Effect of Morning Exercise with or without Breaks in Prolonged Sitting on Blood Pressure in Older Overweight/Obese Adults: Evidence for Sex Differences

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Short title: Prolonged sitting, exercise and blood pressure

Number of tables: 1

Number of figures: 5

Word count: 5982

Subject terms: Ageing, primary prevention, exercise

Keywords: Blood pressure, exercise, obesity, sex differences, sedentary behavior, older

adults

Abstract

Both exercise and breaks in prolonged sitting can reduce blood pressure (BP) in older overweight/obese adults. We investigated whether there is an additive BP lowering effect when exercise is combined with subsequent breaks in sitting. Sex differences, and concurrent changes in plasma catecholamines as a potential candidate mechanism underlying BP responses, were also examined. Sedentary older adults (n=67; 67±7 years; BMI 31.2±4.1 kg/m^2), completed three conditions in random order: SIT: uninterrupted sitting (8hr, control); EX+SIT: sitting (1hr), moderate-intensity walking (30min), uninterrupted sitting (6.5hr); EX+BR: sitting (1hr), moderate-intensity walking (30min), sitting interrupted every 30-minutes with 3-minutes of light-intensity walking (6.5hr). Serial BP and plasma epinephrine/norepinephrine measurements occurred over 8-hours. The 8-hour average systolic and diastolic BP (mmHg 95% CI) was lower in EX+SIT -3.4 [-4.5 to -2.3], -0.8 [-1.6 to -0.04] and EX+BR -5.1 [-6.2 to -4.0], -1.1 [-1.8 to -0.3] respectively, relative to SIT (all P<0.05). There was an additional reduction in average systolic BP of -1.7 [-2.8 to -0.6] in EX+BR relative to EX+SIT (P=0.003). This additional reduction in systolic BP was driven by females -3.2 [-4.7 to -1.7; P<0.001 EX+BR vs EX+SIT). Average epinephrine decreased in EX+SIT and EX+BR in females (-13%, -12%) but increased in males (+12%, +23%) respectively, relative to SIT (P<0.05). No differences in average norepinephrine were observed. Morning exercise reduces BP over a period of 8-hours in older overweight/obese adults compared to prolonged sitting. Combining exercise with regular breaks in sitting may be of more benefit for lowering BP in females than in males.

Clinical Trial Registration

INTRODUCTION

Blood pressure (BP) reduction remains a key consideration in exercise training interventions seeking to prevent cardiovascular and related diseases in those at increased risk, particularly in sedentary, older overweight to obese adults.[1,2] Such interventions typically involve deliberate planned bouts of moderate-intensity exercise on a weekly basis.[3] However, recent evidence indicates that sedentary behaviors – defined by low energy expenditure (<1.5 metabolic equivalents) in a sitting or reclining position[4] – may also be a distinct (and highly prevalent) behavioral consideration for BP control.[5] Indeed, a number of experimental studies in overweight/obese and hypertensive adults have noted reductions in BP when sitting is interrupted with intermittent light-intensity activity.[6–9]

However, no previous study has examined whether the acute BP lowering effects of exercise are attenuated by subsequent exposure to prolonged sitting or enhanced by subsequent exposure to breaks in sitting. In addition, factors that may modify or explain exercise-induced reductions in BP, such as sex differences and catecholamine levels,[10–12] remain largely unexplored in the context of various patterns of exercise and prolonged sitting. We therefore investigated the BP lowering effects of a morning bout of moderate-intensity exercise with and without subsequent light-intensity walking breaks from sitting, relative to prolonged sitting alone. In exploratory analyses we investigated sex differences, and concurrent changes in plasma catecholamines as a potential candidate mechanism underlying BP responses. We hypothesized that an acute bout of exercise would reduce BP over an 8-hour period, relative to prolonged uninterrupted sitting, and that the BP reduction following acute exercise would be further enhanced by subsequent exposure to intermittent breaks in sitting.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. This experiment was a sub-study of a larger randomized crossover trial (ACTRN12614000737639) and the detailed methods, rationale and design sections have been published independently.[13]

Participants

Men and postmenopausal women (n=67, 35♀, age ≥ 55 to ≤ 80 years; BMI ≥ 25 kg/m^2 to < 45 kg/m^2; English-speaking) were recruited from the local community and tested at two sites: the Physical Activity Laboratory, Baker Heart and Diabetes Institute, Melbourne, Australia; and, the Human Cardiovascular Exercise Research Laboratory, School of Human Sciences (Exercise and Sport Science), The University of Western Australia (UWA), Perth, Australia. Recruitment occurred between February 2015 and July 2017 (see Table S1 in the online-only data supplement for full inclusion/exclusion criteria). Participants gave informed consent prior to taking part.

Study Design

Participants completed three laboratory trial conditions in a random order, each separated by a minimum of six days (Figure 1). These conditions involved: *Sitting (SIT)*: uninterrupted sitting (8hr, control); *Exercise+Sitting (EX+SIT)*: sitting (1hr), moderate intensity treadmill walking (30min) followed by uninterrupted sitting (6.5hr); *Exercise+Breaks (EX+BR)*: sitting (1hr), moderate intensity treadmill walking (30mins) followed by sitting (6.5hr) interrupted every 30 minutes with three minutes of light intensity treadmill walking. A familiarization session was completed three to five days prior to testing, in which participants

were familiarized with all testing equipment and procedures, including treadmill walking. The speed and incline of the treadmill were standardized during the familiarization session and remained the same across all conditions for a given participant. Treadmill speed remained 3.2km/h for all participants during the moderate intensity exercise bout and light-intensity breaks. Treadmill incline was used to achieve a moderate intensity defined as 65-75% of age predicted maximum heart rate. The three-minute light intensity walking breaks were 3.2km/h with no incline for all participants. Heart rate (Polar Electro, Kempele, Finland) and ratings of perceived exertion (RPE scale 6-20; light intensity 9-11 RPE; moderate-intensity 12-15 RPE) were collected at five minute intervals during the 30-minute bout of exercise and at the end of each three minute walking break. During the 48 hours prior to testing, participants were instructed to avoid caffeine, alcohol and moderate to vigorous physical activity. In addition, food intake was standardized from the night before each trial day, where participants consumed a standardized dinner at home between 7pm and 9pm in place of their regular dinner. This meal was tailored for each participant to meet 33% of estimated daily energy requirements, with a macronutrient profile of 55–58% energy from carbohydrate, 29–31% from fat and 12–15% from protein, as previously described.[13]

Insert figure 1 about here

Experimental day protocol

Participants reported to the laboratory at ~0700 following an overnight fast (>10 hours).

Participants remained seated while equipment was set up, prior to the start of the experiment

(0hr) which occurred at ~0800. Baseline recordings of BP and heart rate were obtained prior

to the administration of a standardized breakfast meal. Breakfast and lunch were administered

at 40 minutes and 4 hours 40 minutes into the experiment. All meals were standardized

according the same criteria as the evening meal (see above) and remained the same for a

given participant during all conditions. Study outcomes were measured at multiple time

points across the day (Figure 1). Throughout the day participants were instructed to remain

seated apart from leaving the chair to void or to perform pre-determined treadmill walking in

the EX+SIT and EX+BR conditions. While sitting, participants were instructed to read or

work quietly on a laptop and avoid activities which may raise BP such as watching TV or

making non-essential phone calls. Participants were supervised to ensure consistent behavior

across each of the study conditions.

Resting blood pressure and heart rate

Resting BP and heart rate were measured in a seated upright position; calculated as the

average of three serial measurements taken one minute apart using an automated oscillatory

method (HEM-907, Omron, Kyoto, Japan). All measures of resting BP and heart rate were

taken during steady state sitting periods across the day, such that in the EX+BR condition the

resting measures were collected at least 25 minutes after the most recent activity break.

Measurements were taken on the same arm for all conditions, contralateral to the arm with an

indwelling cannula.

Blood sampling

Venous blood samples were collected using an indwelling cannula inserted in an antecubital vein. Plasma samples for analysis of epinephrine and norepinephrine were collected into tubes containing ethylene glycol-bis(β-aminoethyl ether)-N,N,N′,N′-tetraacetic acid and reduced glutathione. Fluoride/oxalate, lithium heparin and serum tubes were used to collect fasting samples for analysis of glucose, lipids and insulin respectively. Serum samples clotted for one hour at room temperature (22-24°C) prior to centrifuging. Plasma samples were centrifuged immediately after collection. All samples were centrifuged at 2000rpm (931 x g) for 15 minutes at 4°C and stored at -80°C. Plasma concentrations of epinephrine and norepinephrine were determined from thawed samples by high performance liquid chromatography with coulometric detection, following extraction from plasma using alumina adsorption.[14] Samples were batch analyzed such that all conditions for a given participants were analyzed in the same run by a technician blinded to the study conditions. Fasting glucose was analyzed using the hexokinase method. Fasting insulin was analyzed using a chemiluminescent microparticle immunoassay (Architect ci16200; Abbott Diagnos- tics, Santa Clara, CA). Fasting lipids were analyzed using a COBAS Integra 400+ analyzer (Roche Diagnostics, Indianapolis, IN).

Statistical analysis

Generalized linear mixed models with random intercepts were used to evaluate the differential effects of the experimental conditions on the selected outcomes. A treatment by time interaction term was included in regression models to calculate the marginal means at individual time points which were used to graph the time course for different outcomes. Treatment by sex and treatment by time by sex interaction terms were included in regression models to examine sex differences between conditions in the 8-hour average and time course

respectively. Associations between epinephrine, norepinephrine and BP variables were assessed using Spearman's rank correlation coefficients. Outcome variables were adjusted for baseline, age, sex, waist circumference, treatment order and testing site. Unadjusted data for participant characteristics were compared by independent samples t-test. A probability level of 0.05 was adopted. Statistical analyses were performed blinded to the study conditions using Stata 15 for Windows (StataCorp LP).

RESULTS

A total of 69 participants were randomized. However, due to dropout 67 completed at least one condition and 65 completed all conditions (see Figure S1 in the online-only data supplement for the full CONSORT flow diagram). Intention-to-treat analysis was performed on the full data set of 67 participants. Participants were older (67±7 years) adults who were overweight to obese (31.1±4.1 kg/m^2), and 37% were hypertensive. In addition, females had a slightly higher body mass index (31.9±4.4 vs 30.4±3.7 kg/m^2, P=0.01), resting heart rate (63±1 vs 60±1 bpm, P=0.002), fasting serum insulin (66.2±37.0 vs 53.0±26.2 pmol/L, P=0.007) and fasting plasma cholesterol (5.7±1.0 vs 4.8±0.8 mmol/L, P<0.001) respectively than males. Full participant characteristics are included in Table 1 and participant medication usage is included in the supplemental material (see Table S2 in the online-only data supplement for participant medication usage).

Blood pressure and heart rate responses

Average systolic BP and diastolic BP over eight hours were lower in both EX+SIT and EX+BR relative to SIT (Figure 2, all P<0.05). Average mean arterial BP (MAP) mmHg [95%

CI] over eight hours was also lower in both EX+SIT 84 [83-86] and EX+BR 84 [82-85] relative to SIT 86 [84-88, $P<0.01$]. There was an additional reduction in average systolic BP of -1.7 [-2.8 to -0.6] in EX+BR relative to EX+SIT (Figure 2B, $P=0.003$), demonstrating a significant benefit of intermittent walking breaks in addition to exercise for systolic BP relative to exercise followed by prolonged sitting. These reductions in BP occurred in the context of a higher average heart rate in both EX+SIT and EX+BR relative to SIT (Figure 2F, all $P<0.001$). A higher average heart rate was also observed in EX+BR relative to EX+SIT (Figure 2F, $P<0.001$).

Sex differences

Significant treatment by sex interactions were observed for systolic BP ($P=0.02$) and MAP ($P=0.04$) but not diastolic BP ($P=0.18$). Only females demonstrated a reduced systolic BP mmHg [95% CI] -3.2 [-4.7 to -1.7] and MAP -1.6 [-2.7 to -0.5] in the EX+BR condition relative to EX+SIT (Figure 3A, C, all $P<0.01$). In addition, only females demonstrated a reduced diastolic BP in EX+BR relative to SIT (Figure 3B, $P=0.001$). Significant treatment by sex interactions were observed for epinephrine ($P<0.001$) but not norepinephrine ($P=0.65$). Females demonstrated decreased epinephrine pmol/L [95% CI] in both EX+SIT -31.6 [-58.8 to -4.4] and EX+BR -29.3 [-57.3 to -1.3] relative to SIT (Figure 3E, all $P<0.05$). Conversely, males demonstrated increased epinephrine in both EX+SIT 28.8 [4.1 to 53.4] and EX+BR 55.7 [31.4 to 80.0] relative to SIT (Figure 3F, $P<0.05$). An additional increase in epinephrine was observed in EX+BR 26.9 [2.3 to 51.6] relative to EX+SIT in males (Figure 3F, $P=0.03$). No differences were observed in the average norepinephrine over 8-hours for males or females (Figure 3E).

Sex differences in temporal variation

Significant time by sex interactions were observed for systolic BP ($P<0.001$) and diastolic BP ($P=0.04$). A significant treatment by sex interaction was observed for systolic BP ($P=0.02$) but not diastolic BP ($P=0.18$). Treatment by time by sex interactions were not significant for systolic BP ($P=0.40$) or diastolic BP ($P=0.73$). The temporal pattern for systolic BP appeared to be different between males and females. In all three conditions, the pattern for females was that of a dip after breakfast followed by a rise before lunch, then another dip after lunch followed by a rise towards the end of the day (Figure 4A). Conversely, the pattern for males was relatively more stable across the day during SIT, and during EX+SIT and EX+BR the pattern was that of an initial dip following exercise with a gradual rise across the rest of the day (Figure 4B). The temporal pattern in diastolic BP was more similar between males and females with post-meal dips after breakfast and lunch in all conditions (Figure 4C, D). Time by sex interactions were not significant for epinephrine ($P=0.17$) or norepinephrine ($P=0.07$). A significant treatment by sex interaction was observed for epinephrine ($P<0.001$) but not norepinephrine ($P=0.56$). Treatment by time by sex interactions were not significant for epinephrine ($P=0.53$) or norepinephrine ($P=0.80$). The female pattern of response in epinephrine was that of a decrease during EX+SIT and EX+BR, and an increase during SIT, whereas the male pattern of response was an increase during EX+SIT and EX+BR, and decrease in SIT (Figure 4E, F). The pattern of response in norepinephrine was that of an initial increase immediately post exercise relative to SIT, followed by a subsequent decline (Figure 5C, D, $P<0.05$ EX+SIT or EX+BR vs SIT).

DISCUSSION

Our study is the first to demonstrate that post-exercise reductions in BP can be further enhanced by subsequently breaking up prolonged sitting with light-intensity walking breaks

over a period of eight hours. This finding expands the evidence-base around the potential of a combined approach of exercise *and* breaks in sitting, and has several clinical and public health implications for BP control in older overweight/obese adults. Specifically, the additional BP lowering effect occurred on top of the effect of an exercise bout commensurate to a level recommended in public health guidelines (30 minutes at moderate intensity). In addition, this finding may inform the design of future exercise interventions seeking to optimise BP responses across the whole day in a population at increased risk for cardiovascular disease. Optimizing BP reductions in such interventions is likely to lead to improved clinical outcomes.

We observed a 3.4 mmHg and 0.8 mmHg reduction in 8-hour average systolic and diastolic BP respectively during the exercise plus sitting condition, which increased to a 5.1 mmHg and 1.1 mmHg reduction in 8-hour average BP respectively during the exercise plus breaks condition. If these effects were to be sustained over a longer period of time, they would be comparable to the effects of monotherapy with many common antihypertensive drugs.[15–18] In context, pharmacological intervention to reduce resting systolic BP by 10mmHg or diastolic BP by 5 mmHg approximates to a 22% and 41% reduction in coronary heart disease and stroke mortalities respectively.[18] Exercise training therefore, may supplement the role of antihypertensive medication, as it directly lowers BP in addition to improving other risk factors.[3] Future studies should be directed at understanding whether repeated exposures to a combined approach of exercise plus breaks in sitting leads to improved BP control over longer periods of time.

A body of literature exists pertaining to the acute hypotensive effect exercise.[19–22] Post-exercise hypotension may persist for between 12 to 22 hours.[22,23] Despite this, few studies

have measured post-exercise hypotension in a controlled setting beyond 2-3 hours and in the context of other activity-related behaviors.[24] Although previous studies have characterized a BP lowering benefit from intermittent breaks in prolonged sitting compared to uninterrupted sitting,[6,7,9] no previous study has examined the additive beneficial effects of combining exercise with breaks in sitting. The present study was designed to reflect different patterns of exercise and sedentary behavior that may occur in society, but in the context of a controlled and supervised experimental setting. The differential effects of exercise with and without breaks in prolonged sitting on BP, could be due to the beneficial effects of increased frequency or overall activity levels, or due to the detrimental effects of subsequent prolonged sitting in the context of prior exercise. Both perspectives highlight the idea that no behavior occurs in isolation, and that a comprehensive approach to understanding the health implications of multiple behaviors is likely required.

A number of mechanisms have been proposed to explain the effects of both acute exercise and prolonged sitting on BP.[5,10] Reductions in BP following acute exercise are attributed primarily to changes in arteriolar function and tone, rather than decreased cardiac output.[24,25] Reductions in resting BP may also stimulate the baroreflex to increase cardiac output,[26] which would implicate reduced peripheral resistance if BP remained lowered. Our findings concur, as heart rate remained elevated for ~2 hours post exercise, while BP remained lower during this time in EX+SIT and EX+BR relative to SIT. Given that decreased cardiac output in the post-exercise conditions is unlikely, there is strong reason to implicate the vasculature and total peripheral resistance in the hypotensive effect. Vascular resistance is controlled at the level of arterioles, or so-called resistance vessels, which are intricately regulated by a combination of compensatory neural, endocrine, paracrine and localized bio-mechanical mechanisms.[5,27] In the current study, post-exercise increases in blood flow and shear stress

and subsequent nitric oxide mediated vasodilation may have acted to lower total peripheral resistance.[27] Conversely, prolonged sitting may reduce flow and shear stress via mechanical bending of the lower-limb arteries,[28] reducing metabolic demand,[29] and increasing peripheral fluid accumulation (and reducing venous return).[30] In addition, biological variation likely evokes different pathways of physiological causation among participants in relation to BP control, as has been described for sex differences in the vascular response to exercise.[31,32]

Previous sex differences have been reported on the relationships between neural control of the heart and vasculature in humans,[11] with associations dependent upon age and hormonal status. For example, post-menopausal females exhibit larger reductions in BP following exercise relative to premenopausal females.[33] This diminished response in premenopausal females is likely due improved endothelial function at baseline.[33] In one study, premenopausal females maintained a preserved flow mediated dilation response in the popliteal artery following three hours of sitting, relative to males, despite similar reductions in blood flow and shear rate.[31] In the current study, the female participants were all post-menopausal. Therefore, a protective vascular effect from prolonged sitting is less likely due to a reduced vasodilator capacity of vascular β-adrenergic recptors,[11] and reduced estrogenic nitric oxide upregulation.[32] Our results support this idea as exposure to prolonged sitting following exercise in the EX+SIT condition resulted in a diminished systolic BP response relative to EX+BR in females but not in males.

The different pattern of response in systolic BP across the day warrants notice. Females demonstrated a fluctuating pattern with post-meal decreases in systolic BP, whereas males demonstrated a relatively more stable pattern. As the baroreflex is responsible for correcting acute fluctuations in BP,[26] it is possible that greater baroreflex sensitivity in males stabilized

potential post-meal decreases in systolic BP. Interestingly, diastolic BP fluctuated similarly in both sexes, implicating cardiac function in the discrepancy between temporal patterns. Indeed, the baroreflex corrects changes in BP primarily by affecting cardiac output over peripheral resistance at rest and during lower exercise intensities, and vice versa during higher exercise intensities.[34]

We also observed differences in epinephrine response between sexes, with females showing decreases on average across the day, but males showing significant increases in the exercise conditions. Typically exercise acutely increases epinephrine levels, with greater increases seen following higher intensity exercise.[35] However, the relative exercise intensity was similar between sexes, based on heart rate data expressed as a percent of age predicted maximum heart rate (see Table S3 in the online-only data supplement for heart rate response during exercise). Other factors such as a reduced cardiorespiratory fitness and increased body fat may blunt exercise induced increases in epinephrine,[35] and would seem more plausible in the context of the current study. Although not direct measures of fitness or body fat, females had a lower resting heart rate and higher body mass index compared to males. An increase in blood flow through tissues responsible for epinephrine clearance, such as the liver, may increase clearance.[36] It is therefore possible that the decrease in epinephrine observed for females in the current study is related to both a suppression of exercised induced secretion, coupled with increased clearance. Indeed, an exercise induced decrease in epinephrine has previously been observed in postmenopausal women.[37] To what extent differences in epinephrine explain the differences in BP, however, remain unclear as changes in epinephrine were not correlated to changes in BP.

The well-controlled randomized crossover design is a strength of this study as it provides

control for person-specific factors and affords smaller sample sizes. Trial conditions were also well standardized, with strict but pragmatic control for potential confounder variables such as diet, physical activity, medications and baseline values. There are also some limitations to our study. The exercise conditions were not matched for energy expenditure. This should be investigated in future studies to better elucidate mechanisms of BP lowering in relation to continuous versus fractionized activity. More mechanistic investigation may also lead to further elucidation of potential sex differences. We did not include a fourth condition involving breaks in sitting alone. This was intentional as we considered the evidence that an acute 30-minute bout of exercise impacts BP responses to be very strong, and there are a number of studies that support the BP lowering effect of active breaks compared to uninterrupted sitting alone.[6–9] We therefore focussed on a "superiority" approach to determine whether the addition of active breaks to an exercise bout enhanced the BP benefit.

Perspectives

Previous experimental research has sought to separate the effects of exercise and sedentary behaviour on BP. However, these behaviors co-exist in society and likely interact in ways that have important implications for health. We have studied the combined effects of exercise with prolonged sitting and exercise with breaks in sitting to better understand how BP may be affected by various patterns of these behaviors. We found that a morning bout of exercise combined with subsequent breaks in sitting lowered BP more than exercise followed by prolonged sitting. Moreover, this additional BP lowering effect was driven by female participants. While longer-term studies are required to corroborate our findings, this line of evidence may inform clinical and public health discussions around tailored strategies to optimize BP targets in older adults with increased cardiovascular disease risk.

Disclosures

None.

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Novelty and Significance

What is new?

- The blood pressure lowering effect of exercise is attenuated by subsequent exposure to prolonged sitting but enhanced by subsequent exposure to intermittent breaks in prolonged sitting.

- Female participants demonstrated an additional BP lowering effect following exercise plus breaks in sitting, relative to exercise plus prolonged sitting.

- Males demonstrated equal BP lowering effects following exercise with or without subsequent breaks in sitting.

What is Relevant?

- These findings are relevant to clinical and public health discussions around tailored strategies to optimize BP targets in older adults with increased cardiovascular disease risk.

Summary

These findings highlight the idea that no behavior exists in isolation, and studying the *combined* effects of different behaviors may lead to a comprehensive understanding of their health implications.

Figure Legends

Figure 1. Experimental design. Participants completed three conditions in a random order separated by a minimum of six days. Conditions were: Sitting (SIT): uninterrupted sitting (8hr, control); Exercise + Sitting (EX+SIT): sitting (1hr), moderate-intensity walking (30min, denoted by walking figure) followed by uninterrupted sitting (6.5hr); Exercise + Breaks (EX+BR): sitting (1hr), moderate-intensity walking (30min) followed by sitting (6.5hr) interrupted every 30 minutes with 3 minutes of light-intensity walking. Walking breaks are denoted by dashed lines in the EX+BR condition.

Figure 2. Overall blood pressure and heart rate responses. Panels A, B and C represent the systolic, diastolic and heart rate responses respectively, displayed as a time course over the day. Panels D, E and F represent the systolic, diastolic and heart rate responses respectively, displayed as the eight hour average across the day. The shaded area represents the moderate-intensity exercise bout performed in EX+SIT and EX+BR. Data are marginal means and 95% CI; * $P<0.05$ SIT vs EX+BR; † $P<0.05$ SIT vs EX+SIT.

Figure 3. Average blood pressure and catecholamine responses stratified by sex. Data are displayed as the eight hour average across the day, stratified by sex. MAP, mean arterial pressure. Data are marginal means and 95% CI.

Figure 4. Time course of blood pressure and heart rate responses stratified by sex. Panels A, B, and C represent the systolic, diastolic and heart rate responses respectively in females. Panels D, E, and F represent the systolic, diastolic and heart rate responses respectively in males. MAP, mean arterial pressure. The shaded area represents the moderate-intensity

exercise bout performed in EX+SIT and EX+BR. Data are marginal means and 95% CI; *
P<0.05 SIT vs EX+BR; † *P*<0.05 SIT vs EX+SIT.

Figure 5. Time course of plasma epinephrine and norepinephrine responses stratified by sex.
Panels A and B represent epinephrine and norepinephrine response respectively in females.
Panels C and D represent epinephrine and norepinephrine response respectively in males.
MAP, mean arterial pressure. The shaded area represents the moderate-intensity exercise bout
performed in EX+SIT and EX+BR. Data are marginal means and 95% CI; * *P*<0.05 SIT vs
EX+BR; † *P*<0.05 SIT vs EX+SIT.