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ORIGINAL RESEARCH

Vascular and Inflammatory Acute Responses after a Resistance Exercise Session in Young Women with Excessive Adiposity

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BACKGROUND: Endothelial dysfunction and low-grade inflammation are both positively associated to states of excessive adiposity but reports on the acute effects of resistance exercise on these variables are still lacking. We evaluated these acute effects of resistance exercise on vascular reactivity and on the inflammatory profile in young women.
METHODS: Participants were divided into two groups: lean Controls (n=16) and Overweight (n=16). The resistance exercise session consisted of unilateral elbow flexions for five sets of 10 repetitions at 70% of one repetition maximum. Blood pressure, heart rate, forearm blood flow, vascular conductance, cytokines, adipopeptides and endothelin-1 were evaluated at rest and during the acute post-exercise period.
RESULTS: The overweight group had higher forearm blood flow at rest ($p=0.03$) and during post-exercise ($p<0.001$) while forearm vascular conductance was higher only during post-exercise, at 20 ($p=0.02$) and 40 min ($p<0.001$). Endothelial-dependent vasodilation was higher during the post-exercise period in the Overweight group compared to controls ($p=0.01$). In the Overweight group, the resistance exercise session reduced interleukin-6 ($p=0.02$) and leptin ($p<0.001$) but increased endothelin-1 levels ($p=0.02$).
CONCLUSIONS: We conclude that the single resistance exercise session elicited an acute increment of baseline vascular reactivity and an increased endothelial-dependent vasodilation with concomitant changes in inflammatory profile and endothelin-1 in our tested women with excessive adiposity.

KEYWORDS: metabolic syndrome, exercise , inflammation.

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INTRODUCTION

In skeletal muscle, blood flow dynamics are determined by local factors, including primarily the muscle pump, rapid vasodilatory mechanisms, and, to a lesser extent, autoregulatory mechanisms that perpetuate the vasodilation.[1] Exercise-induced elevations of blood flow increase shear stress, which stimulates endothelial synthesis and the release of nitric oxide.[2] Exercise programs have important acute effects on release of vasoactive substances and on vascular tone, which is controlled mainly by local factors.[3]

Low-grade inflammation and microvascular dysfunction are both related to obesity.[4,5] Microvascular dysfunction occurs especially in insulin resistant

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subjects, but may also be present independently of the metabolic syndrome phenotype;[6] this suggests that changes in vascular reactivity occur in response to inflammatory cytokines released from adipose tissue.[7] We have reported that resistance training is related to long-term antiinflammatory effects elicited by up-regulation of cytokines, possibly through temporal summation of acute inflammatory responses due to resistance exercise bouts.[8]

Healthy subjects show increments of forearm blood flow (FBF) and vascular conductance (FVC) after acute exercise bouts,[9-11] but few reports have analyzed the impact of obesity on these responses.[12,13] The integrity of vascular homeostasis is impaired in obese individuals and is clinically expressed as endothelial dysfunction, which could be explained through adverse cardiovascular effects on blood pressure, oxygen delivery, removal of metabolic waste, and the responses of heart rate during exercise.[13] Because endothelial dysfunction and inflammation are possible findings associated to obesity, we have hypothesized that women with excessive adiposity could exhibit such dysfunction and inflammation. In this case, an isolated acute resistance exercise could concomitantly change vascular reactivity and the inflammatory profile of these women. Therefore, this study aimed to evaluate acute effects of an isolated resistance exercise session on vascular reactivity, endothelial function and inflammatory markers in women with excessive adiposity.

METHODS

Subjects

Thirty-two young (18-30 years) non-smoking women volunteered for the study and were assigned to two groups according to body mass index (BMI - cut-off value of 25 kg/m^2). Groups were categorized as **control** (BMI from 18.5 to 24.9 kg/m^2) and **Overweight** (BMI ≥ 25 kg/m^2). Except for excessive adiposity, subjects in the Overweight group were healthy and free from overt cardiovascular or metabolic diseases, judged from medical history, blood glucose, lipid profile and ergometric treadmill test results. None were taking drugs or nutritional supplements and all of them were at least six months away from any regular exercise. They were instructed to refrain from alcohol and caffeine for 24 hours prior to the day in which the experiment took place and to avoid any exercise during this period. The study complied with the Declaration of Helsinki, and was approved by the institutional Ethics Committee. All volunteers signed an informed consent.

Study Design

The testing procedures were divided into 2 sessions, performed 7 days before the intervention: 1) a familiarization session: twenty repetitions at submaximal and near maximal intensity levels, with verbal instructions when performing exercises regarding lifting cadence and technique; 2) a one-repetition maximum (1-RM) test (performed twice) for the right arm, unilateral elbow flexion (seated dumbell biceps curl). On intervention day, the anthropometric variables were measured and volunteers performed the experimental resistance exercise session, which consisted of 5 sets of 10 elbow flexions of the right arm at 70% of 1-RM with a one-minute rest interval between them. Measurements of blood pressure, heart rate and Forearm Blood Flow were made at rest and during 40 min after the resistance exercise session, as illustrated in Figure 1. The inflammatory profile (cytokines) and endothelin-1 (ET-1) were evaluated at rest in both groups. Samples from the Overweight group were re-collected at 55 min after the resistance exercise session.

Anthropometrics

The same trained examiner, who performed duplicate anthropometric measures, evaluated all subjects: body mass (kg), height (m), waist and hip circumferences (cm) and waist-to-hip ratio. BMI was calculated as body mass in kilograms divided by the squared height in meters (kg/m^2).

Treadmill Ergometric Test

Two to six weeks before entering the study, overweight women performed an ergometric ramp treadmill protocol test to guarantee lack of coronary risk. Briefly, this test started at relatively low speed, gradually increased together with the ramp angle inclination that started at grade zero and was also progressively increased (by 25W steps), at intervals of 120 sec. The increment of inclination was calculated according to estimated functional capacity. These protocols lasted 6 to 12 min.[14]

Muscular Strength Assessment

As previously stated, before testing, volunteers underwent two sessions of familiarization with proposed resistance exercise protocol; to determine test-retest reliability, 1-RM was performed on two nonconsecutive days 72 hours apart. After a specific warm-up, with light resistance load, 1-RM was determined in fewer than five attempts with resting interval of 5 min between them. 1-RM was considered as the heaviest resistance achieved on either of the two test days.

Acute Resistance Exercise Bout

The resistance exercise session consisted of one arm-elbow flexion in a sitting position for five sets of 10 repetitions at 70% of 1-RM load, with one minute of rest between sets. A metronome was used to maintain concentric and eccentric repetition velocity at two seconds/cycle.

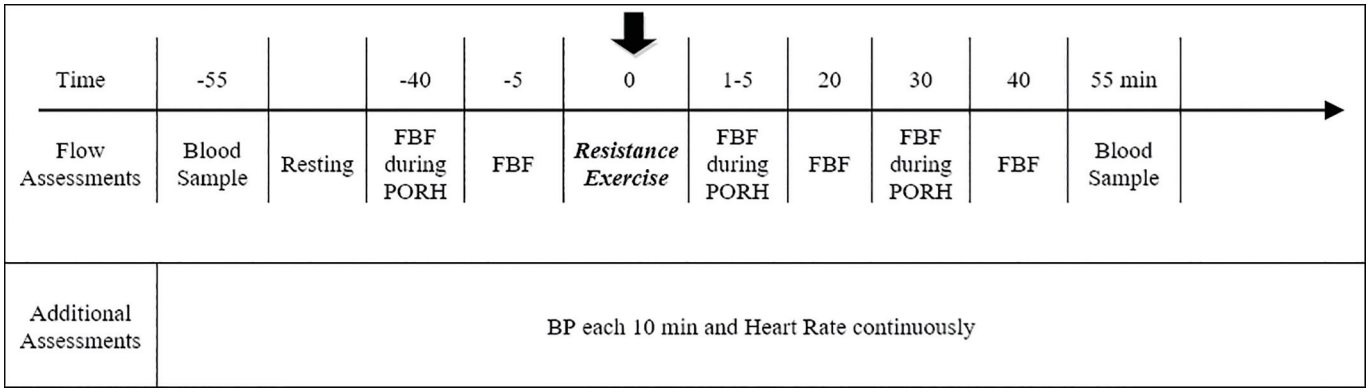

Figure 1: Procedures and assessments employed. FBF – Forearm blood flow (Baseline measurements); PORH – Post-occlusive reactive hyperemia response; BP – blood pressure.

Blood Pressure Assessment

On the left (non-exercised) arm, a semiautomatic sphygmomanometer (*Spacelabs Medical, Redmond, WA, USA*) was used for all blood pressure assessments in supine position. Evaluations were performed before the resistance exercise and during the post-resistance exercise period at 3, 10, 20, 30 and 40 minutes.

Heart Rate, Forearm Blood Flow and Forearm Vascular Conductance Assessments

Heart rate was assessed during the resistance exercise session through measurements using lead II of the electrocardiogram *(Lifewindow LW6000, Digicare Biomedical Technology, West Palm Beach, WA-USA)*. In the left arm, Forearm Blood Flow, expressed in ml/min/100 ml of tissue, was evaluated non-invasively by venous occlusion plethysmography *(EC-6; Hokanson, Bellevue, WA, USA)* with the subject in supine position, as previously described:[15] briefly, a mercury-in-silastic strain gauge was placed on the forearm upper third maximal diameter while two inflatable cuffs were placed on the wrist and middle arm. Four flow curves were obtained during each experimental period and mean FBF was derived from each curve. Baseline measurements of FBF were assessed immediately before the exercise session and at 20 and 40 min after the resistance exercise. We performed three-minute ischemia bouts by inflating an arm cuff 40 mmHg above systolic blood pressure. Immediately after cuff release, endothelial-dependent vasodilatation was evaluated during the post-occlusive reactive hyperemia (PORH) response. FBF during PORH were assessed before, immediately after and 30 minutes after the exercise session. Forearm vascular conductance (FVC) was calculated as FVC = (FBF/mean blood pressure) X 1000.[8] FBF and FVC are interrelated, since the latter means that FBF was normalized by levels of blood pressure during the assessment of FBF at each time point.

Biochemical Analyses

Laboratory measurements were performed using an automated method *(Modular Analytics PP; Roche, Basel, Switzerland)*. After 10-12 hours fast, fasting plasma glucose, total cholesterol and triglycerides were measured by enzyme colorimetric GOD-PAP only in the Overweight group. Both groups had their blood samples (10 ml) collected before the resistance exercise session for measurements of inflammatory profile and ET-1 analyses. At 55 min post-exercise, only samples from Overweight group were collected (13 samples). All samples were immediately centrifuged and stored at -80°C. Adiponectin, high sensitive interleukin-6 (IL-6), leptin, resistin, high sensitive tumor necrosis factor alpha (TNF–α) and ET-1 were determined by ELISA (Enzyme Linked Immunosorbent Assay, *R & D Systems, Minneapolis, MN, USA)*. The intra- and inter-assay coefficients and sensitivity for adiponectin, IL-6, leptin, resistin, TNF-α and ET-1 are displayed in Table 1.

Table 1. Intra- and inter-assay coefficients and sensitivity for assayed parameters

	Instra-assay coefficient	Inter-assay coefficient	Sensitivity
Adiponectin	4.0%	2.7%	0.00025 µg/ml
IL-6	3.9%	8.4%	0.04 pg/ml
Leptin	2.0%	1.9%	0.0078 ng/ml
Resistin	1.6%	4.0%	0.03 ng/ml
TNF-α	5.9%	8.8%	0.1 pg/ml
ET-1	2.0%	4.9%	0.087 pg/ml

IL-6. Interleukin-6; TNF-α Tumor necrosis factor-α endothelin-1

Statistical Analyses

The statistical analyses were performed using the softwares Statistica 6.0 (*Statsoft; Tulsa, OK, USA*) and Stata 11 (*StataCorp; College Station, TX, USA*). Paired t-tests were used to compare anthropometric data, 1-RM load, systolic, diastolic and mean blood pressures and heart rates between groups at rest. Two-way ANOVAs with repeated measures were used to compare intra- and inter-group differences in blood pressure and heart rate. Least square difference (LSD) *post-hoc* tests were used when main significant effects were obtained with these analyses. Kruskal-Wallis and Mann-Whitey tests compared respectively intra- and

inter-group differences in FBF and FVC at baseline and during PORH. Serially measured FBF and FVC data were analyzed with generalized estimating equations (GEE) model[16] using the Gaussian family, identity link function and autoregressive correlation structure. The models included demographic (age), anthropometric (waist-to-hip ratio and BMI or adiposity status) and physiological (heart rate and mean blood pressure) covariates. Additionally, BMI was tested separately as a continuous (adiposity status) and as a categorical (<25 or ≥25 $kg.m^{-2}$) variable. The one that produced the best model was used. Variables were transformed when there was strong separation from normality. The best subsets of covariates were selected using the quasilikelihood under independence model information criterion (QIC).[17] Additionally, the Mann-Whitney test was used to compare inflammatory cytokines and ET-1 levels between groups and the Wilcoxon test to compare them between resting and after resistance exercise session in the Overweight group. Statistically significant differences were assumed to be present at $P<0.05$.

RESULTS

Subjects' Characteristics

Thirty-two young women volunteered to the study and were divided into lean Control and Overweight groups (16 subjects each). Table 2 depicts Subjects' characteristics:

Table 2. Subjects' characteristics (mean ± SD).

Variable	Control (n=16)	Ow (n=16)
Age (years)	23.3 ± 3.6	26.9 ± 2.7
Height (cm)	165.5 ± 7.1	164.2 ± 6.2
Weight (kg)	59.3 ± 7.9	**86.1 ± 13.0***
BMI ($kg.m^{-2}$)	21.1 ± 1.6	**31.5 ± 4.2***
Waist-to-hip ratio	0.77 ± 0.0	**0.71 ± 0.0***
SBP (mmHg)	106.0 ± 9.9	121.2 ± 11.0
DBP (mmHg)	64.3 ± 8.6	**75.6 ± 10.6***
MBP (mmHg)	78.7 ± 8.4	**90.1 ± 9.8***
Heart Rate (bpm)	66.2 ± 7.7	66.8 ± 10.0
Glucose (mg/dl)	-	87.9 ± 5.5
Total Cholesterol (mg/dl)	-	159.4 ± 26.2
Triglycerides (mg/dl)	-	111.3 ± 56.8
Maximal Heart Rate (bpm)	-	161.7 ± 53.8
Maximal SBP (mmHg)	-	170.0 ± 17.4
Maximal VO_2 (ml/kg.min)	-	31.6 ± 6.2
1-RM for arm-elbow flexion (kg)	8.8 ± 1.7	8.2 ± 1.6

Ow – Overweight group; BMI – body max index; SBP - systolic blood pressure; DBP - diastolic blood pressure, MBP – mean blood pressure; VO_2 – oxygen consumption; 1-RM – one-repetition maximum load. Significant difference to control group (*p<0.05) exhibited in bold type.

differences between groups were observed for Weight, BMI, Waist-to-hip ratio and mean blood pressure.

Blood Pressure and Heart Rate

Table 3 presents responses of systolic, diastolic, mean blood pressure and heart rate after resistance exercise for both groups: significant differences were observed for diastolic and mean blood pressure at rest ($p<0.001$ and $p=0.001$, respectively), immediately after ($p<0.001$ and $p<0.001$, respectively) and at 20 min post-exercise ($p<0.001$ and $p<0.001$, respectively). We also noted that the overweight group and the lean controls exhibited significantly ($p < 0.001$ and $p < 0.001$, respectively) reduced diastolic blood pressure immediately post-exercise. Of interest, only lean controls showed reductions in mean blood pressure immediately post-exercise ($p<0.001$).

Forearm Blood Flow and Vascular Conductance

Figure 2 depicts baseline FBF and FVC at rest and during post-exercise period. The FBF was higher in Overweight group than control individuals at rest ($p=0.03$), 20 ($p<0.001$) and 40 minutes´ post-exercise ($p<0.001$) (Figure 2A). At rest condition, FVC was not different between groups, but it was higher at 20 min ($p=0.02$) and 40 min ($p<0.001$) post-exercise in Overweight group compared to controls (Figure 2B). When BMI was analyzed as a continuum without establishing cutoff points, we noticed that adiposity level was negatively associated to increasing levels of the inverse transformation of baseline FBF ($\beta=-0.2246$; $p<0.001$) and also of baseline FVC ($\beta=-0.0119$; $p=0.012$) which mean that higher adiposity resulted in higher baseline FBF and FVC in our sample.

Table 4 depicts responses to resistance exercise session for both groups on FBF and FVC during PORH. No differences between controls and Overweight group were observed on endothelial-dependent vasodilatation, but surprisingly at 30 min post-exercise Overweight group had higher responses than controls on the referred variable ($p=0.01$). Clinical aspects of adiposity level were studied in respect to cutoff points of BMI, and testing our data on a categorical fashion we observed that BMI was positively associated to endothelial-dependent vasodilatation (natural logarithm transformation; $\beta=0.0173$; $p=0.041$) meaning that higher BMI, as a categorical variable, resulted in higher endothelial-dependent vasodilatation in our sample. While endothelial-dependent vasodilatation resulted in some differences between groups, FVC during PORH did not.

Cytokines, Adipopeptides and Endothelin-1

Table 5 depicts cytokines, adipopeptides and ET-1 at baseline for both groups and post-exercise responses for the Overweight group. Adiponectin was at lower ($p<0.001$) while IL-6 ($p<0.001$) and leptin ($p<0.001$) levels were at higher levels in this group. We should highlight that during the post-exercise period, significant reductions in IL-6

Table 3. Systolic, diastolic and mean blood pressures and heart rate values and their acute responses to resistance exercise for both groups (mean ± SD).

Measures	Groups	Resting	After	10 min	20 min	30 min	40 min
Systolic blood pressure (mmHg)	Control (n=16)	106.0 ± 9.9	106.7 ± 11.3	107.6 ± 9.8	106.6 ± 10.0	108.4 ± 10.6	109.1 ± 11.3
	Ow (n=16)	121.2 ± 11	121.4 ± 9.6	119.8 ± 7.6	121.2 ± 9.2	120.8 ± 8.6	121.9 ± 8.5
Diastolic blood pressure (mmHg)	Control (n=16)	64.3 ± 8.7	**55.7 ± 5.4**$^{\#\#}$	59.8 ± 6.4	60.3 ± 6.9	63.8 ± 5.8	66.0 ± 7.4
	Ow (n=16)	**75.6 ± 10.6***	**69.0 ± 10.9 *$^{\#\#}$**	71.4 ± 9.9	**74.2 ± 9.1***	73.2 ± 10.7	74.6 ± 9.8
Mean blood pressure (mmHg)	Control (n=16)	78.7 ± 8.4	**72.2 ± 5.6**$^{\#\#}$	76.4 ± 7.0	75.7 ± 7.0	79.4 ± 6.8	81.5 ± 8.0
	Ow (n=16)	**90.1 ± 9.8***	**86.2 ± 9.1***	87.4 ± 7.8	**89.0 ± 8.7***	89.4 ± 9.4	90.2 ± 9.2
Heart rate (bpm)	Control (n=16)	66.2 ± 7.8	65.3 ± 9.9	64.7 ± 10.4	62.8 ± 8.4	65.0 ± 9.5	65.4 ± 8.3
	Ow (n=16)	66.8 ± 10.0	64.9 ± 11.3	64.8 ± 11.3	64.9 ± 10.5	65.3 ± 9.6	66.2 ± 8.6

Ow – Overweight group; min - minutes; mmHg – millimeters of mercury; bpm - beats per minute. Significant difference to control group (*p<0.001); intra-group differences according to resting levels ($^{\#\#}$p< 0.001) exhibited in bold type.

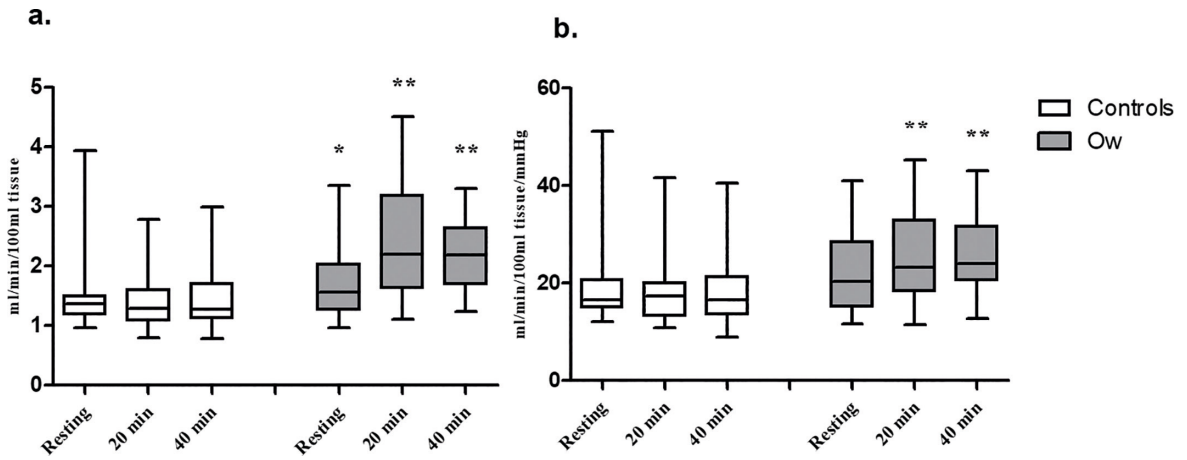

Figure 2: Acute responses of baseline forearm blood flow (a) and vascular conductance (b) after a resistance exercise session on controls and overweight (Overweight) women. Significant difference compared to controls (*p<0.05; **p<0.001).

Table 4. Forearm blood flow and vascular conductance acute responses to resistance exercise for both groups. Data are expressed as median [1st-3rd quartiles].

Variable	Groups	Resting	After	30 min
FBF during PORH (ml/ min/100ml tissue)	Control (n=16)	5.68 [5.30-7.85]	5.40 [4.43-6.60]	4.94 [4.54-6.74]
	Ow (n=16)	6.54 [5.29-8.13]	7.94 [6.22-8.92]	**7.08 [6.34-8.46]***
FVC during PORH (ml/ min/100ml tissue /mmHg)	Control (n=16)	78.41 [66.35-92.80]	74.72 [65.35-90.43]	67.30 [61.36-88.59]
	Ow (n=16)	77.46 [62.72-90.98]	97.76 [73.06-116-83]	77.32 [66.28-107.33]

FBF – forearm blood flow; PORH – post-occlusive reactive hyperemia; FVC – vascular conductance; significant difference to control group (*p<0.05) exhibited in bold type.

Table 5. Cytokines, adipopeptides and endothelin-1 levels at rest for both groups and acute responses to resistance exercise in obese group. Data are expressed as median [1st-3rd].

Blood Sample Analysis Cytokines and Adipopeptides	Control (n=16)	Ow (n=13)	
		Resting	After
Adiponectin (µg/ml)	10.8 [7.6-14.3]	5.9 [3.9-10.0]	5.2 [3.8-7.7]
High sensitive IL-6 (pg/ml)	0.7 [0.5-0.9]	2.4 [1.4-2.8]	**1.6 [1.2-2.8]**$^{\#}$
Leptin (ng/ml)	13.0 [11.6-16.8]	49.6 [32.8-54.5]	**45.9 [28.9-51.4]**$^{\#\#}$
Resistin (ng/ml)	7.9 [6.9-10.0]	8.4 [7.3-9.4]	8.2 [6.6-10.3]
High sensitive TNF–α (pg/ml)	1.2 [1.0-1.5]	1.7 [1.2-2.0]	1.8 [1.2-1.9]
Endothelin-1 (pg/ml)	1.06 [0.92-1.21]	0.88 [0.77-1.05]	**0.95 [0.85-1.28]**$^{\#}$

Ow – Overweight group; significant difference to control group (*p<0.001); significant difference in comparison to resting levels $^{\#}$p<0.05; $^{\#\#}$p< 0.001) exhibited in bold type.

(p=0.02) and leptin (p<0.001) levels were observed while ET-1 levels increased (p=0.02).

DISCUSSION

Our key findings suggest that acute resistance exercise resulted in elevated FBF, FVC and endothelial-dependent vasodilatation responses in otherwise healthy women with excessive adiposity compared to lean controls. By considering BMI as a continuum without establishing cutoff values, the adiposity level could be associated to increased baseline FBF and FVC, indicating that higher adiposity resulted in higher blood flow and improved FVC. Surprisingly, by categorizing levels of adiposity with respect to BMI established cutoff values, we noticed a positive association with endothelial-dependent vasodilatation, meaning that grades of adiposity were directly correlated to an amplification of the endothelial response. Before intervention, the Overweight group presented significantly higher diastolic and mean blood pressures, concomitantly associated to a state of low-grade inflammation. After the resistance exercise session in the Overweight group, we observed reduced levels of blood pressure and also of some biomarkers of inflammation. According to classical cardiovascular risk factors, the Overweight group recruited for the study should be viewed as a metabolically healthy group. Although the Overweight group already exhibited a state of low-grade inflammation and higher blood pressure at rest compared to controls, both groups had the same endothelial reactivity at resting conditions. Post-exercise responses showed that higher adiposity could be associated to bigger endothelial responses and this finding could be explained by the fat distribution in the Overweight group. A better fat distribution was noticed in the Overweight group compared to lean controls, expressed by significantly lower waist-to-hip ratios in this overweight group. Reinforcing this hypothesis, we have previously reported that lower waist-to-hip ratio could be associated to cardiovascular protection, expressed by increased endothelium responses after agonistic pharmacologic stimulation.[18]

Few studies have analyzed the impact of adiposity on acute blood flow response to exercise.[12,13] Recently, Limberg and co-workers demonstrated that forearm and leg exercises increased Forearm and leg blood flow similarly in young sedentary obese and lean individuals.[13] Our results suggest that acute resistance exercise elicits not only increments in FBF but also in vascular conductance responses in the Overweight group compared to controls, indicating that vascular reactivity in response to resistance exercise is preserved despite excessive adiposity.

Some studies described positive acute effects of resistance exercise bouts on FBF and FVC on healthy subjects.[9-11] On the other hand, in overweight premenopausal women, Kingsley and Figueiroa did not show altered FBF in response to an isolated resistance exercise for the lower body (leg press).[12] In fact, FBF and FVC of the upper body may even present reductions after lower body exercises. Polito and Farinatti showed that lower body resistance exercise resulted in FBF and FVC reductions, even with concomitant systolic blood pressure reductions[19]. Similarly, in our protocol we analyzed FBF in the non-exercised arm and observed increments of FBF, FVC and endothelial-dependent vasodilatation in the Overweight group, which could possibly be associated to the performance of an isolated unilateral resistance exercise performed by the upper body. Therefore, it is reasonable to suppose that observed reductions of FBF and FVC described by Polito and Farinatti are probably due to compensatory vascular response to non-described elevations in BF and FVC of the lower body.[19]

Post-exercise hypotensive effects were observed in both studied groups, but reductions in women with excessive adiposity resulted in similar post-exercise diastolic and mean blood pressure values of controls, confirming the immediate acute hypotensive effect of a single resistance exercise bout. Comparing our findings to previous ones,[19-22] we could suggest that the duration and the magnitude of the hypotensive response are possibly related to the amount of muscle mass recruited and training volume activated, as previously suggested.[19] Physiological mechanisms for hypotensive response after resistance exercise are related to reduction on vascular resistance, possibly due to increased shear stress on the vascular wall with subsequent increments on blood flow of exercised muscles.

We have analyzed acute responses to resistance exercise on cytokines, adipopeptides and ET-1 in a sample of young women with excessive adiposity. Few studies have analyzed these responses after resistance exercise[23-26] and the majority of them suggested that an acute resistance exercise session resulted in acute and/or sub-acute anti-inflammatory effect represented by increases in adiponectin[23,26] and reductions in IL-6,[27] leptin[18,24,27] and resistin.[26,27] We can suggest that, when tested as an intra-group analysis, there exists an acute anti-inflammatory effect of resistance exercise by reductions in IL-6 and leptin without any change in adiponectin on Overweight group. It should be stressed that studies using a microdialysis method to investigate muscle interstitial levels of IL-6 at a post-training period (at 65 and 110 min) showed increments in IL-6 levels into the muscle interstitium which was not seen in plasmatic levels of this cytokine.[28] Many contradictions still exist in this area and possibly some of them may be related to the periods elected for blood sample collections, employed methodologies and also differences between intersticial and plasmatic levels. No difference in ET-1 levels between groups at resting was noted and this is another finding that corroborates our view that the Overweight group were metabolically healthy (i.e. without

endothelial dysfunction, hypertension, lipid disorders and diabetes).

Some limitations of our study should be pointed out. BMI was the only method used to establish a state of excessive adiposity. We did notice differences in cytokines, adipopeptides and ET-1 levels in intra-group analysis in the Overweight group; ideally, the assessment of these plasmatic biomarkers should also have been performed in controls and, additionally, in more than one sample during the post-exercise period. Previously, it was suggested that these acute responses are exclusively observed in subjects with some grade of inflammation at resting.[26] Therefore, a new investigation could conceivably study the influence of excessive adiposity on the low-grade inflammatory state and the responses of this state in different groups after an acute bout of resistance exercise.

CONCLUSION

In conclusion, the present study shows that an acute resistance exercise session increased forearm blood flow and vascular conductance especially in women with excessive adiposity, possibly by endothelial-dependent mechanisms and concomitantly with changes on the inflammatory profile and ET-1 level.

CONFLICT OF INTEREST

Authors report no conflict of interest relating to this project.

AUTHOR PARTICIPATION

Conceptualization: LGKA, BFS, EB; Formal analysis: LGKA, BFS, MGCS, BS. Funding acquisition: EB. Investigation: BFS, ID, AECG, MGCS. Methodology: LGKA, BFS, ID, MGCS, BS. Project administration: EB. Supervision: LGKA, EB. Writing: LGKA, BFS, SRMN. Writing – review & editing: LGKA, SRMN, EB.

RESPOSTAS VASCULARES E INFLAMATÓRIAS AGUDAS DEPOIS DE UMA SESSÃO DE EXERCÍCIO RESISTIDO EM MULHERES JOVENS COM EXCESSO DE ADIPOSIDADE

ANTECEDENTES: A disfunção endotelial e a inflamação de baixo grau estão positivamente associadas a estados de adiposidade excessiva; entretanto os efeitos agudos do exercício resistido sobre estas variáveis ainda não estão esclarecidos. Avaliamos os efeitos agudos do exercício resistido sobre a reatividade vascular e sobre o perfil inflamatório em mulheres jovens.

MÉTODOS: As participantes foram divididas em dois grupos: controles magras (n = 16) e aquelas com sobrepeso (n = 16). A sessão de exercício resistido consistiu de flexões unilaterais de cotovelo em cinco séries de 10 repetições (com 70% de uma repetição máxima). Avaliamos tanto no repouso quanto durante o período pós-exercício agudo a pressão arterial, a frequência cardíaca, o fluxo sanguíneo do antebraço (FBF) e a condutância vascular (CVF), as citocinas, os adipopeptídeos e a endotelina-1.

RESULTADOS: O grupo com sobrepeso apresentou maior FBF em repouso (p = 0,03) e pós-exercício (p <0,001), enquanto a CVF foi maior somente após o exercício, aos 20 min (p = 0,02) e aos 40 min (p <0,001) . A vasodilatação endotélio-dependente durante o período pós-exercício foi maior no grupo Overweight em relação aos controles (p = 0,01). No grupo Overweight, a sessão de exercício resistido reduziu a interleucina-6 (p = 0,02) e a leptina (p <0,001) e o aumentou os níveis de endotelina-1 (p = 0,02).

CONCLUSÃO: Concluímos que a sessão de exercício resistido provocou um incremento agudo da reatividade vascular basal e um aumento da vasodilatação endotélio-dependente com alterações concomitantes no perfil inflamatório e da endotelina-1 em mulheres com adiposidade excessiva.

PALAVRAS-CHAVE: Exercício resistido; saúde cardiovascular; obesidade.

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