.8)	83 (16.6)	0.187
Women	18-39	9 (2.9)	255 (82.0)	3 (1.0)	44 (14.2)	0.228
	40-59	51 (5.3)	593 (61.8)	14 (1.5)	301 (31.4)	0.147
	≥60	42 (8.4)	342 (68.1)	60 (12.0)	58 (11.6)	0.269

Table 4.3 demonstrates the most concordant values seen for age 18-39 years between classifications of obesity based on BF% versus BMI in both gender (Kappa=0.286 for men and 0.148 for women) and also based on BF% versus Prior-HWDI (Kappa=0.358). However, Kappa coefficient was small (<0.40), suggesting only fair agreement between these assessments. For all age groups, Kappa statistics were higher in men than women between classifications of obesity based on BF% versus BMI. For men age 18-39 years, there was agreement for 71% of the participants, 25% were misclassified as non-obese based on BF%, while meeting obesity criteria based on BMI. Only 4% were classified as obese based on BF%, but non-obese by BMI. For age 18-39 years, the concordance seen between classifications of obesity based on BF% versus Prior-HWDI. A total of 4.4% of participants were misclassified as non-obese by BF%, but were found to be obese by Prior-HWDI. In contrast, 4.6% were misclassified as obese by BF%, but were in fact non-

obese by Prior-HWDI. The most concordance seen for age 18-39 years between classifications of obesity based on New-HWDI versus BF% in men (Kappa=0.255) and the most concordance was seen for age  $\geq 60$  years in women (Kappa=0.269). Kappa statistics suggested only fair agreement between the two assessments.

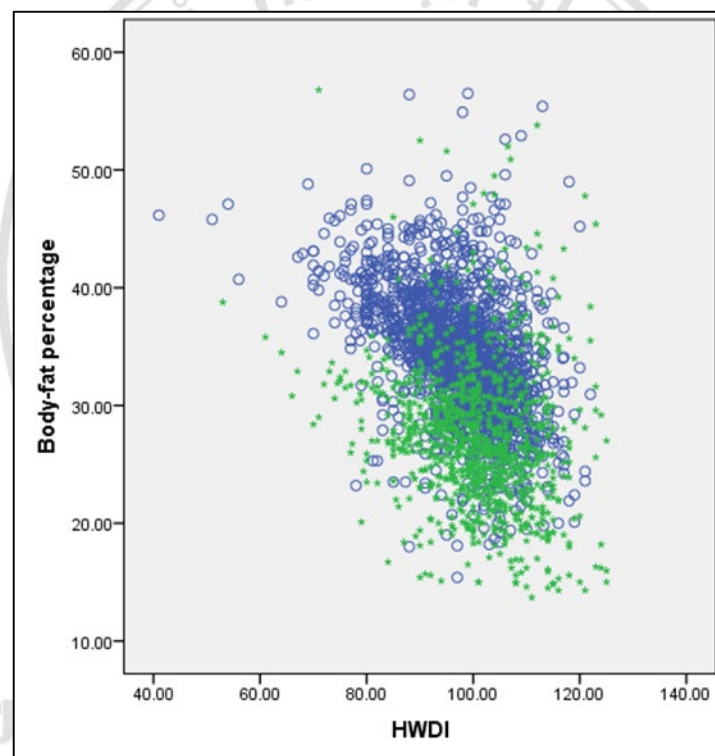


**Figure 4.2** Scatter plot between (A) Prior-HWDI, (B) New-HWDI and (C) BMI vs BF% stratified by gender (men in blue; women in green) and by age group (1) 18-39 years, (2) 40-59 years and (3)  $\geq 60$  years.

Figure 4.2 presents a scatter plot of (A) Prior-HWDI vs. BF%, (B) New-HWDI vs. BF% and (C) BMI vs. BF% classified by gender and by age group. For example for 1B: Women (blue) who fall above blue line are obese according to body-fat percentage. Men (green) who fall above green horizontal line are obese according to body-fat percentage. The upper right quadrant bordered by blue horizontal line (body-fat percentage  $> 40\%$ ) and blue vertical line (New-HWDI=90) demonstrates number of women misclassified as “non-obese” by the New-HWDI. Figure 2- (1A) (2A) and (3A) presented scatter plots

between Prior-HWDI and BF%. While considered underestimated value, cut-off of Prior-HWDI identified non-obese but BF% identified obese, found that men (green area) received an underestimated value higher than women (blue area) in all age groups and most found in men age 60 years or over. Figure 2- (1B) (2B) and (3B) presented scatter plots between New-HWDI and BF%, which's found that when compared with the Figure 2- (1A) (2A) and (3A), the proportion of underestimated values deceased, especially in men age 60 years or over (from 46.6% to 23.8%: Figure (3A) vs. (3B)).

#### 4.3 Relationship between HWDI and BF%



**Figure 4.3** Relationship between HWDI and body-fat percentage, (o) for women and (\*) for men.

#### *Relationship between HWDI and BF%*

Figure 4.3 shows the relationship between HWDI and BF%. Statistically, an inverse relationship between HWDI and BF% was found as HWDI increased while BF% value significantly decreased. Pearson's correlation coefficient ( $r = -0.200$  ( $p < 0.001$ )) was found for men and  $r = -0.473$  ( $p < 0.001$ ) for women. Furthermore, the relationship

between HWDI and BF% was statistically significant even when analyzed with respect to age group and gender ( $p < 0.001$ ).

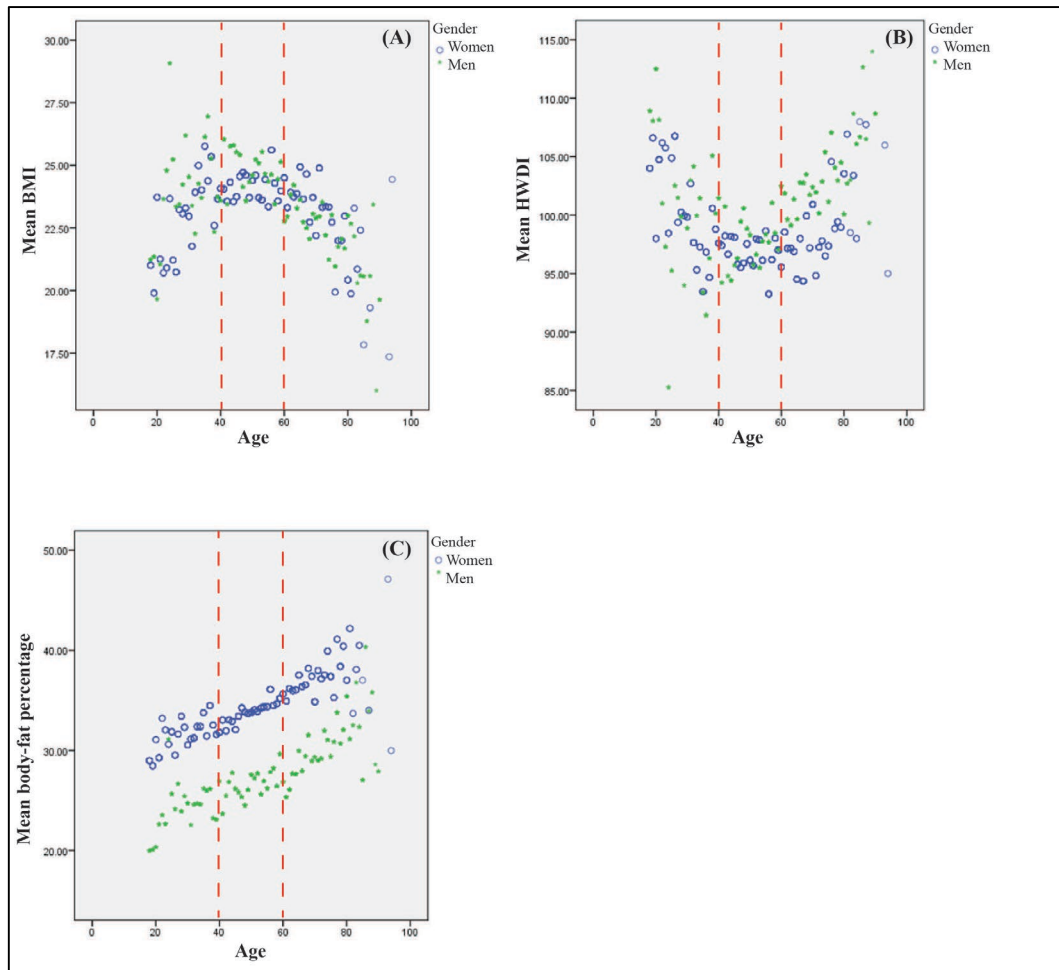
Table 4.4 Regression analysis for changes in BF% with HWDI, age and gender

Covariates	Regression Coefficients	Standard Error	p	SEE (%)	Adjusted R <sup>2</sup>
Overall			<b>&lt;0.001</b>	4.80	0.452
Intercept	48.267	1.000			
HWDI	-0.221	0.010	<b>&lt;0.001</b>		
Age	0.148	0.006	<b>&lt;0.001</b>		
Gender	-6.791	0.195	<b>&lt;0.001</b>		
Men			<b>&lt;0.001</b>	5.37	0.215
Intercept	34.508	1.784			
HWDI	-0.159	0.017	<b>&lt;0.001</b>		
Age	0.161	0.011	<b>&lt;0.001</b>		
Women			<b>&lt;0.001</b>	4.39	0.337
Intercept	53.35	1.210			
HWDI	-0.265	0.011	<b>&lt;0.001</b>		
Age	0.132	0.008	<b>&lt;0.001</b>		

p from Wald's test.  
p in bold correspond to  $p < 0.05$   
SEE = Standard Error of Estimate

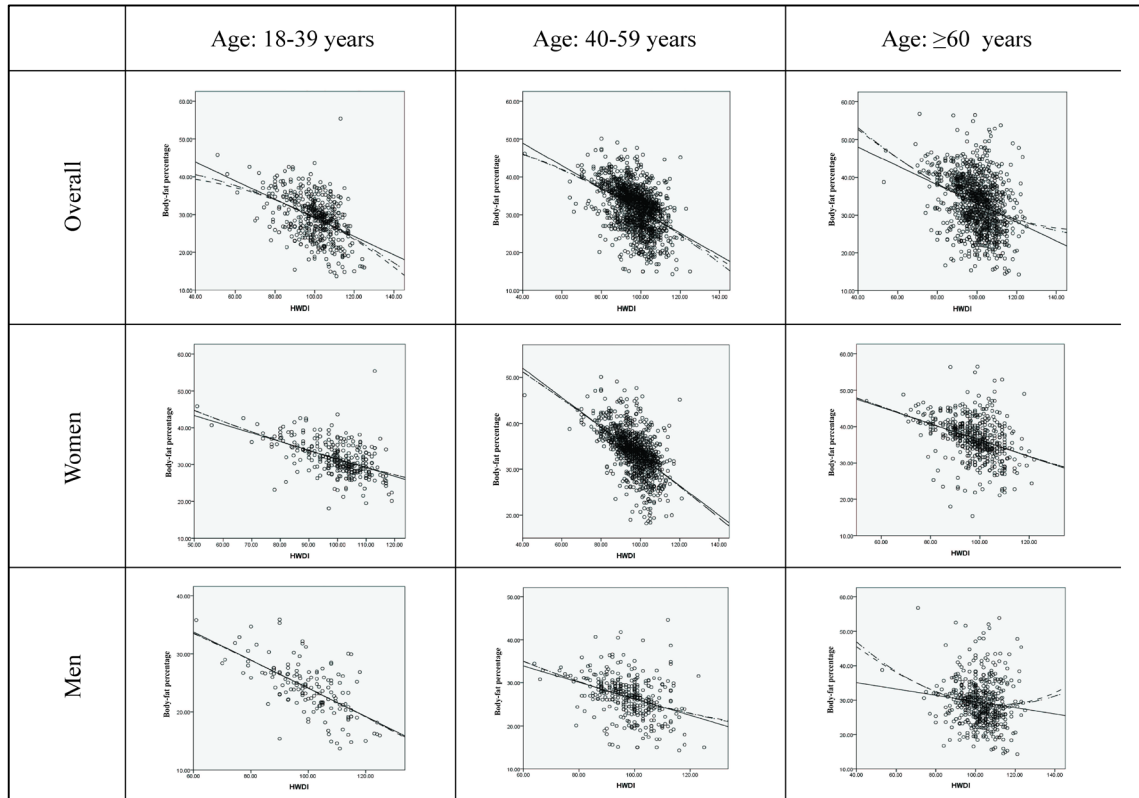
Table 4.4 show the effect of age and gender in the HWDI-BF% relationship age and gender were found to be significant predictor variables in the regression models ( $p < 0.001$ ), where gender contributing more effect to the relationship. The results of a multivariate linear regression analysis, which includes the HWDI and age variables, yielded a BF% for men of  $34.508 - 0.159 (HWDI) + 0.161 (age)$  [Adjusted R<sup>2</sup> = 0.215, Standard Error of Estimate (SEE) = 5.37%,  $p < 0.001$ ], and, for women,  $53.35 - 0.265 (HWDI) + 0.132 (Age)$  [Adjusted R<sup>2</sup> = 0.337, SEE = 4.39%,  $p < 0.001$ ]





**Figure 4.4** Relationship between (A) mean BMI and age, (B) mean HWDI and age, and (C) mean body-fat percentage and age, stratified by gender. , (o) for women and (\*) for men

Figure 4.4 shows the relationship between average BMI and age. It was found that, from age 18-39 years old, the mean BMI increases as age increases but, after reaching 60 years of age, the mean BMI decreases as age increases (see Figure 4.4-A). The reverse can be found for the relationship between mean HWDI and age.



**Figure 4.5** HWDI and body-fat percentage in relation to age and gender.

- Observed
- Linear
- Quadratic
- Cubic

### ***Predictive Modeling of BF% by Gender***

In this study, several forms of relationship between HWDI and BF% were studied: linear, quadratic, and cubic. However, Figure 4.5 shows that the relationship tended to be in linear form more than the others, and so we elected to use a linear form in the construction of the BF% prediction model. The results of a multivariate linear regression analysis, which includes the HWDI and age variables, yielded a BF% for men of  $34.508 - 0.159 (HWDI) + 0.161 (age)$  [Adjusted  $R^2 = 0.215$ , Standard Error of Estimate (SEE) = 5.37%,  $p < 0.001$ ], and, for women,  $53.35 - 0.265 (HWDI) + 0.132 (Age)$  [Adjusted  $R^2 = 0.337$ , SEE = 4.39%,  $p < 0.001$ ] (see Table 4.4)