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# Is a small muscle mass index really detrimental for insulin sensitivity in postmenopausal women of various body composition status?

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**Abstract**

**Objectives:** We sought to determine if a small muscle mass index (MMI) is actually detrimental for insulin sensitivity when studying a large group of postmenopausal women displaying various body composition statuses and when age and visceral fat mass (VFM) are taken into account. **Methods:** A cross-sectional study was conducted in 99 healthy postmenopausal women with a BMI of 28±4 kg/m$^2$. Fat mass and total fat-free mass (FFM) were obtained from DXA and VFM and MMI were estimated respectively by the equation of Bertin and by: Total FFM (kg)/height (m)$^2$. Fasting plasma insulin and glucose were obtained to calculate QUICKI and HOMA as an insulin sensitivity index. **Results:** Total MMI and VFM were both significantly inversely correlated with QUICKI and positively with HOMA even when adjusted for VFM. A stepwise linear regression confirmed Total MMI and VFM as independent predictors of HOMA and plasma insulin level. **Conclusions:** A small muscle mass might not be detrimental for the maintenance of insulin sensitivity and could even be beneficial in sedentary postmenopausal women. The impact of muscle mass loss on insulin sensitivity in older adults needs to be further investigated.

**Keywords:** Fat-free Mass, Visceral Fat Mass, Type 2 Diabetes, Menopause, Sarcopenia

## Introduction

The increasing rate of metabolic abnormalities such as type 2 diabetes is perhaps the most important social and financial problem facing our society. It is an uncompromising problem associated with considerable disability, morbidity and functional decline. Furthermore, the loss of muscle mass and function, insulin resistance and obesity that accompanies aging may contribute to these disabilities and morbidities.

Thus, insulin resistance is a state where an increased concentration of plasma insulin is required to exert its normal biologic response[1]. It has been shown to increase with menopause transition[2] and to be associated with alterations in body fat distribution[3]. Insulin resistance has also been shown to increase the risk of developing metabolic abnormalities such as glucose intolerance, atherosclerosis, type 2 diabetes, hypertension, dyslipidemia, and cardiovascular diseases[4], all of which can affect functional capacity and quality of life of postmenopausal women.

Skeletal muscle mass is the major site of insulin stimulated glucose uptake and has been reported to account for more than 85% of the total glucose uptake under insulin stimulated conditions such as a hyperinsulinemic-euglycemic clamp technique[5]. For this reason, it is widely reported and purported that a large skeletal muscle mass may be an important determinant of insulin sensitivity. In the same line, it is also believed that the age-related decrease in muscle mass[6], would be detrimental to insulin sensitivity in postmenopausal women. However, studies demonstrating a clear positive and direct association between muscle mass and insulin sensitivity or glucose tolerance in older adults are scarces.

Indeed, even if some studies conducted over the past years have recognized that a high fat-free mass (mostly lean body mass) is associated with a high level of insulin sensitivity or glucose tolerance[38-40], some studies found no association between skeletal muscle mass and either glucose tolerance or in-

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sulin sensitivity[7,8], and some others found that a higher skeletal muscle mass is positively associated with a large number of metabolic alterations (insulin resistance or type 2 diabetes)[9-13]. Moreover and interestingly, a close look at these studies conducted in postmenopausal women showed that: 1) among studies finding no association between skeletal muscle mass and glucose tolerance and insulin sensitivity, one was conducted with overweight and obese postmenopausal women[7] while the other with non-obese postmenopausal women only[8] but both adjusted for VFM and 2) all studies finding a positive relation between a higher muscle mass and metabolic alterations were conducted among overweight and obese postmenopausal women[9-13] but none were adjusted for visceral fat mass, a major predictor of insulin resistance[10,11,41].

Thus, to the views of these inconsistencies the question concerning the relation between skeletal muscle mass remains to be addressed with a group displaying various body composition statuses while adjusting for visceral fat mass.

To the best of our knowledge, this will be the first study to examine the potential magnitude and direction of the association between skeletal muscle mass and insulin sensitivity in postmenopausal women displaying a wide range of muscle and fat mass, when both age and visceral fat mass are taken into account.

## Methods

*Subjects*

Ninety-nine (99) postmenopausal women aged 48 to 75 years (mean±SD age: 63±6 years) were recruited by the use of advertisements in local newspaper in Sherbrooke, Quebec (Canada) to participate in studies conducted in our laboratory starting in November 2007. To be included in the study, subjects had to meet the following criteria: being healthy, having a body mass index (BMI) superior to 18.50 kg/m$^2$ (BMI range: 18.75-44.60 kg/m$^2$ and mean±SD: 28.26±4.18 kg/m$^2$), without any major physical incapacity and without hormonal replacement therapy (HRT; at the time of the study, women had never been on HRT or off HRT for at least one year), having a sedentary life (any participation in structured physical activities during the previous year), being weight stable (±2 kg) for at least six (6) months prior to the study, non-smokers, moderate drinker (max 15 g of alcohol/day; the equivalent of one alcoholic beverage per day), having no medication that could influence glucose or lipid metabolism and absence of menses for the past twelve (12) months. A phone interview was conducted to screen for the aforementioned inclusion criteria. After subjects were thoroughly explained the nature and goals of the study, they provided written informed consent. Protocols were approved by the Ethics Committee of the Sherbrooke University Geriatric Institute.

*Study procedures*

After a phone screening, subjects were invited for a visit at the Research Centre on Aging (Sherbrooke University Geriatric Institute). Upon arrival (7:00 am), a 12-h fasting blood sample (fasting plasma glucose and insulin level) was obtained followed by measures of body composition such as body weight, height, body mass index (BMI), fat mass, Total Fat-free mass (Total FFM), appendicular Fat-free mass (FFMapp), Total muscle mass index (Total MMI), appendicular muscle mass index (MMIapp) and visceral fat mass (VFM).

*Body composition measurements:*

Body weight was determined to the nearest 0,2 kg using an electronic scale (SECA707. Hambourg. Germany) and height was measured using a tape measure fixed to the wall with the subject in stocking feet. Body mass index (BMI) was calculated as body weight (kg) relative to height$^2$ (m). Determination of fat mass, percentage of total fat mass (%FM) and Fat-free mass (Total FFM and FFMapp) were assessed in a supine position by the use of dual energy X-ray absorptiometry (DXA; GE Prodigy Lunar. Madison. WI. USA). In our laboratory, the coefficients of variations for repeated measures of fat mass (FM) and Total Fat-free mass (Total FFM) in ten (10) adults (measured one week apart) are 5.7% and 1.1% respectively[15]. Total Fat-free mass is defined herein as the mass of tissue representing soft tissue exclusively (mineral body mass excluded).

Total and appendicular Muscle Mass Index (Total MMI and MMIapp)

Total MMI[16] is generally used as an index of sarcopenia due to its relation to functional capacity declines with aging and is calculated as Fat-free mass (FFM) (kg) relative to height (m$^2$):

$$\textbf{Total MMI} = \textbf{Total FFM (kg)} / \textbf{height (m)}^2$$

We intentionally used Total Fat-free mass (Total FFM) in the calculation of Total MMI because it has been demonstrated that trunk muscle is highly important to prevent the loss of functional capacity with aging[17].

To confirm the robustness of our results based on Total MMI, we also used other index of muscle size such as appendicular muscle mass index (MMIapp).

$$\textbf{MMIapp} = \textbf{FFMapp (kg)} / \textbf{height (m)}^2$$

Estimated Visceral Fat Mass (VFM)

VFM was estimated by the following equation developed by Bertin et al.[18]:

$$\frac{\textbf{79.6} * \{\textbf{SD (cm)} - [(\textbf{TED (cm)} - \textbf{TID (cm)})/2] * \textbf{TID}\}}{\textbf{Height (cm)}}$$

(SD= sagital diameter; TED= transverse external diameter; TID= transverse internal diameter).

SD represents the distance between the back and the highest point of the abdomen and it is assessed using a sagittometer. The transverse external diameter (TED) and the transverse internal diameter (TID) are two abdominal transverse diameters that have been defined on the DXA scan for the estimation of VFM. TED corresponding to the abdominal width measured three pixels (3.6 cm) above the upper end of the iliac crests (umbilical level) whereas TID, which was the lean core of the

abdomen stripped of the subcutaneous adipose tissue at the same level than TED. TID corresponded therefore to TED without the subcutaneous fat width (SFW) present on each side of the abdomen. SFW was equal to half of the difference between these two diameters[18].

It is worth noting that this measure of VFM by DXA was shown to present a correlation of r=0.94 (p<0.0001) with CT scan data obtained in overweight women[18].

*Blood collection and biochemical analyses*

Blood samples were obtained in the morning, after a 12-hour fast. Venipuncture was done with the participants in a sitting position. Venous blood was drawn and placed in Vacutainer tubes (Becton-Dickinson, Franklin Lakes, NJ. USA).

Plasma glucose was analysed immediately in the clinical laboratory of the Geriatric Institute and measured with the chemistry analyser Vitros 950 using the glucose oxidase method (Johnson and Johnson. USA). The test – retest CV for glucose was 2.0%. Plasma insulin was analysed at the Sherbrooke University Hospital Center by a double – antibody radioimmunoassay (Inter Medico, Canada) or at the Research Centre on Aging by the ELISA methodology. The test – retest CV for insulin was 8.0% at the Sherbrooke University Hospital Center and 7.0% at the Research Center on Aging.

*Insulin sensitivity (IS)*

Insulin sensitivity was assessed indirectly by the use of two different non-invasive measurement techniques: the quantitative insulin sensitivity check index (**QUICKI**) and the homeostasis model assessment (**HOMA**)[19]. In this study, fasting insulin and glucose values were measured the same morning the subjects came for the body composition measurement and this, after a 12-hour fast.

The quantitative insulin sensitivity check index (**QUICKI**) is based on the following standard equation[20] developed by Defronzo et al.[21].

$$\frac{1}{\log(\text{fasting insulin (mU/mL)}) + \log(\text{fasting glucose (mg/dL)})}$$

QUICKI has been shown to significantly correlate, in both normal weight and overweight individuals, with insulin sensitivity derived from the hyperinsulinemic-euglycemic clamp technique and to be a good predictor of insulin sensitivity[21,22]. As such, QUICKI provides an estimate of insulin sensitivity with a variability and discriminant power comparable to that of the hyperinsulinemic-euglycemic clamp technique. It has been established that adults presenting a QUICKI value below 0.357 present typical manifestations of metabolic syndrome such as overweight, hypertension, hyperlipidemia or cardiovascular disease and so altered insulin sensitivity compared to adults with a QUICKI superior to 0.357[22].

The homeostasis model assessment (**HOMA**) is based on the updated equation developed by Wallace et al.[23].

$$\frac{\text{Fasting insulin concentration (µU/ml)) X Fasting glucose concentration (mg/dl))}}{22.5}$$

| Variables | Means ±SD |
|---|---|
| Age (yrs) | 63±6 |
| Years of menopause | 8±5 |
| Weight (kg) | 70.36±11.41 |
| Height (m) | 1.57±0.04 |
| BMI (kg/m$^2$) | 28.26±4.18 |
| Total FFM (kg) | 38.50±4.17 |
| FFMapp (kg) | 17.21±2.00 |
| Total FM (kg) | 28.99±8.16 |
| Total FM (%) | 42.18±6.16 |
| VFM (cm$^2$) | 71.32±30.10 |
| Total MMI (kg/m$^2$) | 15.47±1.50 |
| MMIapp (kg/m$^2$) | 6.89±0.68 |
| nsulin plasma level (pmol/L) | 54.07±29.46 |
| Glucose plasma level (mmol/L) | 4.81±0.53 |
| QUICKI | 0.36±0.02 |
| HOMA | 1.66±1.04 |

*MMI= Total FFM (kg)/height (m$^2$); appendicular MMI= appendicular FFM (kg)/height (m$^2$); appendicular FFM= leg FFM + arm FFM (kg).*

**Table 1.** Physical and biochemical characteristics of subjects.

The HOMA approach has been widely used in clinical research to assess insulin sensitivity and is appropriated for large epidemiologic studies[24]. Like QUICKI, HOMA has been validated to determine insulin sensitivity and has been shown to correlate significantly with the hyperinsulinemic-euglycemic clamp technique[23] and to have a high sensitivity and specificity to measure insulin resistance (IR)[24]. With HOMA, a normal insulin sensitivity is represented as a value of 100% or above.

*Statistical Analysis*

Values are displayed as mean values±S.D. Normality of distribution was verified with use of the *Kolmogorov-Smirnov* (p<0.05). Pearson's correlations were performed to examine the relations between plasma insulin level or insulin sensitivity (HOMA and QUICKI) with all body composition variables. Partial correlations were performed to examine the relationship between Total MMI and plasma insulin level, HOMA or QUICKI and between MMIapp and plasma insulin level, HOMA or QUICKI after controlling for VFM and age. A stepwise regression analysis was used to determine the independent predictors of plasma insulin level and insulin sensitivity. Analyses were performed using SPSS software 12.0 (Chicago, IL). Significance level was set at $p<0.05$.

## Results

Characteristics of subjects are presented in Table 1. Pearson's correlations were performed between QUICKI, HOMA or plasma insulin level and all body composition variables such as BMI, total fat-free mass (Total FFM), appendicular fat-free mass (FFMapp), Total MMI, MMIapp, total fat mass (FM Total), and Visceral Fat Mass (VFM). We observed a lin-

| | QUICKI (n=99) | HOMA (n=99) | Insulin plasma level (n=98) | Visceral Fat Mass (n=98) |
|---|---|---|---|---|
| Age (yrs) | 0.239* | -0.210* | -0.170 | -0.141 |
| BMI (kg/m²) | -0.492** | 0.481** | 0.461** | 0.804** |
| Total FFM (kg) | -0.333** | 0.397** | 0.390** | 0.587** |
| FFMapp (kg) | -0.211* | 0.221** | 0.234* | 0.426** |
| Total FM (kg) | -0.407** | 0.360** | 0.343** | 0.735** |
| Total FM (%) | -0.350** | 0.258** | 0.241* | 0.611** |
| VFM (cm²) | -0.504** | 0.508** | 0.498** | - |
| MMIapp (kg/m²) | -0.333** | 0.339** | 0.341** | 0.552** |
| Total MMI (kg/m²) | -0.447** | 0.515** | 0.493** | 0.689** |

** p≤0.05; ** p≤0.01. MMI= Total FFM (kg)/height (m²); appendicular FFM = leg FFM + arm FFM (kg); insulin plasma level in pmol/L.*

**Table 2.** Pearson's correlation coefficients.

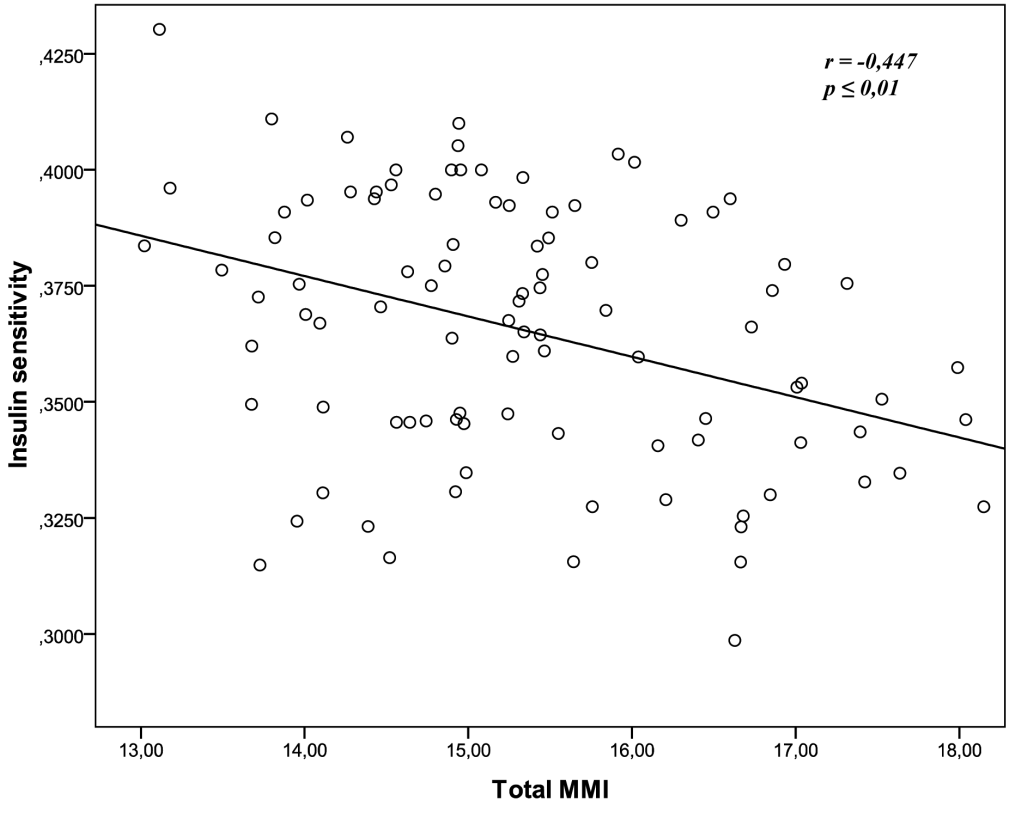


**Figure 1a.** Correlation between Insulin Sensitivity and Total MMI. *(Total MMI=Total Muscle Mass Index (FFM (kg)/height (m²)); Insulin sensibility was measured by QUICKI).*

ear, positive and significant relationship between the diverse markers of insulin (HOMA and plasma insulin level) and VFM (0.498<r<0.508; all p≤0.01) but a negative one between QUICKI and VFM (-0.504; p≤0.01). Unexpectedly, however, we observed a linear and positive relationship between the insulin resistance and all FFM indices (FFM and MMI) (0.221<r<0.515; all p≤0.01). In agreement, QUICKI, an index of insulin sensitivity was negatively correlated with Total MMI (-0.447; p≤0.01) and MMIapp (-0.333; p≤0.01). These findings suggest that MMI (Total and app) and VFM both have a close relationship with plasma insulin level and insulin sensitivity respectively measured by HOMA and QUICKI (Table 2 and Figures 1 and 2). In agreement, even after correcting for age and VFM, correlations between MMI and insulin sensitivity

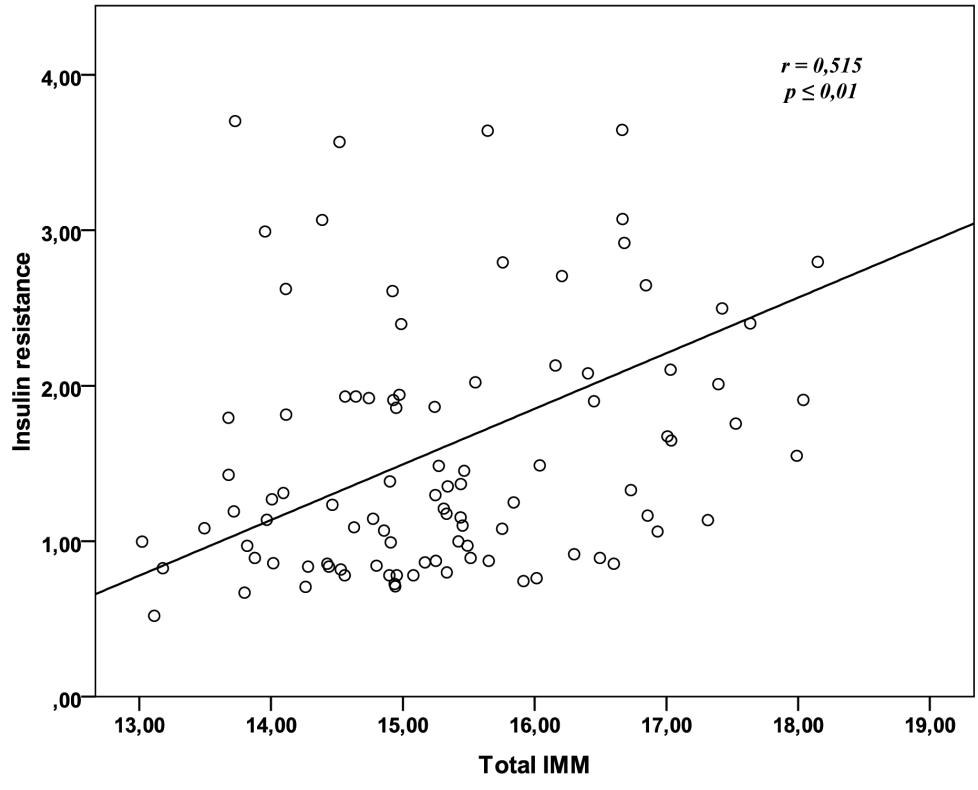


**Figure 1b.** Correlation between Insulin Resistance and Total MMI. *(Total MMI=Total Muscle Mass Index (FFM (kg)/height (m²)); Insulin resistance was measured by HOMA)*.

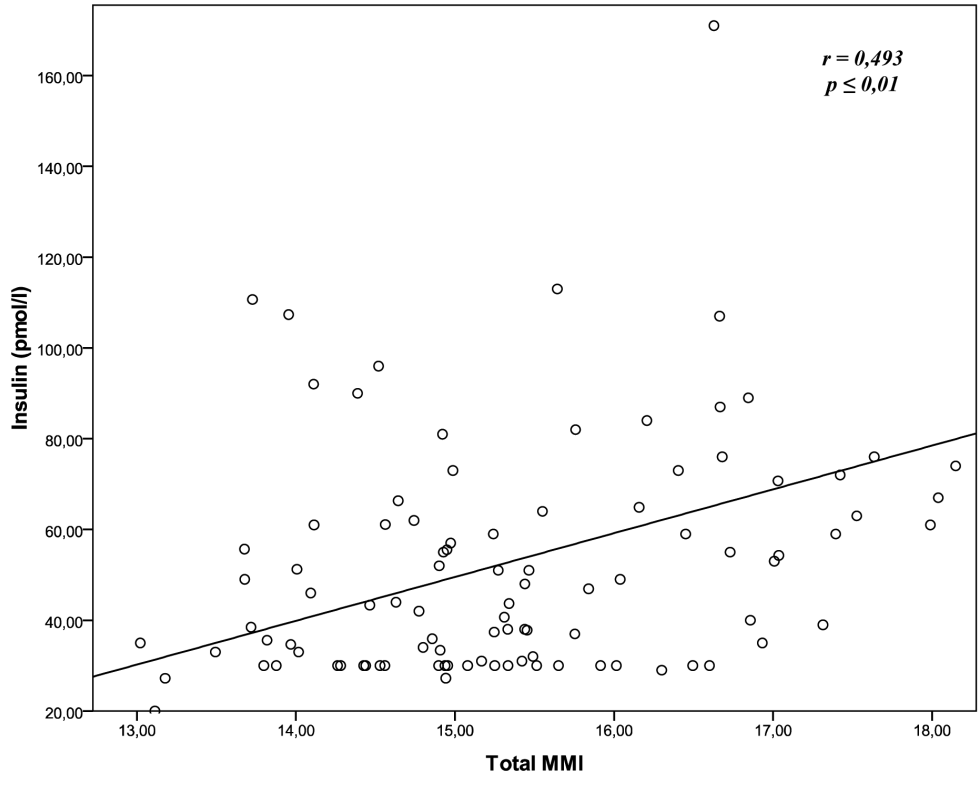


**Figure 1c.** Correlation between plasma insulin level and Total MMI. *(Total MMI=Total Muscle Mass Index (FFM (kg)/height (m²)); plasma Insulin level=pmol/l)*.

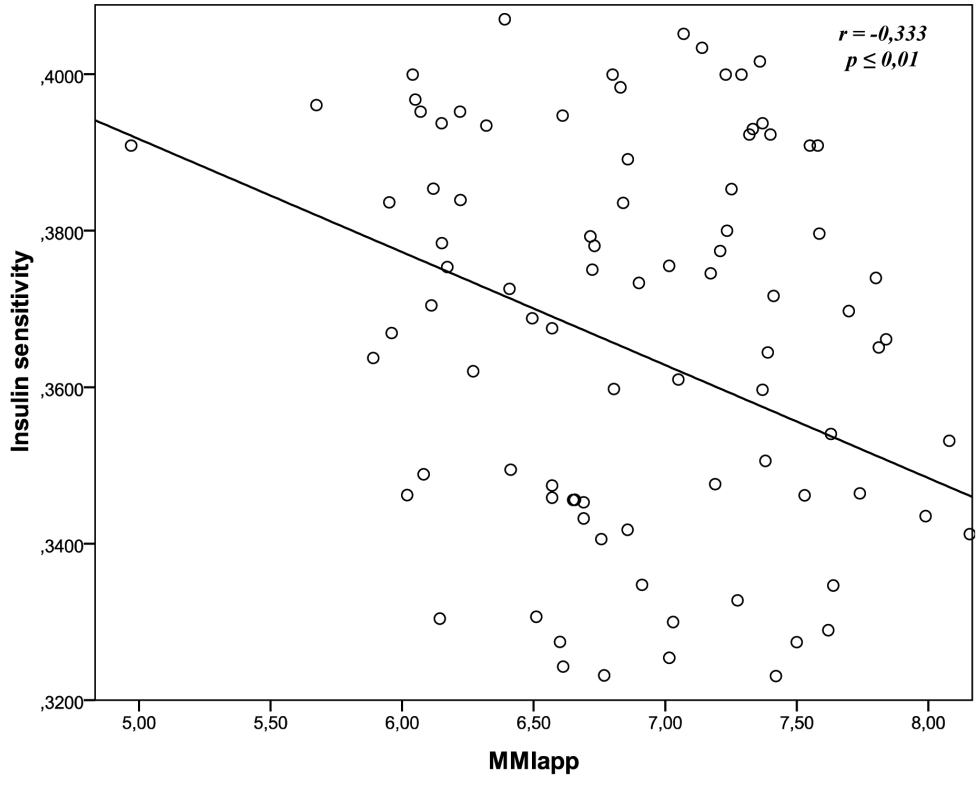


**Figure 2a.** Correlation between Insulin Sensitivity and MMIapp. *(MMIapp=Appendicular Muscle Mass Index (FFMapp (kg)/height (m²)); Insulin sensibility was measured by QUICKI)*.

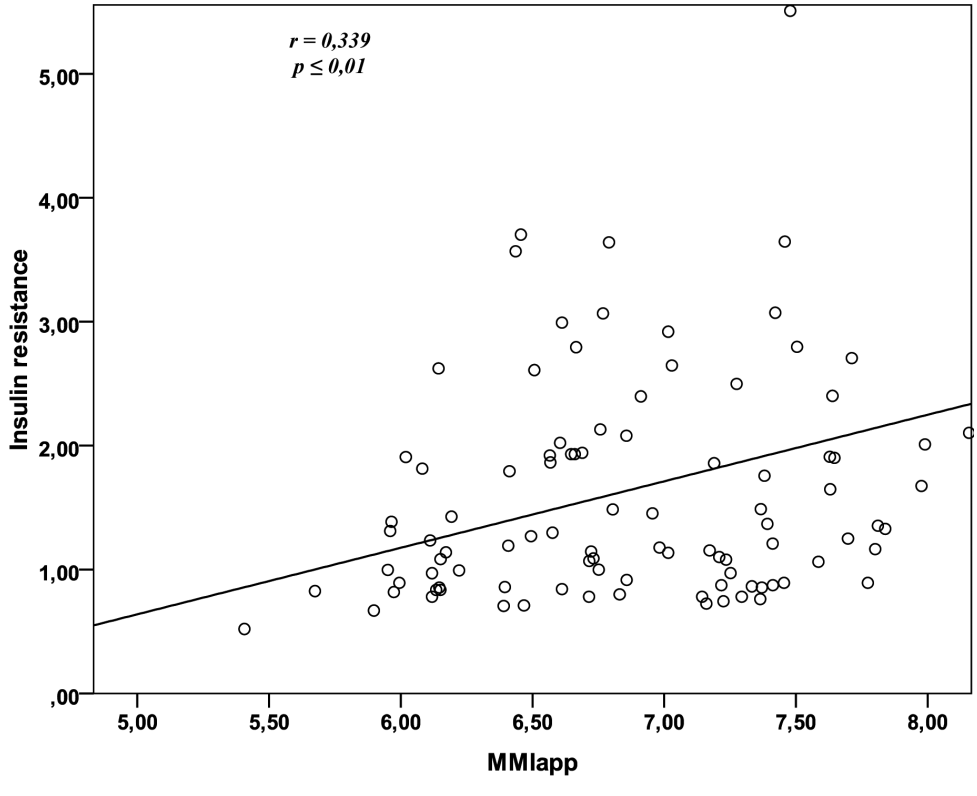


**Figure 2b.** Correlation between Insulin Resistance and MMIapp. *(MMIapp=Appendicular Muscle Mass Index (FFMapp (kg)/height (m²)); Insulin resistance was measured by HOMA)*.

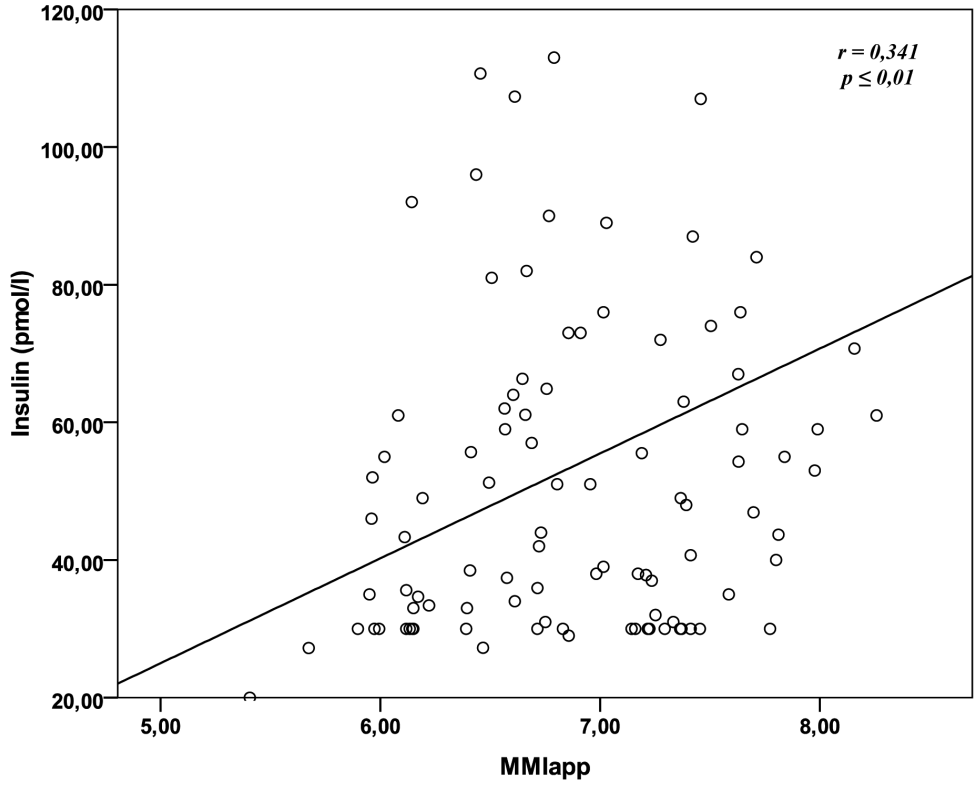


**Figure 2c.** Correlation between plasma insulin level and MMIapp. *(MMIapp=Appendicular Muscle Mass Index (FFMapp (kg)/height (m²)); Insulin plasma level=pmol/l).*

markers (HOMA and plasma insulin level) remained significant (0.231≤r≤0.251; p≤0.023).

Furthermore, to countercheck this assumption, a stepwise linear regression analysis was performed to predict insulin sensitivity markers using age, BMI, Total FFM, FFMapp, Total FM, VFM, MMIapp and Total MMI in the model. We observed that Total MMI and VFM were both independent predictors of the various markers of insulin sensitivity and resistance (adjusted $r^2$ between 0.246 and 0.313, all p≤0.02; Table 3 and 5) except for QUICKI where VFM was the only independent predictor (adjusted $r^2$=0.246; p≤0.001) but however Total MMI was close to attain statistical significant level for QUICKI (p=0.089) (Table 4).

| Model | $R^2$ | β | P |
|---|---|---|---|
| Model | 0.313 | | |
| VFM ($cm^2$) | | 0.325 | 0.007 |
| Total MMI ($kg/m^2$) | | 0.283 | 0.018 |

*MMI=Total FFM (kg)/height (m²); VFM=Visceral Fat Mass*

**Table 3.** Best predictive model for insulin resistance (HOMA).

## Discussion

To the best of our knowledge, this is the first observational study to examine the magnitude and direction of the association between skeletal muscle mass (represented by MMI and considered as an index of relative muscle mass for the determination of sarcopenia) and insulin sensitivity in postmenopausal women displaying a wide range of muscle and fat mass, when age and VFM are taken into account.

Our findings support that, MMI indices are significantly and negatively correlated with insulin sensitivity in healthy and sedentary postmenopausal women even when adjusting for age and VFM. Therefore, the direction of these correlations implied that a greater MMI may be detrimental to insulin sensitivity. Thus, these subjects may not be protected against insulin resistance by having high muscle mass, in contradiction with what is generally purported. In support, Total MMI was found to be an independent but negative predictor of insulin sensitivity in this population adjusting for age and VFM.

Our results thus do not support the general belief that is, a greater skeletal muscle mass is associated with a better glucose disposal or a better glucose homeostasis in postmenopausal women. Nevertheless, there is no actual scientific literature to support this assumption clearly. In fact at least three studies[7,8,25] concluded that no association was found between muscle mass

| Model | $R^2$ | β | P |
|---|---|---|---|
| VFM ($cm^2$) | 0.246 | -0.504 | 0.000 |
| *VFM=Visceral Fat Mass* | | | |

**Table 4.** Best predictive model for insulin sensitivity (QUICKI).

| Model | $R^2$ | β | P |
|---|---|---|---|
| Model | 0.278 | | |
| VFM ($cm^2$) | | 0.295 | 0.015 |
| Total MMI ($kg/m^2$) | | 0.295 | 0.015 |
| *MMI=Total FFM (kg)/height ($m^2$); VFM=Visceral Fat Mass* | | | |

**Table 5.** Best predictive model for plasma insulin level.

and insulin sensitivity. Indeed, we recently showed that insulin sensitivity was similar in three groups of women divided based on muscle mass (type 2 sarcopenic, type 1 sarcopenic and non-sarcopenic)[8]. However, in this study, fat mass was highly heterogeneous in those groups and we failed to adjust results for VFM. Also, Kuk et al.[7] showed that skeletal muscle mass was not significantly correlated to glucose or insulin metabolism in obese or overweight healthy women and men who were aged from 20 to 69 years old. Nevertheless, considering only overweight or obese individuals may have masked a potential relationship between skeletal muscle mass and insulin sensitivity. Conversely, when looking closely to the scientific literature, we found that several studies displayed results in accordance with ours without directly addressing insulin sensitivity because it was not their main objective[11-13,27]. For instance, Castaneda et al.[12] found, in a multi-ethnic group of individuals with type 2 diabetes and poor glycemic control that, regardless of the ethnicity, a low muscle mass was associated with a lower prevalence of type 2 diabetes. Also, Aubertin-Leheudre et al.[13] showed that sarcopenic-obese women have lower cardiovascular diseases risk factors than obese non-sarcopenic postmenopausal women. Thus, theses studies showed that those who had a greater muscle mass were more likely to be insulin resistant. In addition, Brochu et al.[27] and You et al.[11], reported a higher skeletal muscle mass in overweight and obese postmenopausal women to display a higher number of metabolic alterations including an impaired glucose homeostasis compared to those with normal metabolic profile.

Our results also showed that VFM remains a positive predictor of insulin resistance, as previously shown[7,27,28]. Interestingly, Brochu et al.[27] concluded that the contribution of VFM to insulin resistance may be exacerbated by an increased skeletal muscle mass, which is in line with our results. It has to be mentioned that these results do not apply in a context of intervention when specific strategies such as exercise and nutrition may have lead to simultaneous increases in muscle mass and insulin sensitivity[28-31].

Although this was an observational study, we can speculate regarding potential mechanisms underlying our observations. The first hypothesis concerns type II muscles fibers. The age-related loss of muscle mass (sarcopenia) characterized by a loss of type II muscle fibers (decrease in number and size) towards the maintenance or an increase of type I muscle fibers[32,34]. Because type IIb muscle fibers are insulin resistant and glycolytic[33], their lower proportion in a smaller muscle mass would positively alter glucose metabolism. This observation is confirmed by Nyholm et al. who showed that insulin resistant first degree relatives of type 2 diabetes patients are characterized by an increase in the number of type IIb muscle fibers[35]. Furthermore, Lillioja et al. observed significant correlations between insulin-stimulated glucose uptake and type I (positive) and type IIb (negative) muscle fibers in men[37]. Finally our results are also supported by those of Kern et al., who showed that type I muscle fibers contain approximately 5 times more glucose transporter-4 (Glut 4) and 2 times more Glut 4 mRNA than type II muscle fibers. These may also indicate that the difference in muscle glucose responsiveness may be due to the difference in the type of muscles fibers[49]. A second hypothesis is that the accumulation of intramuscular triglycerides (TG;[42-44]) interferes with the enzymatic cascade of the response to insulin. More specifically, TG's byproducts, diacylglycerides and ceramides[45,46] have been related to age and to an impairment of the insulin signal pathway in skeletal muscle[45,46] by altering the lipid oxidative capacity of the muscle. These, in turn, would lead to metabolic abnormalities such as insulin resistance and type 2 diabetes[47,48]. A third possible mechanism concerns the relation between blood flow, insulin sensibility and muscles fiber types. Indeed it has been shown that blood flow contributes to a good insulin sensitivity by driving glucose and insulin toward the muscle[50]. It is two- to fourfold greater in type I fibers than in type II fibers[51]. Furthermore, it has been shown that the impaired vasodilatation associated with insulin resistance at muscles level[52] is characterized mostly by feed arteries that are more vulnerable to the development of vascular dysfunction at type II fibers than in type I fibers[53]. Collectively these confirm that a small muscle mass may display better insulin sensitivity and thus may be more protective to this population, possibly through a greater proportion of type I fibers.

The present study has some limitations. First, the observational nature of the study did not allow us addressing implied mechanisms. More investigations are obviously needed to confirm our results and understand involved mechanisms, especially with the use of more sophisticated methods to measure insulin sensitivity and resistance although QUICKI and HOMA have a strong correlation with hyperinsulinemic-euglycemic clamp technique[19,21]. Second, the use of two different assays (RIA and ELISA) to measure insulin may introduced some biases in the results. Nevertheless, the literature confirms that RIA and ELISA produce equivalent values for insulin (Tandhanand-Banchuin N, Vannasaeng S, Ploybutr S, Sriussadaporn S, 1993; Suh-Lailam BB, Chiaro TR, Davis K W,

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Wilson AR, Tebo AE, 2011) and we assured that the mean and CV% were equivalent for both types of assays. Third, women in our study appeared to have a low VFM. Although Bertin's equation is highly correlated (r=0.94) with VFM measured by the gold standard (i.e. CT scan) in a similar population, it cannot be ruled out that VFM was underestimated in our study. Another limit of the study is that, although subjects were fasted for 12 hrs before blood draw, dietary intakes were not controlled for during the days prior to testing. It thus cannot be totally ruled out that dietary intake in the days prior to testing influenced HOMA values. Nevertheless, we are the first to investigate this question in a large range of BMIs including a large range of fat mass and skeletal muscle mass, and to take both skeletal muscle mass and VFM into account.

## Conclusion

A huge body of literature purports that a large muscle mass is associated with a better insulin sensitivity and/or glucose disposal although very few data are available to support this assumption. Our results indicate a negative correlation between muscle mass and insulin sensitivity in sedentary postmenopausal women, suggesting that a lower muscle mass may not be detrimental for the maintenance of insulin sensitivity or could even be beneficial. Although this needs to be further investigated, we can minimally conclude that the direction of the impact of muscle mass on insulin sensitivity in older adults is not as clear as some pretend and that implied mechanisms deserve attention.

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*J.L. wrote the manuscript and researched data. M.A-L., F.B., C.L. and M.L. researched data. M.A-L. and I.J.D. contributed to the discussion and reviewed the manuscript.*

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