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10.20960/nh.05721

06/06/2025

OR 5721

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El músculo esquelético y la grasa corporal interactúan con la presión arterial en la enfermedad vascular cerebral: estudio de caracterización de la Encuesta Nacional de Salud de Chile 2016-17

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Received: 15/01/2025
Accepted: 06/04/2025
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Institutional Review Board Statement: the study was conducted according to the guidelines laid down in the Declaration of Helsinki, and the CNHS 2016–2017 has been reviewed by the Ministry of Health and ethically approved by the School of Medicine of the Pontifical Catholic University of Chile (16-019). All participants of the CNHS 2016–2017 provided written consent before participation.

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: The datasets of the current study are available by the Epidemiological Unit of the Chilean Health Ministry at http://epi.minsal.cl/encuesta-ens-descargable/.

Conflicts of Interest: The authors declare no conflict of interest.

Artificial intelligence: The authors declare not to have used artificial intelligence (AI) or any AI-assisted technologies in the elaboration of the article.

ABSTRACT

Background: peripheral (PVD) and cerebral vascular disease (CeVD) are two vascular conditions of relevance in older adults. However, there is little epidemiological studies about the body composition role (i.e., skeletal muscle mass [by calf circumference] and adiposity [by waist circumference]) in the diabetes and hypertension (HTN) prevalence in PVD and CeVD conditions.

Aim: to describe the characteristics of population with PVD and CeVD by different body composition phenotypes and determine the interaction between PVD/CeVD, and body composition with the HTN and diabetes prevalence.

Methods: a cross-sectional study of the Chilean population based on the National Health Survey 2016-17. A sample size of n = 233 participants was characterized according to previous PVD and CeVD or not No-PVD/No-CeVD history. Four body composition phenotypes were described such as; low skeletal muscle mass plus high waist circumference (Lsmm-Hwc), low skeletal muscle mass plus low waist circumference (Lsmm-Lwc), high skeletal muscle mass plus high waist circumference (Hsmm-Hwc), and high skeletal muscle mass plus low waist circumference (Hsmm-Lwc), by main outcomes as systolic (SBP), and diastolic BP (DBP) and fasting glucose.

Results: there was a significant interaction between body composition (Groups x CeVD), in SBP (CeVD, F (3.40), p = 0.002, ES: 0.007), where SBP in Lsmm-Lwc was higher (*diff* +28 mmHg) versus the Hsmm-Lwc reference group. Lsmm-Hwc (odds ratio [OR], 3.2 [1.8; 5.9], $p < 0.0001$), Lsmm-Lwc (OR, 1.7 [1.0; 3.1], p = 0.047), and Hsmm-Hwc (OR, 2.2 [1.5;

3.3], $p < 0.0001$) showed a higher risk for suffering from PVD vs. Hsmm-Lwc group.

Conclusion: Chilean adults with both PVD and CeVD are shown to be aged ~60, with obesity and hypertensive condition, and report lower handgrip strength in comparison with adult peers with higher muscle mass and lower waist circumference.

Keywords: Peripheral vascular disease. Cerebrovascular disease. Skeletal muscle mass. Waist circumference. Lifestyle.

RESUMEN

Antecedentes: la enfermedad vascular periférica (EVP) y la enfermedad vascular cerebral (EVC) son dos afecciones vasculares con alta prevalencia en adultos mayores. Sin embargo, existe poca información sobre el rol de la composición corporal (es decir, masa muscular esquelética y adiposidad) en la prevalencia de diabetes e hipertensión (HTN) en EVP y EVC.

Objetivo: describir las características de la población con EVP y EVC según diferentes fenotipos de composición corporal y determinar la interacción entre EVP/EVC y la composición corporal con la prevalencia de HTA y diabetes.

Métodos: estudio transversal de la población chilena basado en la Encuesta Nacional de Salud 2016-17. Se caracterizó a un tamaño de muestra de (n = 233) participantes según antecedentes de EVP y EVC o sin EVP/EVC. Los fenotipos de composición corporal fueron baja masa muscular esquelética más circunferencia de cintura alta (Lsmm-Hwc), baja masa muscular esquelética más circunferencia de cintura baja (Lsmm-Lwc), alta masa muscular esquelética más circunferencia de cintura alta (Hsmm-Hwc) y alta masa muscular esquelética más

circunferencia de cintura baja (Hsmm-Lwc). Las variables principales fueron la presión sistólica (PAS), diastólica (PAD) y glucosa en ayunas.
Resultados: hubo una interacción significativa entre la composición corporal (Grupos x EVC), en PAS (EVC, F (3,40), p = 0,002; ES: 0,007), donde la PAS en Lsmm-Lwc fue mayor (dif +28 mmHg) versus el grupo de referencia Hsmm-Lwc. Lsmm-Hwc (OR: 3,2 [1,8; 5,9], p < 0,0001), Lsmm-Lwc (OR: 1,7 [1,0; 3,1], p = 0,047) y Hsmm-Hwc (OR: 2,2 [1,5; 3,3], p < 0,0001) mostraron un mayor riesgo de padecer EVP vs. el grupo Hsmm-Lwc.
Conclusión: los adultos chilenos con EVP y EVC muestran una edad ~60, en condición de obesidad e hipertensión y menor fuerza de prensión manual en comparación con sus pares adultos con mayor masa muscular y menor circunferencia de cintura.

Palabras clave: Enfermedad vascular periférica. Enfermedad cerebrovascular. Masa muscular esquelética. Circunferencia de la cintura. Estilo de vida.

INTRODUCTION

Peripheral vascular disease (PVD) and cerebral vascular disease (CeVD) are two vascular conditions of high prevalence in older adults (1), and a worrying situation to those countries with a major proportion of elderly people (2). PVD is particularly described in adults ~ 70 years and with prevalence of about 15 to 20 % (3,4). On the other hand, CeVD (i.e., haemorrhage/ischemic) is mainly reported in those men ~ 50 years and in women ~ 70 years old (5). Unfortunately, independent of the PVD development, males are more susceptible to more severe CeVD as the intracerebral haemorrhage compared to women (6).

Although early diagnosis is essential in preventing CeVD, both PVD and CeVD diseases are associated with other preliminary and preventable vascular/metabolic (i.e., from “vascular” and “metabolic/endocrine” origin) comorbidities such as arterial hypertension (HTN, 27.6 % prevalence in Chilean), endothelial dysfunction and diabetes (12.3 % prevalence in Chilean adults) (7,8). Unfortunately, the leading causes of HTN and diabetes are more related to environmental causes such as sedentarism (i.e., high spent time in sedentary activities), physical inactivity (i.e., not adhering to international physical activity guidelines of 150 to 300 min/week of low-to-moderate intensity physical activity, or alternative 75-to-150 min/week of vigorous-intensity physical activity) (9) and in general to an unhealthy lifestyle [i.e., poor diet (10), low time of sleep (11,12), and tobacco habit (13)] that are all in the adult population considered as “modifiable risk factors” (14-16).

The World Health Organization (WHO) has noticed a worrying increase of HTN in those Chilean adults aged 30 to 70 years old from ~ 36 % in young adults to almost ~ 71 % in those of 70 years old, where only 34 % of this 70th year population are under a “controlled” condition (i.e., medical, pharmacological, or under other types of professional monitoring) (17), being the other percentage in “high risk” of suffering vascular disease as PVD or CeVD. Furthermore, in both HTN and diabetes conditions, a healthy lifestyle (i.e., adhering to the international physical activity guidelines, having a healthy diet, in additional to avoid the abovementioned risk factors) plays a “protector” role in the population that has suffered from PVD or CeVD (10,18). From here, the acquisition of a healthy lifestyle is key for maintaining better health, good physical condition and preventing both HTN and diabetes diseases. In this line, skeletal muscle mass (SMM) has been demonstrated to be better in physically active adults, as well as body fat has shown to be similarly lower in these active adults. In contrast, inactive adults also show lower SMM and higher body fat, which are associated with more

HTN and diabetes prevalence (19). In fact, part of the negative consequences of an unhealthy lifestyle are the reductions in SMM and increased different stores of body fat including total fat mass, visceral, subcutaneous, and plasma fat that changes dramatically the overall body composition. From here, epidemiological studies have reported that acquiring an appropriate SMM and lower body fat levels as a healthier body composition phenotype is relevant to protect the vascular/metabolic health in adult population with PVD or CeVD and thus prevent the acquisition of other comorbidities such as HTN or diabetes.

Thus, in order to characterize the role of a better/higher SMM and lower body fat in the Chilean population with both PVD and CeVD in their relationship with HTN and diabetes prevalence, the aims of this study were i) to describe the characteristics of the adult population with PVD and CeVD in function of different body composition phenotypes based on SMM and waist circumference (i.e., as adiposity marker), and ii) to determine the interaction between PVD/CeVD and different body composition phenotypes with the HTN and diabetes prevalence in Chilean adults. We hypothesized that adults with lower SMM based on calf circumference, and higher adiposity, based on waist circumference outcome, show higher levels of blood pressure and low glucose control than adult peers with better SMM and lower waist circumference.

MATERIALS AND METHODS

Participants

A cross-sectional descriptive study based on the Chilean National Health Survey 2016-2017 (NHS16-17), reported as a multi-stage study, developed in at-home conditions and using random methods with participation of a representative and geographical sample size of this

country. The total NHS16-17 sample was 6233 participants, and the present study included only a partial amount of this population, according to those who show or declared PVD or CeVD information. The study was approved by the Ethical Committee of the Escuela de Medicina de la Pontificia Universidad Católica de Chile (16-019), and all participants signed an informed consent as previously reported (14,20).

The participants were adults classified into four categories: peripheral vascular disease (PVD, n = 209) or no peripheral vascular disease (No-PVD, n = 2580), and cerebral-vascular disease (CeVD, n = 122) or no cerebral-vascular disease (No-CeVD, n = 2674). After the classification of these groups, each disease condition was described according to four different body composition phenotypes combining SMM using “calf circumference” and adiposity using “waist circumference” as outcomes, as follows; low skeletal muscle mass plus high waist circumference (Lsmm-Hwc), low skeletal muscle mass plus low waist circumference (Lsmm-Lwc), high skeletal muscle mass plus high waist circumference (Hsmm-Hwc), and high skeletal muscle mass plus low waist circumference (Hsmm-Lwc) that was used as a reference phenotype. The general characteristics of the four disease conditions and phenotypes are described in (Table I).

Peripheral and cerebral vascular disease history

Using the data of the questionnaire applied in the NHS16-17, by the questions; 1) Has a doctor ever told you had or suffered a peripheral vascular disease (PVD) or disease of the arteries in your legs? and 2) Has a doctor ever told you have suffered a vascular accident or cerebral thrombosis (or stroke) (CeVD)? The alternatives of responses were: “Yes”, “No”, “I do not know”, or “Without/No Response” from each participant. From here, the sample size was categorized into (PVD, n = 209) and without or no PVD (No-PVD, n = 2580), being some participants with response of “I do not know” PVD (n = 26) eliminated, similarly as

others that “do not response” the question (n = 1). In parallel, others were categorized in (CeVD, n = 122) and (No-CeVD, n = 2674) conditions.

Diabetes outcomes

For diabetes measurement, fasting plasma glucose (FPG), and glycated hemoglobin (HbA1c) were reported. These outcomes were measured with 8 h of fasting and were measured similarly as reported in previous studies (14).

Arterial hypertension outcomes

To HTN outcomes, systolic (SBP) and diastolic (DBP) blood pressure were reported. Each SBP/DBP was measured in the left arm (x 3 times), and the average was registered in mmHg. The blood pressure categorization of the American Heart Association 2018; “Normal BP” was defined as SBP/DBP less than 120/80 mmHg, “elevated BP” (Ele) as SBP/DBP between 120-129/80 mmHg, “stage 1 HTN” as SBP/DBP between 130-139/80-89 mmHg, and “stage 2 HTN” as SBP/DBP ≥ 140/90 mmHg, was used (21). The readings were taken using an automatic monitor (OMRON™, model HEM 7114, USA) used in several previous epidemiological studies (16), and widely recommended by the American Heart Association (22). This measurement was developed by nursing in at-home conditions.

Anthropometric measurements (secondary outcomes)

Weight was determined by an electronic scale OMRON™ (Model HBF-514C OMRON™ Corporation, Tokyo, Japan), with a sensitivity of 100 g and a maximum weight capacity of ~ 150 kg. Height was measured by an inextensible tape installed on the wall of each home of participants, and waist circumference (WC) was similarly measured by an inextensible tape, similar to previous studies (23). With weight and height, the body

mass index (BMI) was calculated and thus described categorically as follows; underweight, normal weight, overweight, obesity I, obesity II, obesity III, and morbid obesity, following the WHO criteria (24).

Other cardiometabolic risk factors

The lipid profile as total cholesterol (Tc), low-density lipid cholesterol (LDL-c), high-density lipid cholesterol (HDL-c), and plasma triglycerides (Tg) were measured according to the National Cholesterol Education Program (NCEP ATP-III) categorization (25). Additionally, other non-alcoholic fatty liver disease outcomes such as gamma-glutamyl transaminase (GGT), and pyruvic glutamyl transaminase [GPT]), C-Reactive protein (C-RP), the amount (min·day) of physical activity of strength as handgrip muscle strength (HGS), and the total vigorous, moderate, and low-intensity by standardized questionnaires as the Global Physical Activity Questionnaire version 2 (GPAQv2) (26,27).

Statistical analysis

Continuous outcomes are shown as mean plus 95 % confidence interval (95 % CI). The normality of distribution was tested by the Shapiro-Wilk test. The interaction of the four phenotypes proposed (Lsmm-Hwc, Lsmm-Lwc, Hsmm-Hwc, and Hsmm-Lwc) with each PVD or No-PVD and CeVD or No-CeVD categories in function of each main and secondary outcomes were tested by Univariant analyses ANOVA (Groups; PVD or CeVD; and Groups x PVD or CeVD). By multinominal logistic regression, the risk for suffering from “diabetes suspect”, “HTN suspect”, or report a poor body composition phenotype (Lsmm-Hwc, Lsmm-Lwc, Hsmm-Hwc) were compared with the reference groups (Ref.) of no peripheral vascular disease (No-PVD), no cerebral vascular disease (No-CeVD), and with the healthy body composition phenotype (Hsmm-Lwc), reported using the odds ratios (OR) and showing the information in mean and (95 % CI). The main interaction tested were (Groups x PVD and Groups x

CeVD) to establish body composition and vascular disease conditions with each independent blood pressure and FPG outcome. The Wald Chi-square and the pseudo-McFadden R^2 were reported for predicting each dependent outcome. Additionally, we calculated the effect size (ES) by the Cohen's *d* test (28) corrected for small samples (< 20 subjects) (29), with threshold values at 0.20, 0.60, 1.2, and 2.0 for “small”, “moderate”, “large”, and “very large” ES, respectively. These analyses were adjusted by geographic area, region, sex, and age. All statistical analyses were developed using the SPSS™ software 25 version for Windows (IBM SPSS Inc., Chicago, IL, USA). All statistical tests were carried out using the SPSS™ software 25 version for Windows (IBM SPSS Inc., Chicago, IL, USA).

RESULTS

Baseline characteristics

Characteristics of the categories of PVD, No-PVD, CeVD, No-CeVD are shown in (Table I).

Diabetes and hypertension outcomes

There was no significant interaction between body composition phenotypes (Groups x PVD) or (Groups x CeVD) in diabetes outcomes FPG, and HbA1c (Fig. 1, panels A, B, C, D). There was significant interaction between body composition (Groups), and by categories of (CeVD) in diabetes outcome FPG of cerebral vascular disease (Fig. 1, panel B). In fasting glucose of CeVD categories, the Hsmm-Hwc phenotype showed higher FPG vs. Ref phenotype (diff + 16.8 mg/dL) (Fig. 1, panel B).

There was no significant interaction between body composition phenotypes (Groups x PVD) in hypertensive outcomes SBP, and DBP (Fig. 1, panels E, G). Similarly, no significant interaction between body

composition phenotypes (Groups x CeVD) was observed in hypertensive outcome DBP (Fig. 1, panels H). There was significant interaction between body composition (Groups x CeVD), in SBP (CeVD, F (3.40), p = 0.002, ES, 0.007) (Fig. 1, panel F). In SBP of PVD categories, the Lsmm-Lwc phenotype showed (diff + 30 mmHg), and the same outcome in the CeVD categories (diff + 28 mmHg) (Fig. 1, panel B). In DBP of PVD categories, the Hsmm-Hwc phenotype showed (diff + 6 mmHg), and the same outcome in the CeVD categories (diff + 2 mmHg) in phenotypes Lsmm-Lwc and Hsmm-Hwc (Fig. 1, panel G, H).

Lipid profile (secondary outcomes)

There was no significant interaction between body composition (Groups x PVD) or (Groups x CeVD) in lipid profile outcomes (Fig. 2, panels A-H).

Risk for diabetes, arterial hypertension, or poor body composition

In comparison with the Ref. model (i.e., “No-PVD or Hsmm−Lwc”), multinominal logistic regression reported that each Lsmm-Hwc (β, 1.185, OR, 3.2 [1.8; 5.9], $p < 0.0001$), Lsmm-Lwc (β, 0.580, OR, 1.7 [1.0; 3.1], p = 0.047), and Hsmm-Hwc phenotype group (β, 0.815, OR, 2.2 [1.5; 3.3], $p < 0.0001$) showed a higher risk for suffering from PVD (Table II).

In comparison with the Ref. model (i.e., “No-CeVD or Hsmm−Lwc”), subjects with “HTN suspect” (β, −1.325, OR, 0.2 [0.1; 0.4], $p < 0.0001$), “diabetes suspect” (β, −0.444, OR, 0.6 [0.4; 0.9], p = 0.038), Lsmm-Hwc (β, 0.843, OR, 2.3 [1.0; 5.1], p = 0.037), and Lsmm-Lwc (β, 0.840, OR, 2.3 [1.1; 4.6], p = 0.019) (Table II).

DISCUSSION

This study aimed to describe the characteristics of the adult population with PVD and CeVD in the function of different body composition phenotypes based on skeletal muscle mass and waist circumference and to determine the interaction between PVD/CeVD and body composition with the HTN and diabetes prevalence in Chilean adult population. The main findings of the present study were *i*) there was a significant interaction among body composition phenotypes Groups x CeVD in systolic blood pressure, *ii*) to each PVD and CeVD condition, the poorest body composition phenotype Lsmm-Hwc showed higher FPG, glycated hemoglobin, SBP/DBP blood pressure, highlighting the key role of the skeletal muscle mass and adipose tissue in the regulation of both metabolic and vascular control, and *iii*) these findings were displayed with elevated risk for the suffering of PVD in the groups Lsmm-Hwc OR 3.2, Lsmm-Lwc OR 1.7, Hsmm-Hwc OR 2.2, and the risk for suffering of CeVD in the group Lsmm-Hwc OR 2.3 and group Lsmm-Lwc OR 2.3 (Table II).

Previous studies have characterized PVD and CeVD populations, however considering some socio-demographic events such as the growing older adult population, the higher levels of physical inactivity and in general the poorly lifestyle of adults is that there is a need to characterize both PVD and CeVD Chilean adults around their resulting phenotypes of body composition how population express their lifestyle. It is worrying that while some literature reports that PVD is a disease that usually could start at ~ 70 years old (4), but by the present study our results provide information that the Chilean population is suffering from PVD at ~ 60 years old.

About the main outcomes, in the present study there was a significant interaction among body composition phenotypes Groups x CeVD in SBP, where particularly those individuals with lower SMM and higher WC as the Lsmm-Hwc group showed + 28 mmHg of SBP, Lsmm-Lwc + 14 mmHg, and Hsmm-Hwc + 19 mmHg vs. the Ref. phenotype Hsmm-Lwc

group (Fig. 1). It has been reported that the lifestyle of the population (physical activity, diet, tobacco habit, alcohol consumption, sleep and others) play a role in the SMM and body fat accumulation where it is interesting to note that the Ref. Hsmm-Lwc group of better skeletal muscle and lower adiposity showed normal values of SBP (mean: 122 mmHg; “normotensive”) (Fig. 1). Additionally, although we did not detect body composition Groups x PVD interaction, each Lsmm-Hwc (+ 30 mmHg), Lsmm-Lwc (+ 25 mmHg) and Hsmm-Hwc (+ 28 mmHg) phenotype showed exacerbated SBP vs. Ref. group. From here, in the adult population with history of peripheral or cerebrovascular disease conditions, it is relevant to highlight the role of the skeletal muscle and a lower adiposity by increasing the promotion of physical activity and a healthy lifestyle in this adult groups of population.

Although it was a secondary aim, FPG showed to be higher in the Lsmm-Hwc group when compared with the Ref. group. It is well known that skeletal muscle accounts for more than 80 % of glucose uptake under insulin-stimulated conditions, which means that independent of age, when SMM is maintained appropriately under a physically active lifestyle the glucose control is better and there is lower risk for diabetes. In this study we do not observe significant results in FPG and HbA1c outcomes in the main interaction tested (Groups x PVD and Groups x CeVD), however in FPG there were significant interactions in CeVD in both body composition phenotypes Groups proposed (Lsmm-Hwc + 2.7 mg/dL, Lsmm-Lwc + 14.3 mg/dL, and Hsmm-Hwc + 16.8 mg/dL showed higher levels of glucose vs. Ref. and between the CeVD/No-CeVD condition which means that different mixtures of body composition with higher/lower SMM, and higher/lower WC could increase or decrease the glucose levels being the Ref. Hsmm-Lwc phenotype is the group with better glucose control (mean: 92.7 mg/dL) (Fig. 1). Due to physiologically the diabetes is nowadays a known metabolic disease with a high role in their physiopathology centered in the lipid droplet

accumulation (i.e., fat accumulation into muscle cells), in contrast with the Hsmm-Hwc group results that showed (diff + 16.8 mg/dL) vs. Ref phenotype (Fig. 1, panel B), it is relevant to mention that independent of having a higher muscle mass, the fat accumulation as a higher waist circumference, but more specifically, the intramyocellular fat accumulation could be part of the responsible of these results (30). About our second main finding, we have also highlighted the role of the skeletal muscle mass and adipose tissue in the regulation of both metabolic and vascular control, where previous studies have shown that improving skeletal muscle mass in ~ 1 % can decrease FPG -6 mg/dL in women with insulin resistance (31). The main part of literature, have described as the increases in Glut-4 carrier of glucose transport as part of the main mechanisms responsible for glucose control improvements after muscle mass increases (32). On the other hand, previous experimental studies have shown that skeletal muscle mass increase of ~ 19 to 34 % (i.e., by leg extension exercise) have been linked with -4 to -5 mmHg of SBP decreases, and at the same time with vascular improvements by flow mediated dilation of ~ 3.2 to 6.8 % in this outcome (33), being evidenced that muscle mass increases could led for vascular improvements.

In other secondary outcomes as lipid profile (Tc, HDL-c, LDL-c, Tg), we do not detect body composition phenotypes Groups x PVD, however, in Tg each Lsmm-Hwc + 55.7 mg/dL, Lsmm-Lwc + 20.1 mg/dL, and Hsmm-Hwc + 40.8 mg/dL showed higher levels of Tg vs. Ref. Hsmm-Lwc group, being the similar situation in CeVD condition with Lsmm-Hwc + 10.7 mg/dL, Lsmm-Lwc + 0.1 mg/dL, and Hsmm-Hwc + 9.5 mg/dL of Tg vs. Ref. group (Fig. 2). An interesting situation is that each Ref. The Hsmm-Lwc group in PVD and CeVD categories have Tg under normal conditions. The way how? liver produces Tg, as well as other lipoproteins such as LDL-c and HDL-c is widely dependent on energy expenditure (i.e., skeletal muscle movement as physical activity/exercise and diet)

modulating thus a positive or negative energy balance. Thus, when the population describe higher levels of Tg denotes a dysregulation more than from a physiological perspective (effect) from an environmental behavior (i.e., lifestyle) being a need to recover the nature of human body which is the movement, save the energy stores and then to recover those energy sources by diet (fat, carbohydrates, proteins) with maintenance of the balance ratio energy intake/energy expenditure.

We also detected an elevated risk for suffering PVD in the groups Lsmm-Hwc OR 3.2, Lsmm-Lwc OR 1.7, Hsmm-Hwc OR 2.2, and the risk for suffering CeVD in the group Lsmm-Hwc OR 2.3 and group Lsmm-Lwc OR 2.3 (Table II). These results contribute in part to confirm our hypothesis that under a low SMM and higher adiposity by WC as was used in the present study a poor body composition show some degree of association/interaction in the acquisition of vascular disorders, however, clearly, our association study does not clarify causality, our present study add new information regarding the relevance of including more SMM and adiposity outcomes for future PVD, CeVD, and other vascular conditions in Chilean adults. Similarly, the risk of suffering of CeVD was elevated in those with poor SMM or elevated adiposity, where recent studies have shown that adiposity (by visceral adiposity tissue) was highly associated with markers of CeVD and atherosclerosis in the large and medium arteries using magnetic resonance imaging technology and computed tomography angiography (34). On the other hand, due to part of our findings, it was observed that PVD participants of the present study declare to be aged ~ 60 years old, this is a worrying concern, because at public health level, there is a need to be anticipated to these vascular diseases, where screening regularly (i.e., annually in adults) the physical activity patterns for example, the handgrip muscle strength as it is incorporated into the National Health Survey, it can be possible to avoid several PAV and future CeVD cases.

Strength and limitations

Some limitations of our study are; a) we did not diagnose clinically PVD and CeVD conditions, where we used the; b) each body composition phenotypes were modelled by calculating “calf circumference” (as SMM marker) and “waist circumference” (as adiposity marker); and c) as any observational correlational study, this associative study does not denote cause-effect in their relationships reported, iii) the auto reported diseases is not exactly the same as diseases diagnosed which may affect the results of the study. Among some strengths are: a) the NHS16-17 is a representative study of Chile; and b) the present study reports information about anthropometric, cardiovascular, metabolic and physical activity levels being all risk factors frequently used in adults and showing an integral work.

CONCLUSION

In addition, the sample size of Chilean population included in the present cross-sectional study with PVD and CeVD show as risk factors to be ~ 60 aged, in obesity and hypertensive condition, report lower handgrip strength and physical activity of vigorous and light-intensity per week in comparison with adult peers without these vascular disease conditions. These results should continue to be explored by additional epidemiological studies including more robust body composition and vascular outcomes.

REFERENCES

1. Comeau KD, Shokoples BG, Schiffrin EL. Sex differences in the immune system in relation to hypertension and vascular disease. Canadian Journal of Cardiology 2022;38(12):1828-43.
2. Martin SS, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, et al. 2024 Heart Disease and Stroke Statistics: A Report of US and Global Data From the American Heart Association. Circulation

2024;149(8):e347-e913. DOI: 10.1161/CIR.0000000000001209. Erratum in: Circulation 2024;149(19):e1164. DOI: 10.1161/CIR.0000000000001247

3. Hernando FS, Conejero AM. Peripheral artery disease: pathophysiology, diagnosis and treatment. Revista espanola de cardiologia 2007;60(9):969. DOI: 10.1157/13109651
4. Selvin E, Erlinger TP. Prevalence of and risk factors for peripheral arterial disease in the United States: results from the National Health and Nutrition Examination Survey, 1999–2000. Circulation 2004;110(6):738-43. DOI: 10.1161/01.CIR.0000137913.26087.F0
5. Ikawa F, Kato Y, Kobayashi S. Gender difference in cerebrovascular disease. Nihon rinsho Japanese journal of clinical medicine 2015;73(4):617-24.
6. Suanrueang P. A comparison of the disease occurrence of cerebrovascular diseases, diabetes mellitus, hypertensive diseases, and ischaemic heart diseases among hospitalized older adults in Thailand. Scientific Reports 2024;14(1):123. DOI: 10.1038/s41598-023-49274-z
7. MINSAL. Informe de Encuesta nacional de Salud 2016-2017. Riesgo Cardiovascular Santiago de Chile: Ministerio de Salud de Chile; 2018 Nov 2018.
8. Alvarez C, Tuesta M, Reyes Á, Guede-Rojas F, Peñailillo L, Cigarroa I, et al. Heart rate from progressive volitional cycling test is associated with endothelial dysfunction outcomes in hypertensive chilean adults. International Journal of Environmental Research and Public Health 2023;20(5):4236. DOI: 10.3390/ijerph20054236
9. WHO. WHO Guidelines on Physical Activity and Sedentary Behaviour. Geneva; 2021.
10. Johnsen SP, Overvad K, Stripp C, Tjønneland A, Husted SE, Sørensen HT. Intake of fruit and vegetables and the risk of ischemic stroke in a cohort of Danish men and women. The

American journal of clinical nutrition 2003;78(1):57-64. DOI: 10.1093/ajcn/78.1.57

11. Han H, Wang Y, Li T, Feng C, Kaliszewski C, Su Y, et al. Sleep duration and risks of incident cardiovascular disease and mortality among people with type 2 diabetes. Diabetes Care 2023;46(1):101-10. DOI: 10.1093/ajcn/78.1.57
12. Delgado-Floody P, Latorre-Román PÁ, Jerez-Mayorga D, Caamaño-Navarrete F, Cano-Montoya J, Laredo-Aguilera JA, et al. Poor sleep quality decreases concurrent training benefits in markers of metabolic syndrome and quality of life of morbidly obese patients. International Journal of Environmental Research and Public Health 2020;17(18):6804. DOI: 10.3390/ijerph17186804
13. Behrooz L, Abumoawad A, Rizvi SHM, Hamburg NM. A modern day perspective on smoking in peripheral artery disease. Frontiers in Cardiovascular Medicine 2023;10:1154708. DOI: 10.3389/fcvm.2023.1154708
14. Álvarez C, Ramírez-Campillo R, Miranda-Fuentes C, Ibacache-Saavedra P, Campos-Jara C, Cristi-Montero C, et al. Lifestyle and cardiometabolic risk factors in the ethnic and non-ethnic population> 15 years of age: results from the National Chilean Health Survey 2016-2017. Nutricion hospitalaria 2023;40(2). DOI: 10.20960/nh.04252
15. Booth FW, Chakravarthy MV, Gordon SE, Spangenburg EE. Waging war on physical inactivity: using modern molecular ammunition against an ancient enemy. Journal of Applied Physiology 2002;93(1):3-30. DOI: 10.1152/japplphysiol.00073.2002
16. Petermann F, Duran E, Labraña AM, Martínez MA, Leiva AM, Garrido-Mendez A, et al. Risk factors associated with hypertension. Analysis of the 2009-2010 Chilean health survey. Revista medica de Chile 2017;145(8):996-1004. DOI: 10.4067/s0034-98872017000800996

17. WHO. Global report on hypertension: The race against a silent killer. Geneva; 2023. Contract No.: CC By-NC-SA 3.0 IGO.
18. Lindenstrøm E, Boysen G, Nyboe J. Lifestyle factors and risk of cerebrovascular disease in women. The Copenhagen City Heart Study. Stroke 1993;24(10):1468-72. DOI: 10.1161/01.str.24.10.1468
19. Davies KAB, Pickles S, Sprung VS, Kemp GJ, Alam U, Moore DR, et al. Reduced physical activity in young and older adults: metabolic and musculoskeletal implications. Therapeutic Advances in Endocrinology and Metabolism 2019;10. DOI: 10.1177/2042018819888824
20. Rolland Y, Lauwers-Cances V, Cournot M, Nourhashémi F, Reynish W, Rivière D, et al. Sarcopenia, calf circumference, and physical function of elderly women: a cross-sectional study. Journal of the American Geriatrics Society 2003;51(8):1120-4. DOI: 10.1046/j.1532-5415.2003.51362.x
21. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension 2018;71(6):1269-324. DOI: 10.1161/HYP.0000000000000066
22. O'Brien E, Atkins N, Stergiou G, Karpettas N, Parati G, Asmar R, et al. European Society of Hypertension International Protocol revision 2010 for the validation of blood pressure measuring devices in adults. Blood pressure monitoring 2010;15(1):23-38. DOI: 10.1097/MBP.0b013e3283360e98

23. Concha-Cisternas Y, Vásquez-Gómez J, Castro-Piñero J, Petermann-Rocha F, Parra-Soto S, Matus-Castillo C, et al. Niveles de actividad física y tiempo sedente en personas mayores con fragilidad: resultados de la Encuesta Nacional de Salud 2016-2017. Nutricion hospitalaria 2023;40(1):28-34. DOI: 10.20960/nh.04335
24. WHO. Obesity: preventing and managing the global epidemic. 2000:894:i–xii, 1–253.
25. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation 2002;106(25):3143-421.
26. Díaz-Martínez X, Petermann F, Leiva AM, Garrido-Méndez A, Salas-Bravo C, Martínez MA, et al. No cumplir con las recomendaciones de actividad física se asocia a mayores niveles de obesidad, diabetes, hipertensión y síndrome metabólico en población chilena. Revista medica de Chile 2018;146:585-95. DOI: 10.4067/s0034-98872018000500585
27. Poblete-Valderrama F, Rivera CF, Petermann-Rocha F, Leiva AM, Martínez-Sanguinetti MA, Troncoso C, et al. Actividad física y tiempo sedente se asocian a sospecha de deterioro cognitivo en población adulta mayor chilena. Revista medica de Chile 2019;147(10):1247-55. DOI: 10.4067/s0034-98872019001001247
28. Hopkins W, Marshall S, Batterham A, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Medicine+ Science in Sports+ Exercise 2009;41(1):3. DOI: 10.1249/MSS.0b013e31818cb278
29. Hedges LV, Olkin I. Statistical methods for meta-analysis: Academic press; 2014.

30. Abdul-Ghani MA, DeFronzo RA. Pathogenesis of Insulin Resistance in Skeletal Muscle. Journal of Biomedicine and Biotechnology 2010;2010. DOI: 10.1155/2010/476279
31. Alvarez C, Ramirez-Campillo R, Ramirez-Velez R, Izquierdo M. Effects and prevalence of nonresponders after 12 weeks of high-intensity interval or resistance training in women with insulin resistance: a randomized trial. J Appl Physiol (1985) 2017;122(4):985-96. DOI: 10.1152/japplphysiol.01037.2016
32. Cox JH, Cortright RN, Dohm GL, Houmard JA. Effect of aging on response to exercise training in humans: skeletal muscle GLUT-4 and insulin sensitivity. Journal of Applied Physiology 1999;86(6):2019-25. DOI: 10.1152/jappl.1999.86.6.2019
33. Pedralli ML, Marschner RA, Kollet DP, Neto SG, Eibel B, Tanaka H, et al. Different exercise training modalities produce similar endothelial function improvements in individuals with prehypertension or hypertension: a randomized clinical trial Exercise, endothelium and blood pressure. Scientific reports 2020;10(1):1-9. DOI: 10.1038/s41598-020-64365-x
34. Karcher H-S, Holzwarth R, Mueller H-P, Ludolph AC, Huber R, Kassubek J, et al. Body fat distribution as a risk factor for cerebrovascular disease: an MRI-based body fat quantification study. Cerebrovascular diseases 2013;35(4):341-8. DOI: 10.1159/000348703

Table I. Characteristics of an adult population with and without peripheral/no-peripheral vascular disease or cerebral vascular/no-cerebral vascular disease diagnosed based on the Chilean National Health Survey 2016-17

Outcomes	**PVD**	**No-PVD**	**CeVD**	**No-CeVD**
n	209	2580	122	2674
Age (y)	60.0 ± 16.2	48.2 ± 19.3	65.3 ± 14.6	48.4 ± 19.2
Height (m)	156.1 ± 8.7	160.2 ± 9.5	157.3 ± 9.4	160.0 ± 9.4
Weight (kg)	75.1 ± 15.4	73.9 ± 15.5	74.3 ± 16.2	74.0 ± 15.5
Body mass index (kg/m^2)	30.8 ± 6.0	28.8 ± 5.5	30.0 ± 5.9	28.9 ± 5.5
Waist circumference (cm)	98.4 ± 13.5	93.7 ± 14.0	98.3 ± 13.4	93.9 ± 14.0
Calf circumference (cm)	35.8 ± 4.8	35.3 ± 5.0	34.9 ± 7.0	35.4 ± 4.9
Systolic BP (mmHg)	133 ± 24	127 ± 21	140 ± 22	127 ± 21
Diastolic BP (mmHg)	75 ± 11	75 ± 11	76 ± 11	75 ± 11
Fasting plasma glucose	104.4 ± 37.3	99.8 ± 36.2	110.9 ± 44.1	99.7 ± 36.1
Glycated hemoglobin (%)	6.6 ± 1.7	6.3 ± 1.7	6.9 ± 1.7	6.3 ± 1.7
Total cholesterol (mg/dL)	185.1 ± 42.7	181.2 ± 40.0	176.1 ± 45.0	181.6 ± 40.0
Low-density lipids (mg/dL)	107.5 ± 36.5	104.6 ± 33.5	99.0 ± 38.7	105.0 ± 33.5
High-density lipids (mg/dL)	50.0 ± 13.7	47.7 ± 13.3	45.8 ± 12.0	47.9 ± 13.4
Triglycerides (mg/dL)	137.8 ± 81.0	144.4 ± 93.1	156.5 ± 94.3	143.5 ± 92.2
Gamma glutamyl transaminase (UI/L)	34.3 ± 52.7	32.4 ± 49.7	36.0 ± 47.3	32.4 ± 50.0
Pyruvic glutamyl transaminase (UI/L)	23.1 ± 17.0	25.1 ± 19.5	25.4 ± 23.4	25.0 ± 19.2
C-Reactive protein (mg/L)	0.44 ± 0.85	0.44 ± 0.96	0.41 ± 0.72	0.44 ± 0.96

Handgrip muscle strength (kg)	46.4 ± 21.8	56.0 ± 34.7	55.3 ± 39.1	54.9 ± 33.4
Physical activity of vigorous intensity (min/day)	3.0 ± 8.3	4.0 ± 9.8	1.7 ± 3.4	4.0 ± 9.9
Physical activity of moderate intensity (min/day)	4.6 ± 10.1	4.1 ± 9.8	4.5 ± 10.3	4.1 ± 9.8
Physical activity of low intensity (min/day)	12.5 ± 13.2	12.6 ± 14.2	13.0 ± 14.3	12.7 ± 14.1

Data are shown as mean and ± SD. Groups are described as: PVD: peripheral vascular disease; No-PVD: no peripheral vascular disease; CeVD: cerebral vascular disease; No-CeVD: No cerebral vascular disease.

Table II. Multinominal logistic regression with odds ratios by each phenotype group according to the risk for suffering of peripheral vascular disease under different cardiometabolic conditions

Outcomes	**β**	**SE**	**Wald**	**McFadden Pseudo R^2**	**OR (95 % CI)**	**p-value**
"Peripheral Vascular Disease"						
Model 0: "No-PVD or Hsmm−Lwc"	-	-	-	-	*1.00 (Ref.)*	-
Model 1: HTN suspect "Yes"	−0.254	0.176	2.078	0.038	0.7 (0.5; 1.09)	P = 0.149
Model 2: Diabetes suspect "Yes"	−0.055	0.178	0.095		0.9 (0.6; 1.34)	P = 0.758
Model 3: Lsmm−Hwc	1.185	0.302	15.404		3.2 (1.8; 5.9)	*P < 0.0001*
Model 4: Lsmm−Lwc	0.580	0.292	3.935		1.7 (1.0; 3.1)	*P = 0.047*
Model 5: Hsmm−Hwc	0.815	0.201	16.403		2.2 (1.5; 3.3)	*P < 0.0001*
"Cerebral Vascular Disease"						
Model 0: "No-CeVD or Hsmm−Lwc"	-	-	-	-	*1.00 (Ref.)*	-
Model 1: HTN suspect "Yes"	−1.325	0.279	22.563	0.071	0.2 (0.1; 0.4)	*P < 0.0001*
Model 2: Diabetes suspect "Yes"	−0.444	0.214	4.315		0.6 (0.4; 0.9)	*P = 0.038*
Model 3: Lsmm−Hwc	0.843	0.404	4.365		2.3 (1.0; 5.1)	*P = 0.037*
Model 4: Lsmm−Lwc	0.840	0.359	5.469		2.3 (1.1; 4.6)	*P = 0.019*
Model 5: Hsmm−Hwc	0.489	0.285	2.944		1.6 (0.9; 2.8)	P = 0.086

Data are shown as mean and to OR as mean and (95 % CI). Groups are described as: Lsmm-Hwc: low-skeletal muscle mass and high waist circumference phenotypical model; Lsmm-Lwc: low-skeletal muscle mass and low waist circumference phenotypical model; Hsmm-Hwc: high-skeletal muscle mass and high waist circumference phenotypical model; Hsmm-Lwc: high-skeletal muscle mass and low waist circumference phenotypical model; Ref.: reference group; β: beta; SE: standard error; Wald: Wald chi-square; No-PVD: no diagnosis of peripheral vascular disease; No-CeVD: no diagnosis of cerebral vascular disease; HTN: arterial hypertension.

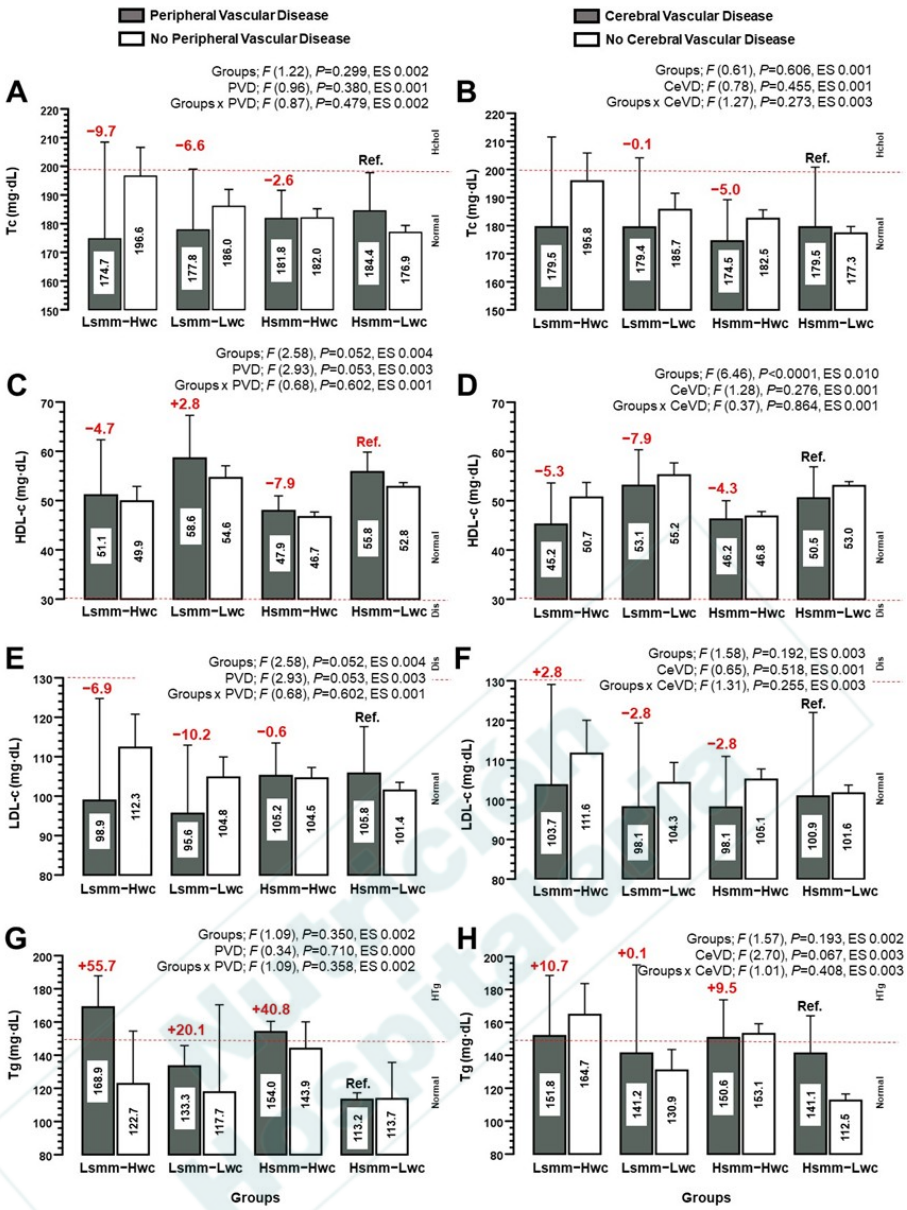

Figure 1. Diabetes (A-D) and arterial hypertension markers (E-H) according to four different categories of body composition phenotypes. Groups: Lsmm-Hwc: low skeletal muscle mass high waist circumference; Lsmm-Lwc: low skeletal muscle mass/low waist circumference; Hsmm-Hwc: high skeletal muscle mass/high waist circumference; Hsmm-Lwc: high skeletal muscle mass/low waist circumference; Ref.: reference group. Data are presented as mean and 95 % CI.

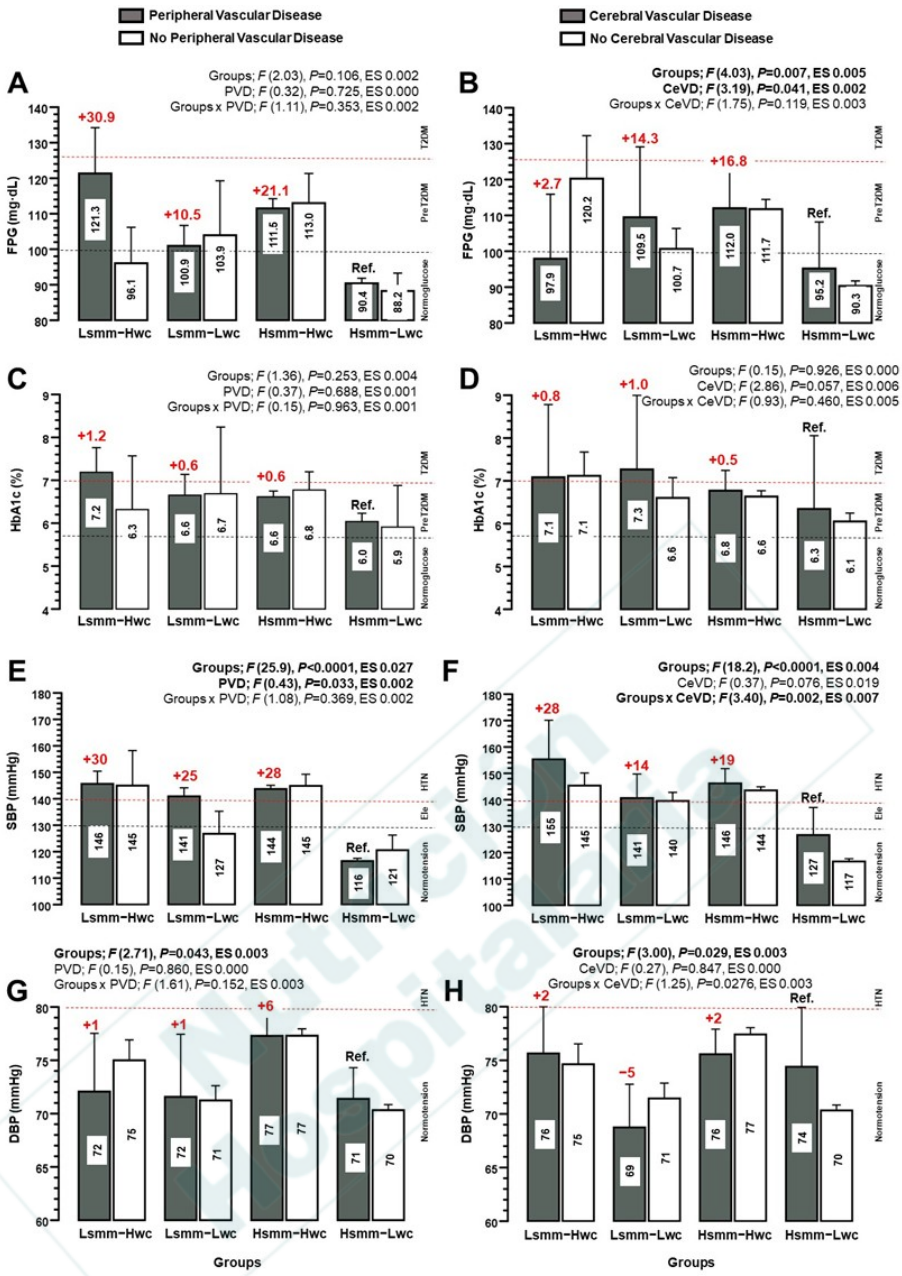

Figure 2. Lipid profile markers according with four differente catgories of body composition phenotypes of different skeletal muscle mass and waist circumference combination, and according of categories of peripheral vascular, and no peripheral vascular disease categories (A,C,E,G), and cerebral/no cerebral vascular disease (B,D,F,H). Groups are described as: Lsmm-Hwc: low skeletal muscle mass plus high waist circumference; Lsmm-Lwc: low skeletal muscle mass plus low waist circumference; Hsmm-Hwc: high skeletal muscle mass plus high waist

circumference; Hsmm-Lwc: high skeletal muscle mass plus low waist circumference. Outcomes are described as: Ref.: reference group. Data are presented as mean and 95 % CI. Hcho: hypercholesterolemia; Dis: dyslipidemia; HTg: hypertriglyceridemia. Red color denotes difference higher vs. the Ref. group. Blue color denotes difference lower vs. the Ref. group. ES: effect size. Significant interactions are described in italics.