QUANTITATIVE RESEARCH

Association of body mass index (BMI) and percent body fat among BMI-defined non-obese middle-aged individuals: Insights from a population-based Canadian sample

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ABSTRACT

OBJECTIVES: To evaluate the association between percent body fat (%BF) and body mass index (BMI) among BMI-defined non-obese individuals between 40 and 69 years of age using a population-based Canadian sample.

DATA AND METHODS: Cross-sectional data from the Canadian Health Measures Survey (2007 and 2009) was used to select all middle-aged individuals with BMI < 30 kg/m^2 (n = 2,656). %BF was determined from anthropometric skinfolds and categorized according to sex-specific equations. Association of other anthropometry measures and metabolic markers were evaluated across different %BF categories. Significance of proportions was evaluated using chi-squared and Bonferroni-adjusted Wald test. Diagnostic performance measures of BMI-defined overweight categories compared to those defined by %BF were reported.

RESULTS: The majority (69%) of the sample was %BF-defined overweight/obese, while 55% were BMI-defined overweight. BMI category was not concordant with %BF classification for 30% of the population. The greatest discordance between %BF and BMI was observed among %BF-defined overweight/obese women (32%). Sensitivity and specificity of BMI-defined overweight compared to %BF-defined overweight/obese were (58%, 94%) among females and (82%, 59%) among males respectively. According to the estimated negative predictive value, if an individual is categorized as BMI-defined non-obese, he/she has a 52% chance of being in the %BF-defined overweight/obese category.

CONCLUSION: Middle-aged individuals classified as normal by BMI may be overweight/obese based on measures of %BF. These individuals may be at risk for chronic diseases, but would not be identified as such based on their BMI classification. Quantifying %BF in this group could inform targeted strategies for disease prevention.

KEY WORDS: Obesity; body mass index; body fat percentage; adipose tissue

La traduction du résumé se trouve à la fin de l'article.

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Obesity is commonly measured using the body mass index scale (BMI, kg/m^2) in primary and subspecialty clinical settings and is classified according to the World Health Organization standardized thresholds: normal (BMI between 18.5 and 24.99 kg/m^2), overweight (BMI between 25.0 and 29.99 kg/m^2) and obese (BMI 30.0 kg/m^2 or more).[1,2] BMI is a low-cost, readily available measure[3] from which risk of incidence and progression of several chronic diseases are predicted according to clinical management guidelines.[4] Although used clinically, previous studies have shown that BMI does not necessarily reflect body composition in terms of percent body fat (%BF) across different populations.[5] However, the majority of studies have focused on association between BMI and %BF among high-risk patients, i.e., BMI-defined obese[6] or elderly,[7] and literature is scarce on the association of BMI and %BF in middle-aged non-obese patients.

Previous studies showed that middle-aged individuals between 40 and 69 years of age have a twofold increase in death rate from cerebrovascular events, ischemic heart disease, or other cardiovascular events compared to other age groups.[8,9] The reason for this increased risk may be due to the higher correlation of location-specific %BF and elevated levels of metabolic risk factors,[10] although this has not specifically been shown in middle-aged non-obese individuals. Increased body fat, regardless of BMI, may trigger metabolic dysfunction via chronic low-grade systemic inflammation[5] and prolonged exposure to systemic inflammatory factors like catabolic cytokines and adipokines.[8,11] Given the risks associated with the presence of excess body fat, the ability to identify patients with high levels of body fat, even in the presence of "normal-weight" or "overweight" BMI, is desirable.

The greatest discordance between BMI and body fat is speculated to be in overweight individuals (BMI between 25 and 29.99 kg/m^2), and this group is of particular interest as overweight individuals

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have longer survival and better quality of life compared to obese ($BMI > 30$ kg/m^2) individuals, and likely have not advanced to a clinical diagnosis of metabolic syndrome.[12] Specifically, understanding the relationship between the amount of body fat and chronic disease may help classify individuals at risk for metabolic syndrome (defined by the International Diabetes Foundation as having three of five indicators: high waist circumference [≥94 cm in males and ≥80 cm in females], elevated triglycerides [≥150 mg/dL or pharmaceutically managed], low HDL cholesterol levels [<40 mg/dL in males or <50 mg/dL in females, or pharmaceutically managed], high blood pressure [>130 mm Hg systolic or >85 mm Hg diastolic], raised fasting blood glucose [≥100 mg/dL]).[4,13] Metabolic syndrome is increasingly associated with a myriad of chronic diseases,[12] and there may be potential to develop targeted obesity staging strategies for opportunistic prevention in this population.

Understanding how BMI reflects %BF in a group of middle-aged (i.e., 40–69 years of age), BMI-defined non-obese individuals is critical to inform possible triaging strategies for individuals at increased risk of obesity-linked diseases such as metabolic disease, arthritis, sleep apnea, pain and cancer.[14] The purpose of this study was to compare and quantify the relationship between BMI and %BF for middle-aged BMI-defined non-obese individuals using a population-based Canadian sample.

DATA AND METHODS

Data source

The Statistics Canada Canadian Health Measures Survey (CHMS) is a population-based survey that represents approximately 96% of Canadians and was collected from 2007 to 2009 (cycle 1) and 2009 to 2011 (cycle 2), across Canada (n = approximately 11,000 individuals).[15] Data were collected via a voluntary, in-home general health survey and clinical mobile examination unit.[16] Our study population included middle-aged individuals 40–69 years of age. Individuals were excluded if they were pregnant, had undergone recent chemotherapy treatments, were diagnosed with hemophilia, neuromuscular or vertebral disorders, or had had an amputation or major surgery in the last three years.

Measures

BMI was calculated by dividing body mass (kilograms) by height^2 (metres^2), measured by personnel in the Statistics Canada mobile examination unit, and then classified according to WHO standardized thresholds: normal (18.5–24.99 kg/m^2), overweight (25.0–29.99 kg/m^2) and obese (30.0 kg/m^2 or more).[1,2] Anthropometric skinfold body fat measurements were acquired using calipers at four sites (triceps, biceps, subscapula, and iliac crest) in the mobile examination unit from individuals up to 69 years old, and with $BMI < 30$ kg/m^2. Therefore individuals with $BMI > 29.99$ kg/m^2 were not evaluated in this study. Body fat was calculated using sex-specific Durnin and Womersley equations[17] and was categorized as: athletic/good (males < 15%, females < 23%), acceptable (males 15%–20%, females 24%–30%) and overweight/obese (males > 21%, females > 31%).

For the secondary analysis, several metabolic markers were also acquired for the population of our study. Serum high-density lipoprotein (HDL) level was quantified from serum samples collected in the mobile examination unit. Self-reported positive high total cholesterol diagnosis and high blood pressure were assessed from responses on the household questionnaire. Here, none of the individuals assessed had a clinical metabolic syndrome diagnosis[12] and therefore metabolic syndrome was not controlled for in this analysis.

Statistical analysis

Age, sex, anthropometric measures (BMI, %BF, waist circumference, waist to height ratio, and average absolute weight change from the lowest to the highest adult weight from 18 years of age onward) and metabolic indicators (serum high-density lipoprotein levels, high cholesterol diagnosis, high blood pressure) were compared within %BF classification and between BMI and %BF classification from eligible individuals using a chi-squared test for independence using Stata (version 13). Sample estimates were weighted, and bootstrapped standard errors (based on 500 replications) were calculated to account for the survey design as per Statistics Canada procedures.[16] These were used to calculate 95% confidence intervals (CI) for percentages of the sample within each strata according to BMI and %BF categorization.

Discordance was defined as the percentage of individuals with normal BMI and overweight/obese %BF, overweight BMI and acceptable %BF, and overweight BMI with athletic/good %BF. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the BMI-defined categories in comparison with those according to %BF definition were calculated.

RESULTS

A total of 2,656 individuals aged 40–69 years and with $BMI < 30$ kg/m^2 were included in the analysis and described in the demographic data (Table 1). The mean age of the entire study population was 52.5 years and approximately 52% of all study participants were female. The percentage of females was significantly higher in the overweight/obese %BF-defined category compared to the athletic/good or acceptable categories (p-value < 0.01). Mean BMI for all participants was 25.3, while mean value for %BF was 27.5. Both BMI and %BF were significantly different across %BF categories (p-value < 0.0001), and there was a positive relationship between BMI and %BF ($p < 0.001$).

Table 2 shows the percentages within each strata for BMI and %BF-defined categories. Overall, 47.2% (43.9–50.5) were overweight as defined by both BMI and %BF. Few individuals in our population had an athletic/good classification based on the %BF scale (7%). Only 6.1% (4.7–7.8) were athletic/good as defined by %BF, which was also normal as defined by BMI; and 17.4% (14.9–20.1) were classified as acceptable by %BF, which were classified as normal according to BMI. Among females, 42.5% (38.6–46.5) were overweight by both BMI and %BF, while among males, 52.1% (47.2–56.9) were overweight as defined by both BMI and %BF.

As shown in Table 3, overall, 68% of the population was %BF-defined overweight/obese while 55% were BMI-defined overweight. Table 3 also shows the discordance, sensitivity, specificity, NPV and PPV of BMI-defined categories in comparison with %BF-defined overweight/obese categories. As shown, there was a sex-specific discordance between BMI and %BF classifications (Table 3). Approximately 27% of men and 32%

Table 1. Measures of body mass index (BMI) and body fat percentage (%BF) among the study population

Measures*	Overall (*n* = 2656)†		Body fat category‡ Athletic/good (*n* = 175)		Acceptable (*n* = 661)		Overweight/obese (*n* = 1820)		*p*-value§
	Mean	SE‖	Mean	SE	Mean	SE	Mean	SE	
Age (years)	52.5	0.21	52.1	0.76	52.8	0.35	52.5	0.32	0.76
Females (%)	51.5	0.83	36.9	5.39	46.2	2.27	54.8	1.23	<0.01
BMI (kg/m^2)	25.3	0.10	21.2	0.23	23.6	0.17	26.3	0.09	<0.0001
%BF	27.5	0.19	15.2	0.45	22.4	0.24	30.6	0.17	<0.0001

* Demographics and obesity measures from sample of respondents from Canadian Health Measures Survey (CHMS).
† Sample sizes (*n*) represent normalized weight counts.
‡ Definition for body fat categories: Athletic/good: for males 5%–15%, for females 8%–23%; Acceptable: for males 15%–20%, for females 24%–30%; Overweight/obese: males > 21%, females > 31%.
§ *p*-value for categorical variables based on an adjusted Pearson chi-squared test for independence; *p*-value for continuous variables based on Bonferroni-adjusted Wald *F* test.
‖ SE: Balanced repeated replication generated standard errors between values from each body fat category. Standard error estimates generated using 500 bootstrap replications.

Table 2. Body fat percentage (%BF) categories versus body mass index (BMI) category classification by sex

%BF categories (*n* = 2656)	BMI categories Normal (BMI < 25 kg/m^2)		Overweight (BMI 25–29.99 kg/m^2)		*p*-value*
	n	Percentage (95% CI)	*n*	Percentage (95% CI)	
Women (*n* = 1367)					
Athletic/good	64	4.7% (3.4–6.4)	0	0% (0–0)	0.001
Acceptable	285	20.8% (17.6–24.5)	21	1.0% (1–2.5)	
Overweight/obese	416	30.4% (26.2–35)	581	42.5% (38.6–46.5)	
Men (*n* = 1289)					
Athletic/good	97	7.5% (5.1–10.9)	13	1% (0.5–2.2)	0.001
Acceptable	177	13.7% (11.2–16.6)	179	13.9% (11.3–16.9)	
Overweight/obese	151	11.7% (8.5–15.9)	672	52.1% (47.2–56.9)	
Overall (*n* = 2656)					
Athletic/good	161	6.1% (4.7–7.8)	13	0.5% (0.2–1.1)	0.001
Acceptable	462	17.4% (14.9–20.1)	200	7.5% (6.1–9.1)	
Overweight/obese	567	21.3% (18.3–24.7)	1253	47.2% (43.9–50.5)	

* *p*-value based on an adjusted Pearson chi-squared test for independence performed for comparison of each %BF category across BMI categories.

Table 3. Prevalence and discriminative ability of BMI-defined overweight compared to body fat-defined overweight/obese categorization

	Prevalence (%BF-defined overweight/obese)	Prevalence (BMI-defined overweight)	Discordance	Sensitivity	Specificity	PPV	NPV
Women (*n* = 1367)	72.9%	44.0%	32.0%	58.3%	94.3%	96.5%	45.6%
Men (*n* = 1289)	63.8%	67.0%	26.6%	81.7%	58.8%	77.8%	64.5%
Overall (*n* = 2656)	68.5%	55.2%	29.4%	68.8%	74.5%	85.5%	52.4%

Note: PPV = positive predictive value; NPV = negative predictive value.

of women demonstrated discordance between BMI and %BF classifications. The greatest discordance between %BF and BMI was observed in the subgroup of overweight/obese %BF and healthy BMI women (~30% discordance). Fourteen percent of men with BMIs classifying them as overweight ($25 \le BMI < 30$) had acceptable %BF (15%–20%), and 12% of men with a normal BMI ($18.5 \le BMI < 25$) were classified as overweight/obese according to %BF (>21%). Overall, 21% of the sample was classified as normal by BMI, but overweight or obese by %BF.

As shown in Table 3, sensitivity and specificity of BMI-defined categorization for the overall sample were 68.8% and 55.2%. Additionally, PPV and NPV were 85.5% and 52.4% respectively. The value of PPV indicates that, according to our data, if a middle-aged individual is categorized as BMI-defined overweight, there is an 85.5% chance he/she will be within the %BF-defined overweight/obese category. On the other hand, the value for NPV indicates that if an individual is categorized as BMI-defined non-obese, she/he has around a 52% chance of being within the %BF-defined overweight or obese category.

Furthermore, Table 3 also shows the discriminative abilities of BMI-defined categorization with respect to %BF classifications for males and females, separately. Sensitivity and specificity of

Table 4. Metabolic markers across body fat and BMI categories among the study population

Metabolic markers*	Overall (n = 2656)		Body fat category: Athletic/good (n = 174)		Acceptable (n = 662)		Overweight/ obese (n = 1820)			BMI: Normal (n = 1190)		Overweight (n = 1466)		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	p-value	Mean	SE	Mean	SE	p-value
HDL (mmol L^{-1})	1.44	0.02	1.59	0.03	1.55	0.03	1.38	0.02	<0.01	1.46	0.05	1.41	0.07	0.12
High blood pressure (%)	16.6	1.15	9.4	2.36	12.8	2.28	18.7	1.38	0.02	15.2	2.1	16.2	2.3	0.31
High total cholesterol (%)	24.4	1.3	9.3	2.4	20.9	2.05	27.1	1.54	<0.01	22.7	2.3	25	2.5	0.29

Note: HDL = high-density lipoprotein.
* Metabolic marker data of the sample from Canadian Health Measures Survey (CHMS) cycles 1 and 2.

BMI-defined overweight compared to %BF-defined overweight/ obese was (58%, 94%) among females and (82%, 59%) among males respectively. The fact that sensitivity among females and specificity among males show a low value indicates lack of discriminative ability of BMI- defined categorization. According to these results, 58.3% of females who are BMI-defined overweight are in fact %BF-defined overweight/obese, while 58.8% of males who are %BF-defined non-obese/overweight are BMI-defined normal.

In the secondary analysis, risk factors including HDL, high blood pressure and high total cholesterol were examined across %BF and BMI groups. As shown in Table 4, all three metabolic measures are significantly different across %BF categories and are increasing from athletic/good to overweight/obese categories (p-values < 0.01). On the other hand, none of the metabolic measures were significantly different across BMI groups for normal and overweight (all p-values > 0.05). As shown, increases in %BF were associated with metabolic risk markers, including reduced HDL levels, increased blood pressure, and elevated cholesterol ($p < 0.05$).

DISCUSSION

The aim of this study was to compare the discordance between %BF and BMI classification systems among middle-aged healthy and overweight Canadians from a representative national population sample. Our findings suggest that BMI, which is the most commonly used measure of obesity, may not be a good indicator for body fat in this population as its negative predictive value with respect to %BF classification was shown to be low; i.e., middle-aged individuals classified as normal BMI had a 52% chance of being within the overweight/obese %BF category. Furthermore, we found that sensitivity and specificity of BMI-defined overweight in terms of %BF classification were low for females and males respectively.

The unique contribution of this study was to shed light on the weak association of BMI and %BF among a subpopulation of middle-aged non-obese individuals. While the majority of studies have evaluated the association of BMI and %BF among obese or elderly populations,[18] this association has rarely been studied among the rather "healthy" subpopulation of middle-aged non-obese. Furthermore, the results of our study highlight the importance of triaging strategies that consider measures other than single BMI outcomes among this subpopulation to identify those at increased risk of metabolically-linked diseases who can benefit most from prevention strategies and further interventions. Future studies need to evaluate obesity staging strategies, including measurement of %BF at different body sites,[14] in addition to combining BMI with laboratory measures and other comorbidities[19] to assess the risk of developing chronic diseases. For instance, chronic disease risk staging strategies, including Edmonton Obesity Staging System in Canada[14] and the King's Obesity Staging Criteria in the UK,[20] have been developed to better characterize individuals with obesity in terms of actual clinical risk. Finally, from the health policy perspective, our study sheds light on the need for future health economics studies to evaluate implementations of such obesity staging systems within the primary care settings targeted at middle-aged non-obese individuals.

According to our results, increases in %BF were associated with metabolic risk markers, including reduced HDL levels, increased blood pressure, and elevated total cholesterol, however these markers were not significantly different across normal and overweight BMI categories. Authors in a previous study evaluated cardiovascular risk factors in the CHMS data with different exclusion criteria and found that, among normal weight men and women, abdominal obesity measures were associated with increased odds of cardiovascular risk factors.[9,21] Our findings indicated a substantial discordance between BMI and %BF classifications in normal and overweight BMI individuals, thereby complementing this previous work, with a focus on a group that has longer survival and better quality of life compared to obese (BMI ≥ 30.0 kg/m^2) individuals.[12] Similarly, in the NHANES cohort, despite good positive associations with lean and fat mass, BMI failed to discriminate between lean and fat mass, and was particularly limited in overweight BMI individuals.[13] Taken together, these international datasets indicate that the discordance between BMI and %BF may be affecting at least 30% of individuals in these two survey populations.

The observed discordance between BMI and body fat found here in normal BMI individuals signifies the understanding of the relationship between BMI and body fat, which may in turn provide opportunities for design of new prevention strategies targeted at normal weight middle-aged Canadians. As discussed in other studies, the link between %BF or BMI and health risk can be confounded by many factors, including nature and location of body fat, other comorbidities and age.[10,22] For instance, increased body fat percentage has been inversely associated with major cardiovascular failure in some studies,[21] while other studies have reported that increased %BF was associated with increased risk of heart failure.[23] Similarly in our analysis, we showed that among non-obese middle-aged individuals, risk factors for metabolic-related measures, including reduced HDL, high cholesterol and high blood pressure, were associated with higher %BF categories and not BMI groups. This is consistent with previous findings in population-based cohorts.[6]

According to our results, sensitivity of BMI-defined categorization was low among females (58.3%), while specificity was low among males (58.8%). Sex differences in terms of BMI definition for overweight categorization within a middle-aged population can cause significant shortcomings in clinical settings.[7] The majority of clinical management guidelines are based on BMI categorization, and therefore, future studies need to be aimed at evaluating cost-effectiveness of measurement tools to evaluate %BF for which validated sex-specific categorization can be performed.[6]

Our results are consistent with previous findings defining an "at risk" subpopulation within the US general population[24] – those with overweight/obese body fat, but normal BMI.[13,24] The CHMS dataset is more recent (2007–2011) than the equivalent US results, and it confirms the findings seen in the US cohort, which indicate that a BMI ≥ 30 kg/m^2 cutoff misclassifies more than half of the people with excess body fat.[13] Although North Americans share similar lifestyles, the differences between the US and Canadian health care systems warrant investigation in both cohorts. Furthermore, the current findings are consistent with previous work demonstrating that BMI is inadequate to predict %BF in a US female population.[12,13,22,25,26] Our findings are consistent with sex-specific misclassifications previously reported in the literature.[27] BMI and %BF classifications were concordant for obesity in 1,876 out of the 2,656 (70%) people. Of interest, few women demonstrated an overweight BMI with an acceptable or athletic/good %BF, whereas this specific discordance was more common in men.

Limitations

This study has several limitations. First, because none of the descriptors for BMI and %BF categories were combined, there could be incorrect categorization within all groups. This work was limited to the above combinations of groups because of Statistics Canada reporting requirements for minimum cell counts of 10 to ensure anonymity. High blood pressure and cholesterol diagnosis were self-report outcomes and were assessed from the responses on the household questionnaire, and other measures related to metabolic syndrome were not captured in the CHMS data. Additionally, measures for ethnicity and income variables were not included in the CHMS data set used for this study. Further, anthropometric skinfold measurements have been shown to underestimate %BF compared to methods such as dual energy X-ray absorptiometry, but DXA is probably not a feasible measure to use routinely, largely due to machine availability and cost.[28] Previous work has demonstrated a stronger correlation with visceral adipose tissue than subcutaneous adipose tissue and metabolic risk. As subcutaneous adipose tissue was measured here by anthropometric skinfold, this suggests that our study is estimating percent body fat conservatively, and therefore conservatively estimating discordance.[29] Finally, although risk for cardiovascular disease or all-cause mortality was not evaluated in the current study, our findings complement previous work by Shields and colleagues who found that measures of abdominal adiposity are associated with increased odds of chronic disease, specifically CVD risk factors, in normal and overweight BMI people.[24]

CONCLUSION

According to the results of our study, BMI measure has a low sensitivity in terms of identifying those with high %BF among middle-aged non-obese individuals. Furthermore, we have shown that increases in %BF, and not BMI, were associated with metabolic risk markers. Our results highlight the need for future studies to better understand the interplay of body fat and chronic disease risk and to evaluate the cost-benefit of implementing obesity staging systems using combined measures of body fat and other risk factors. Such strategies targeted at middle-aged non-obese individuals implemented at the primary care settings could identify those who may benefit most from obesity prevention strategies. Future studies need to evaluate the cost-effectiveness of low-cost tools that evaluate adiposity, such as skinfold anthropometry that was used in this study or other measures such as waist circumference, or DXA.[28] Quantifying percent body fat among middle-aged normal weight individuals, in addition to other measures within obesity staging systems,[30] could inform targeted strategies for disease prevention aimed at improving outcomes that may otherwise escape detection.

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RÉSUMÉ

OBJECTIFS : Évaluer l'association entre l'indice de masse grasse (IMG) et l'indice de masse corporelle (IMC) chez des personnes âgées de 40 à 69 ans, non obèses selon la définition de l'IMC, à l'aide d'un échantillon populationnel canadien.

DONNÉES ET MÉTHODE : À partir des données transversales de l'Enquête canadienne sur les mesures de la santé (2007 et 2009), nous avons sélectionné toutes les personnes d'âge moyen ayant un IMC < 30 kg/m^2 ($n = 2\ 656$). L'IMG de ces personnes a été déterminé à partir de mesures anthropométriques des plis cutanés et catégorisé à l'aide d'équations sexospécifiques. Les associations avec d'autres mesures anthropométriques et indicateurs métaboliques ont été évaluées pour différentes catégories d'IMG. Le caractère significatif des proportions a été analysé en utilisant le test du khi-carré et le test de Wald corrigé à l'aide de la technique de Bonferroni. Nous avons fait état des indicateurs de performance diagnostique des catégories de surpoids définies selon l'IMC comparées à celles définies selon l'IMG.

RÉSULTATS : La majorité (69 %) de l'échantillon était en surpoids ou obèse selon la définition de l'IMG, tandis qu'une proportion de 55 % était en surpoids selon la définition de l'IMC. Pour 30 % de la population, la catégorie d'IMC ne concordait pas avec la classification de l'IMG. La plus grande discordance entre l'IMG et l'IMC a été observée chez les femmes définies comme étant en surpoids ou obèses selon l'IMG (32 %). La sensibilité et la spécificité de la définition du surpoids selon l'IMC comparativement à la définition du surpoids ou de l'obésité selon l'IMG étaient de (58 %, 94 %) chez les femmes et de (82 %, 59 %) chez les hommes, respectivement. Selon la valeur prédictive négative estimative, si une personne est catégorisée comme n'étant pas obèse selon la définition de l'IMC, cette personne a une probabilité de 52 % de faire partie de la catégorie de surpoids ou d'obésité selon la définition de l'IMG.

CONCLUSION : Les personnes d'âge moyen classifiées comme ayant un IMC normal pourraient être en surpoids ou obèses selon les indicateurs de l'IMG. Ces personnes peuvent être vulnérables aux maladies chroniques, mais ne seraient pas identifiées comme telles d'après leur IMC. La quantification de l'IMG dans ce groupe pourrait éclairer des stratégies ciblées de prévention des maladies.

MOTS CLÉS : obésité; indice de masse corporelle; indice de masse grasse; tissu adipeux