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ORIGINAL ARTICLE

Influence of the level of physical activity on physical fitness, lipid profile and health outcomes in overweight/obese adults with similar nutritional status

Influence du niveau d'activité physique sur la condition physique, la composition corporelle et le profil lipidique dans une population d'adultes en surpoids ou obèses

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KEYWORDS
Cardiorespiratory fitness;
Muscle strength;
Weight management;
Metabolic syndrome

Summary
Objective. — To determine the influence of the level of physical activity on physical fitness, body composition and lipid profile and further explore the associations between fitness with these health outcomes in a population of overweight/obese adults.
Methods. — Forty overweight/obesity participants with a caloric intake between a negative balance of 500 kcal/day and their estimated required energy intake were classified according to their level of physical activity. Anthropometric (weight and height), body composition (waist-to-hip ratio, percentage of body fat and fat-free mass), clinical measurements (blood pressure), physical fitness (cardiorespiratory fitness — 6MWT —, handgrip strength and lower-limb muscle strength — MVC —) and lipid profile (total cholesterol — TC —, low — LDL — and high-density lipoprotein cholesterol — HDL —, triglyceride — TG —, and plasma glucose) were determined.

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Results. — Significant differences in MVC and fat-free mass were found between participants with different physical level. Significant associations between all the body composition measures and the strength-related variables (handgrip and MVC) in both physical activity categories also were found. In addition, associations between triglycerides, LDL and total cholesterol with muscle strength and cardiorespiratory fitness were observed only in the low physical activity group. Moreover, MVC explained up to 39% of the variance in metabolic syndrome in those with a moderate level of physical activity.
Conclusions. — Correlations between physical fitness (especially in strength) and health risk factors depending on the level of physical activity were found.

MOTS CLÉS
Aptitude cardiorespiratoire ;
Force musculaire ;
Gestion du poids ;
Syndrome métabolique

Résumé
Objectif. — Déterminer l'influence du niveau d'activité physique sur la condition physique, la composition corporelle et le profil lipidique, ainsi que préciser les associations entre aptitude physique et ces paramètres biologiques dans une population d'adultes en surpoids ou obèses.
Méthodes. — Quarante participants en surpoids ou obèses recevant des apports caloriques compris entre leurs besoins énergétiques et une restriction de 500 kcal/jour ont été classés en fonction de leur niveau d'activité physique, et comparés sur le plan des données anthropométriques (poids et taille), de la composition corporelle (rapport taille/hanche, pourcentage de graisse corporelle et masse maigre), de la pression artérielle, de la condition physique (test de marche de 6 minutes, aptitude cardiorespiratoire, la force de préhension et de la force musculaire des membres inférieurs), du profil lipidique (cholestérol total, cholestérol LDL et HDL, triglycérides et glycémie).
Résultats. — Des différences significatives au niveau de la force musculaire des membres inférieurs cholestérol et de la masse maigre s'observent entre les groupes de niveau d'activité physique différent. Des associations significatives entre toutes les mesures de la composition corporelle et les variables liées à la force (préhension et force musculaire des membres inférieurs) sont observées dans les deux catégories d'activité physique. Une association des paramètres lipidiques (triglycérides, cholestérol LDL et cholestérol total) avec la force musculaire l'aptitude cardiorespiratoire n'a été observée que dans le groupe à faible activité physique. Par ailleurs, la force musculaire des membres inférieurs explique jusqu'à 39 % de la variance du syndrome métabolique chez les sujets ayant un niveau modéré d'activité physique.
Conclusions. — Des corrélations différentes entre la condition physique (en particulier la force musculaire) et les facteurs de risque pour la santé ont été trouvés en fonction du niveau d'activité physique. La force musculaire des membres inférieurs est un important déterminant statistique du syndrome métabolique chez les sujets à faible niveau d'activité physique.

1. Introduction

Metabolic syndrome is characterized by the co-occurrence of central obesity, hypertension, dyslipidemia and hyperglycemia, which represent significant risk factors for cardiovascular disease [1]. This cluster of related metabolic abnormalities is strongly linked with overweight and obesity and is affecting a wide range of people in all age groups. According to the World Health Organization, by 2015, an estimate of ~2.3 billion adults worldwide are expected to be overweight (body mass index [BMI] $\geq$ 25 kg/m^2) and at least 700 million obese (BMI $\geq$ 30 kg/m^2). Therefore, this pandemic is one of the main public health challenges, and identifying risk factors and strategies for prevention and treatment of these conditions are an important public health issue.

Obesity results from an imbalance between nutritional intake and energy expenditure and it is well established that physical activity levels and diet, either independently or in combination, are associated with this disease. We have now evidence that low physical activity levels and excessive energy intake are associated with obesity [2—5] and therefore higher levels of physical activity are associated with several metabolic consequences and a lower incidence of obesity [6]. Thus, changes in lifestyle such as modifications in diet and exercise are considered to be the cornerstones of obesity management [7,8].

Physical activity is thought to positively influence energy balance increasing energy expenditure [6] but also has positive effects on the metabolism of skeletal muscle and insulin sensitivity [8]. Even low levels of physical activity may contribute to maintain a favorable metabolic profile [9], inducing the clearance of triglycerides [10]. Furthermore, changes in physical activity and fitness are inversely correlated with changes in body weight, body mass index (BMI), waist circumference and abdominal adiposity [11—13] and a dose—response relationship has been reported between the amount of exercise and changes in visceral adipose tissue in obese participants [13,14]. In addition, handgrip strength, considered a popular marker of nutritional status has recently been associated with different measures of obesity [15].

It seems that physically active individuals are considerably less likely to be obese than physically inactive and unfit individuals. However, these associations are not completely consistent in the literature [16] and several authors have reported a lack of association between physical activity and the lipid profile, plasma glucose, or resting metabolic rate [17]. While numerous studies have reported the influence of physical activity and fitness on different health outcomes even after controlling for age [18], others have not found this interaction considering the independent association of these parameters [19]. Although the influence of physical exercise on adult obesity is well known, the information when this population is controlled by a constant nutritional intake is scarce. Also if we consider the complex relationships between the level of physical activity on adults with overweight or obesity [20] and the need of understanding the effects of these changes in energy balance on key health outcomes, therefore, the aim of the current cross-sectional study was to assess the association of the physical fitness, body composition and lipid profile on a group of overweight/obese adults with constant nutrition intake and to examine whether different levels of physical activity present an independent relationship with body composition and lipid profile. As Kaino et al. [21] have recently described that physical activity is more important than energy intake in the prevention of a clustering of metabolic risk factors (elevated fasting plasma glucose levels, blood pressure or triglyceride levels and reduced high-density lipoprotein cholesterol), we hypothesized that controlling the nutritional status, the participants with higher levels of physical activity will present a better fitness and metabolic profile.

2. Materials and methods

2.1. Participants

Participants were recruited from a local outpatient clinic (Seville, Spain). Inclusion criteria include both males and females older than 18 years with BMI greater than or equal to 25 kg/m^2. Exclusion criteria include history or evidence of advanced cardiovascular (including SBP > 160 mmHG and DBP > 100 mmHG), renal or hepatic diseases. Participants with type 1 or 2 diabetes or those on medication known to affect type 2 diabetes and cardiovascular risk factors (lipid-lowering, antihypertensive, hypoglycemic, hormone replacement therapy, or insulin), also were excluded. Only those with a similar nutritional status were selected. Out of 150 potentially eligible participants with similar nutrition patterns, 40 volunteers with overweight/obesity gave their written informed consent after receiving detailed information about the aims and study procedures. These participants had a caloric intake between a negative balance of 500 kcal/day and the required estimated energy intake. The authors declare that all experiments on human subjects were conducted in accordance with the Declaration of Helsinki and also certify that this study was approved by the Ethics Committee of the University of Seville.

2.2. Assessments of current physical activity status and daily nutritional intake

To obtain information on physical activity level, the International Physical Activity Questionnaire (IPAQ) was used [22]. The short (self-administered, seven items), last-week version of the IPAQ was administered, asking about the time spent being physically active in the last 7 days. Total energy and activity-specific energy expenditure are quantified in terms of metabolic equivalents/day (METs (metabolic equivalents) · h/day). Physical activities were computed as minutes of sitting, walking, moderate-intensity, and vigorous-intensity activities and also defined on the basis of the intensity of physical activity as light (< 3.0 METs), moderate to vigorous (≥ 3.0 METs), and vigorous (≥ 6.0 METs) intensity.

Daily nutritional intake was assessed on three consecutive days (Sunday, Monday and Tuesday) and during the winter months (January, February and March) to control for seasonal variation in dietary intake. Percent energy from protein, carbohydrates and fat of total energy intake were recorded. Requirements were calculated by adding the estimated energy expenditure from physical activity to basal metabolism.

2.3. Anthropometric, body composition and clinical measurements

Body weight (kg) and height (m) were measured using standardized procedures and equipment, and BMI (kg/m^2) was calculated. Waist circumference was measured to the nearest 0.1 cm at the point midway between the costal margin and crest in the mid-auxiliary line, as was hip circumference at the widest point around the greater trochanter. The waist-to-hip ratio (WHR) was calculated.

Bioelectrical impedance was used to determine body composition using Bodystat©1500 (Bodystat Ltd, Douglas, Isle of Man, UK), which is a four terminal single frequency (500 μA at 50 kHz) analyzer. Resistance and reactance were measured between the right wrist and the right ankle and total body fat, fat-free mass, and their percentages were estimated from the equations proposed by Kyle et al. [23]. Further, skeletal muscle mass was calculated with Janssen's equation [24]. As the bioelectrical impedance analysis system methodology for determining percent body fat is sensitive to hydration status, participants were asked to fast within 4 hours of the test, not exercise within 12 hours of the test and avoid alcohol or diuretics before testing. The device was tested for validity and reliability with results showing good to excellent fat and fat-free mass test—retest reliability [25].

Blood pressure was monitored using the Omron electronic blood pressure equipment (Omron BF-306, Omron Healthcare Europe BV, Hoofddorp, The Netherlands). The blood pressure of the participants was measured three times with at least 2—3 min between successive measurements. All measurements were taken in a quiet room after the participants had been sitting in a chair for 5 min. The mean of the three measurements was used for the analysis.

2.4. Physical fitness

Cardiorespiratory fitness was estimated using the distance results from the six-minute walk test (6MWT) [26]. The walk test was done in a corridor with a length of 70 meters. Standardized instructions were given to walk as far as possible but comfortable pace over a course in six minutes. Subjects were not encouraged during the test but were notified as to the amount of time remaining when within the last minute of the test. The distance walked in 6 minutes was recorded in meters.

Handgrip strength was assessed in both hands by using a hand dynamometer (TKK 5401 Grip-D; Smedley, Takei, Tokyo, Japan) with all participants reporting that they were right-handed. Lower-limb strength was assessed by means of maximal voluntary contraction (MVC) of the knee extensors. MVC was measured by a load cell (Model 333A) connected to an A/D converting system (MuscleLab^{TM}, Ergotest AS, Langesund, Norway). Participants sat upright on a high-backed chair, the hips and legs firmly secured, with the knee positioned at 90° to the thigh, and the arms folded across the chest. Muscle tests for the rectus femoris were performed three times lasting 5 s and separated by 60 s.

2.5. Biochemical and hormonal assays

Blood samples from an antecubital vein were made in fasting conditions. The blood was collected in a vacutainer tube containing tetraacetic diamine ethylene acid (EDTA). The collected venous blood samples were immediately placed in ice. Plasma from the venous blood samples was separated by centrifugation (3000 g, 10 min, 4 °C) and the aliquots of plasma were stored at −80 °C for use in subsequent chemical analyses. Total cholesterol (TC), high-density lipoprotein cholesterol (HDL), triglyceride (TG), and plasma glucose were determined using the Reflotron system (Boehringer-Mannheim, West Germany). Low-density lipoprotein (LDL) was determined indirectly by using Friedewald's formula: $LDL = TC - HDL + (TG/5)$.

2.6. Data analysis

Data are presented as means ± standard deviation (SD), unless otherwise stated. One-way ANOVA was performed to test the differences between the level of physical activity concerning the body composition, physical fitness and lipid profile variables. The association between physical activity and physical fitness, body composition and lipid profile were analyzed using Pearson's correlation coefficients. Partial correlations adjusted for weight were also tested.

The participants were divided into those with or without a clustering of Metabolic Syndrome defined as the presence of at least three of the following non-essential risk factors: (1) elevated triglycerides (≥ 150 mg/dl) and/or reduced HDL cholesterol (< 50 mg/dl), (2) elevated Blood pressure (SBP ≥ 130 and/or DBP ≥ 85 mmHg), (3) elevated fasting plasma glucose (≥ 100 mg/dl) and (4) waist circumference > 102 cm in men and > 88 cm in women. Binary logistic regression was used to predict the occurrence of metabolic syndrome from physical fitness (Cardiorespiratory fitness, handgrip strength and lower-limb strength) as continuous variables, alone and in combination. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS Version 19.0, IBM Incop®). Alpha value was set at .05 level for all test performed.

3. Results

In Table 1, are summarized subject demographic data and anthropometric measurements for all participants. Out of the 40 participants, 70% ($n = 28$) were women and 58% ($n = 23$) were classified as obese by NIH BMI standards (≥ 30 kg/m^2).

Table 2 highlights the physical fitness characteristics of the total sample categorized according to their level of physical activity. Forty-five percent of the participants presented a low prevalence of physical activity and the remaining 55% had moderate prevalence of physical activity. Differences were observed in MVC in favor to those performing the greater levels of physical activity. When the body composition was compared based on the physical activity categories (Table 3), significant differences were observed in fat-free mass ($P = 0.050$) and muscle mass ($P = 0.044$). Non-significant differences were detected in the percentage of body fat, weight or WHR.

Table 4 presents the results of the lipid profile and cardiovascular risk factors according to the physical activity level. Non-significant differences between the physical activity categories were found. However, those with the lower level of physical activity reported 6% more cholesterol and 11% more triglycerides. Differences in cardiovascular risk factors between both physical activity categories were not observed. The strength of the association between physical activity, physical fitness and health outcomes (body composition and the lipid profile) are summarized in Table 5. In low physical activity group MVC ($r = 0.662$, $P < 0.005$) and in both low and moderate physical activity groups, handgrip strength ($r = 0.651$ to 0.835, $P < 0.001$) adjusted by weight were associated with fat-free mass and were negatively associated with the percentage of body fat

Table 1 Descriptive characteristics of participants ($n = 40$).

Variable	Mean (SD)
Gender	
Women (%)	70
Men (%)	30
Age (years)	35 (7.86)
Height (m)	1.66 (0.09)
Weight (kg)	87.89 (17.88)
Body mass index (kg/m^2)	31.62 (4.78)
Obese (%)	58
Overweight (%)	42
Waist circumference (cm)	94.03 (12.44)
Hip circumference (cm)	113.25 (8.89)
Waist-to-hip ratio	0.83 (0.09)
Systolic blood pressure (mmHg)	124.60 (14.90)
Diastolic blood pressure (mmHg)	81.73 (11.61)

Data are reported as mean (SD) or percentage.

Table 2 Assessment of the physical fitness according to the physical activity level.

	Total (*n* = 40)	Low physical activity (*n* = 18)	Moderate physical activity (*n* = 22)	*P*-value
Handgrip strength test right hand (kg)	31.88 (12.13)	29.80 (12.10)	33.57 (12.16)	0.334
Handgrip strength test left hand (kg)	35.81 (34.04)	28.5 (10.07)	32.21 (12.16)	0.306
Maximal voluntary isometric contraction (*n*)	505.14 (206.09)	430.88 (155.07)	565.90 (225.43)	0.038*
6MWT (m)	607.16 (75.73)	605.2 (67.64)	608.77 (83.32)	0.884

Data are reported as mean (SD). 6MWT: six-minute walk test distance.
* $P < 0.05$.

Table 3 Assessment of body composition according to the physical activity level.

	Total (*n* = 40)	Low physical activity (*n* = 18)	Moderate physical activity (*n* = 22)	*P*-value
Weight (kg)	87.89 (17.87)	83.22 (15.27)	91.71 (19.25)	0.137
Body mass index (kg/m^2)	31.62 (4.79)	31.17 (5.25)	31.99 (4.46)	0.600
Waist-to-hip ratio	0.83 (0.09)	0.82 (0.08)	0.84 (0.10)	0.445
Percentage body fat (%)	35.86 (5.54)	35.00 (5.82)	36.56 (6.62)	0.381
Fat-free mass (kg)	55.54 (6.97)	53.39 (5.97)	57.29 (7.36)	0.050*
Muscle mass (kg)	26.88 (2.77)	25.95 (2.77)	27.64 (2.60)	0.044*
Skeletal Muscle index (kg/m^2)	9.70 (0.22)	9.70 (0.25)	9.70 (0.19)	0.964

Data are reported as mean (SD).
* $P < 0.05$.

Table 4 Assessment of the lipid profile and cardiovascular risk factors according to the physical activity level.

	Total (*n* = 40)	Low physical activity (*n* = 18)	Moderate physical activity (*n* = 22)	*P*-value
Triglycerides (mg/dl)	114.62 (44.16)	121.93 (46.00)	108.97 (42.89)	0.370
Total cholesterol (mg/dl)	179.23 (28.87)	185.38 (23.43)	173.95 (32.47)	0.222
LDL cholesterol (mg/dl)	104.71 (31.58)	109.63 (25.49)	101.27 (35.46)	0.456
HDL cholesterol (mg/dl)	50.35 (17.62)	48.13 (15.78)	51.94 (19.04)	0.530
Cardiovascular risk factors				
TC/HDL	3.94 (1.47)	4.06 (1.05)	3.85 (1.75)	0.674
HDL/LDL	2.43 (1.35)	2.53 (0.92)	2.37 (1.60)	0.730

TC: total cholesterol; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein. Data are reported as mean (SD).

($r = -0.694$ to -0.772, $P < 0.001$ for handgrip strength and $r = -0.438$ to -0.581, $P < 0.05$). In addition, in the group with the lower levels of physical activity, associations between handgrip strength and MVC with BMI and fat-free mass were showed. Triglycerides and total cholesterol were also negatively associated with these two fitness outcomes. Finally, an inverse association ($r = -0.751$, $P < 0.001$) between 6MWT and total cholesterol and between 6MWT and LDL ($r = -0.702$, $P < 0.001$) was found in this group. In the group, achieving moderate levels of physical activity additional associations between handgrip strength and SBP were observed.

Finally, the results of the binary logistic regression models showed that MVC was significantly associated with metabolic syndrome in those participants with a moderate level of physical activity, and explained up to 39% of the variance in metabolic syndrome in this group (OR = 0.993, 95% CI = 0.987—0.999, $P = 0.034$).

4. Discussion

This study aimed to determine the influence of the level of physical activity on physical fitness, body composition

Table 5 Partial correlations between body composition and lipid profile with physical fitness across physical activity levels adjusted for weight.

	Handgrip strength test right hand		Handgrip strength test left hand		Maximal voluntary isometric contraction		6MWT	
	Low PA	Moderate PA	Low PA	Moderate PA	Low PA	Moderate PA	Low PA	Moderate PA
Age	−0.058	−0.234	−0.150	−0.203	−0.333	−0.276	−0.680	0.082
BMI	0.887†	−0.447	0.859†	−0.334	0.616*	−0.332	−0.439	0.256
SBP	0.515	0.641*	0.512	0.556	0.324	0.487	−0.363	0.565
DBP	0.244	−0.034	0.105	0.172	−0.106	0.146	−0.272	0.206
Waist	−0.348	0.207	−0.474	0.180	−0.506	0.582	−0.625	0.548
Hip	−0.773*	−0.677*	−0.694*	−0.614*	−0.541*	−0.770†	−0.285	−0.411
WHR	0.216	0.376	0.076	0.329	−0.037	0.691*	−0.266	0.558
Body fat (%)	−0.772†	−0.694†	−0.722†	−0.752†	−0.581*	−0.438*	−0.314	−0.353
Fat-free mass (kg)	0.835†	0.651†	0.813†	0.660†	0.662*	0.352	0.375	0.469*
Muscle mass (kg)	0.848†	0.631*	0.826†	0.640*	0.688*	0.412	0.384	0.504*
Glucose	−0.046	0.421	0.022	0.321	0.233	−0.012	−0.469	−0.073
Triglycerides	−0.897†	−0.332	−0.902†	−0.361	−0.785†	−0.266	−0.340	−0.128
Total cholesterol	−0.758*	−0.342	−0.739*	−0.351	−0.652*	−0.433	−0.751*	0.273
HDL cholesterol	−0.381	−0.041	−0.302	−0.142	−0.082	−0.168	0.135	−0.460
LDL cholesterol	−0.189	−0.223	−0.235	−0.179	−0.357	−0.244	−0.702*	0.456
TC/HDL	0.037	−0.320	−0.023	−0.215	−0.199	−0.045	-0.384	0.325
LDL/HDL	0.065	−0.318	0.013	−0.213	−0.161	−0.058	−0.421	0.332

PA: physical activity; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; WHR: waist-to-hip ratio; TC: total cholesterol; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein. Data are reported as mean (SD).

* $P < 0.05$.

† $P < 0.01$

and lipid profile and explored the associations between fitness with these health outcomes and the presence of metabolic syndrome in a population of overweight/obese adults (48% of the participants had metabolic syndrome). To our knowledge, this is the first study that has assessed participants with a similar nutrition intake due to the discrepancies among findings related to the relative combined contributions of the levels of physical activity with the lipid profile. We found significant differences in MVC but also in fat-free mass between participants with different physical level. Significant associations between all the body composition outcomes and the strength-related variables (handgrip and MVC) in both physical activity categories were found. Also associations between triglycerides, LDL and total cholesterol with muscle strength and cardiorespiratory fitness were observed only in the low physical activity group. Finally, MVC explained up to 39% of the variance in metabolic syndrome in those with a moderate level of physical activity.

These findings may suggest that increasing physical activity is beneficial for improving physical fitness and body composition. Although it is beyond the scope of the current study, Kaino et al. [21] recently suggested that interventions aimed at increasing physical activity rather than focusing on decreasing energy intake may be more important to prevent the clustering of metabolic risk factors. The cross-sectional design of the study precludes any establishment of causality; however, considering that in the current study all participants had a similar nutrition intake, one may hypothesized that the differences may be attributed to the level of physical activity. Future intervention studies focused on enhancing physical fitness should carefully look at this hypothesis.

Results of epidemiological studies are consistent in that those who are physically active had a better fitness and consequently a lower BMI and adipose tissue [12,13]. However, non-significant differences in the percentage of body fat were observed in the current study which is consistent with Irving at al. [27] in that vigorous exercise but not moderate exercise has been shown to reduce total body fat. By contrast, our results (greater levels of physical activity reporting 24% more strength in the lower-limb) are in line with previous studies reporting significant interactions between physical activity and lower-limb muscle strength [28] and can be attributable to the greater muscle mass (15%) reported in the moderate physical activity group. Therefore, our results may be in line of previous reports suggesting that physical activity improves muscle strength and muscle mass and has a key role in the management strategy for obesity [28].

On the other hand, our results contrast with those found in the literature regarding association between physical activity and the lipid profile [29]. However, the fact that the participants in the current study had a similar nutrition intake may, at least in part, explain this lack of association. Despite this, while non-significant changes in the lipid profile according to the level of physical activity were found, which contrast with the results reported by Dancy et al. [30] indicating that active people are less likely to have hyper-triglyceridemia and low HDL cholesterol concentrations, significant associations between physical fitness and these outcomes were observed. It is believed that exercise has a favorable influence on blood lipid and lipoprotein levels [6] and a major finding of the present study was that triglycerides and total cholesterol levels were negatively associated to the muscle strength and LDL and cholesterol were also inversely associated with 6MWT. While previous studies indicated that physical activity does not significantly reduce total cholesterol or LDL [17], this study seems to indicate significant associations between fitness and lipid profile.

Numerous associations between physical fitness, body composition and the lipid profile were found when both levels of physical activity were compared and adjusted for weight. Handgrip strength and MVC were both associated with fat-free mass and were significantly negatively associated with the percentage of body fat which was also accompanied with reductions in hip circumference and BMI in those with the lower levels of physical activity. These results are consistent with Ohkawara et al. [13] who suggested that the level of physical activity was related to decreased visceral adipose tissue and support the idea that relatively modest increases in physical activity might improve BMI status. This is an important finding as central body and waist circumference can be modulated with physical activity and even fewer skeletal muscle contractions may reduce the clearance of triglycerides [10,31]. Additionally, results of epidemiological studies suggest that physical fitness can predict insulin resistance in overweight or obese subjects [32].

Both abdominal obesity and disorders of lipid and carbohydrate metabolism were defined as metabolic syndrome and have been suggested to predispose individuals to cardiovascular disease and type II diabetes [33,34]. These abnormalities were also associated with lower estimated cardiorespiratory fitness, and more self-reports of poor to fair health status and therefore fitness may be important to reduce this association [9]. Previous studies have reported the associations between lifestyle factors and metabolic syndrome [2,3] and another notable finding in our study is that physical fitness, specifically lower-limb muscle strength, was highly associated with a cluster of metabolic abnormalities. It was suggested that the cardiorespiratory fitness level might partially explain this syndrome, with higher cardiorespiratory fitness associated with more favorable metabolic health even among obese individuals [9]. In our study, cardiorespiratory fitness was not associated with metabolic syndrome; however adds a new variable to the puzzle, suggesting that MVC could explain up to 39% of the variance in those subjects who had a moderate level of physical activity which have important implications for obesity management.

Several limitations are noted. The cross-sectional design limited any interpretation of causality. Another limitation of the study was the relatively small sample size. The single week of activity measures in the current study could bias the estimate of habitual activity in either direction and therefore would under/overestimate the association between activity and certain biochemical and anthropometric measures. Further, the IPAQ significantly underestimated sitting and overestimated time spent in other physical activity intensities. Finally, due to the limitations of measurement methods selected for use in this trial (percent body fat via bioelectrical impedance and cardiorespiratory fitness via 6MWT) the results should be interpreted with caution.

5. Conclusions

In conclusion, this study extends our understanding of relationships between physical activity and physical fitness, body composition and lipid profile in overweight/obese adults; thus, showing what further large studies might to show. The correlation between physical fitness (lower-limb and handgrip strength and 6MWT) and health risk factors (serum lipids, triglycerides, total cholesterol, BMI, body fat and fat-free mass) was determined. The findings from this study have an important health implication due to have identified the association between muscle strength (MVC) and metabolic syndrome, which may help professionals to develop potential interventions to prevent these abnormalities.

Disclosure of interest

The authors declare that they have no competing interest.

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