Muscle metaboreflex attenuates spontaneous heart rate baroreflex sensitivity during dynamic exercise

Javier A. Sala-Mercado,1 Masashi Ichinose,1,3 Robert L. Hammond,1,2 Tomoko Ichinose,1,4 Marco Pallante,5 Larry W. Stephenson,2 Donal S. O’Leary,1 and Ferdinando Iellamo5,6

Departments of 1Physiology and 2Surgery, Wayne State University School of Medicine, Detroit, Michigan; 3Laboratory for Applied Human Physiology, Faculty of Human Development, Kobe University, Kobe; 4Laboratory for Human Performance Research, Osaka International University, Osaka, Japan; and 5Dipartimento Medicina Interna, Università di Roma Tor Vergata, and 6Istituto di Ricovero e Cura a Carattere Scientifico San Raffaele Pisana, Rome, Italy

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Sala-Mercado JA, Ichinose M, Hammond RL, Ichinose T, Pallante M, Stephenson LW, O’Leary DS, Iellamo F. Muscle metaboreflex attenuates spontaneous heart rate baroreflex sensitivity during dynamic exercise. Am J Physiol Heart Circ Physiol 292: H2867–H2873, 2007. First published February 2, 2007; doi:10.1152/ajpheart.00043.2007.—Hypoperfusion of active skeletal muscle elicits a reflex pressor response termed the muscle metaboreflex. Dynamic exercise attenuates spontaneous baroreflex sensitivity (SBRS) in the control of heart rate (HR) during rapid, spontaneous changes in blood pressure (BP). Our objective was to determine whether muscle metaboreflex activation (MRA) further diminishes SBRS. Conscious dogs were chronically instrumented for measurement of HR, cardiac output, mean arterial pressure, and left ventricular systolic pressure (LVSP) at rest and during mild (3.2 km/h) or moderate (6.4 km/h at 10% grade) dynamic exercise before and after MRA (via partial reduction of hindlimb blood flow). SBRS was evaluated as the slopes of the linear relations (LRs) between HR and LVSP during spontaneous sequences of at least three consecutive beats when HR changed inversely vs. pressure (expressed as beats·min⁻¹·mmHg⁻¹). During mild exercise, these LRs shifted upward, with a significant decrease in SBRS (−3.0 ± 0.4 vs. −5.2 ± 0.4, P < 0.05 vs. rest). MRA shifted LRs upward and rightward and decreased SBRS (−2.1 ± 0.1, P < 0.05 vs. mild exercise). Moderate exercise shifted LRs upward and rightward and significantly decreased SBRS (−1.2 ± 0.1, P < 0.05 vs. rest). MRA elicited further upward and rightward shifts of the LRs and reductions in SBRS (−0.9 ± 0.1, P < 0.05 vs. moderate exercise). We conclude that dynamic exercise resets the arterial baroreflex to higher BP and HR as exercise intensity increases. In addition, increases in exercise intensity, as well as MRA, attenuate SBRS.

exercise reflexes; pressor response; heart rate variability; arterial baroreflex sensitivity

THE ARTERIAL BAROREFLEX is the primary short-term regulator of systemic blood pressure via modulation of cardiac output (CO) and peripheral vasoconstriction to maintain normal arterial pressure (53). Changes in arterial pressure result in arterial baroreflex-mediated reciprocal changes in heart rate (HR) and sympathetic activity. However, dynamic exercise simultaneously increases arterial pressure and HR. This phenomenon has been explained by previous studies showing that the arterial baroreflex is reset to operate around the prevailing blood pressure generated during exercise (5, 9, 45, 51). In addition to baroreflex resetting during exercise, attenuation of arterial baroreflex sensitivity in the control of HR during rapid, spontaneous changes in blood pressure has been reported (4, 10, 39, 63). According to Iellamo (10), spontaneous baroreflex sensitivity (SBRS) decreases progressively from rest to maximal exercise. More recently, Ogoh et al. (39) examined the effects of sympathetic and parasympathetic blockade on SBRS during dynamic exercise and suggested that the reduction of SBRS during exercise is associated with vagal withdrawal, rather than an increase in sympathetic activity. However, the precise mechanism(s) of the decrease in SBRS during dynamic exercise remains unknown.

Hypoperfusion of exercising skeletal muscle causes the accumulation of metabolic by-products within the active muscle. These metabolites stimulate group III and IV afferent neurons, which evokes a reflex response known as the muscle metaboreflex. Activation of the muscle metaboreflex causes reflex changes in autonomic nerve activity and release of vasoactive hormones, which together increase CO and peripheral vasoconstriction, which in turn causes a rise in mean arterial pressure (MAP) (15, 16, 24, 28–30, 32, 34, 55, 57, 64). Activation of muscle afferents has been proposed as one mechanism responsible for the resetting of the arterial baroreflex (22, 44, 51) and the decrease in SBRS during exercise (10). However, to our knowledge, there is no direct evidence of attenuation of SBRS by muscle metaboreflex activation (MRA) during dynamic exercise. We hypothesized that MRA during dynamic exercise causes resetting of the arterial baroreflex and a decrease in SBRS. We used the spontaneous baroreflex sequence analysis (3, 41) to evaluate SBRS in chronically instrumented dogs during mild and moderate workloads before and during MRA.

MATERIALS AND METHODS

Ten healthy, adult mongrel dogs (~20–25 kg body wt) of either sex were selected for their willingness to run on a motor-driven treadmill. The protocols were reviewed and approved by the Wayne State University Animal Investigation Committee.

Surgical preparation. The animals were prepared in a series of two surgical sessions, with ≥10–14 days between surgeries and ≥1 wk between the last surgery and the first experiment. Before the surgical procedures, each animal was accustomed to human handling and

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trained to run freely on a treadmill. All animals were surgically instrumented under sterile conditions in the same manner, allowing the same animal to be used for multiple studies. Acmoprazine (0.2 mg/kg im) was administered 30 min before anesthetic induction for preoperative sedation. Cefazolin (500 mg iv) was administered immediately before and after each surgery, and then cephalexin (30 mg/kg po, 2 times/day) was given to prevent postoperative infection. For all surgical procedures, the animals were anesthetized with thiopental sodium (25 mg/kg iv), anesthesia was maintained with isoflurane gas (2–3%), and the animals were treated for postoperative discomfort with a transdermal fentanyl patch (Duragesic, Janssen Pharmaceutica), which delivered a dose of 125–150 μg/h for 3 days. During recovery from surgery, buprenorphine (0.015 mg/kg iv), maleate acromazine (0.1 mg/kg iv), and etorolac (10–15 mg·kg⁻¹·day⁻¹·po) were also administered for control of discomfort and sedation as needed.

In the first surgical session, a midline sternotomy was performed. Hydraulic vascular occluders (16 or 14 mm; In Vivo Metrics) were placed on the superior and inferior venae cavae for studies unrelated to the present investigation. The pericardium was then opened, and a 20- or 24-mm blood flow transducer (Transonic Systems) was positioned around the ascending aorta for measurement of CO. A fully implantable telemetered blood pressure transducer (model PAD-70, Data Sciences International) was placed subcutaneously on the left side of the chest; its catheter was tunneled into the thoracic cavity and located inside the left ventricle (LV) for measurement of LV pressure (LVP). Two pairs of sonomicrometry crystals (Sonometrics) were implanted in the endocardium of the LV, and three stainless steel ventricular pacing electrodes (O-Flexon, Ethicon) were sutured to the right ventricular free wall for studies not pertinent to the present investigation. The pericardium was reapproximated loosely, and the chest was closed in layers.

After a 10- to 14-day recovery period, the dogs underwent a second surgical procedure. Through a left abdominal retroperitoneal approach, a 10-mm blood flow probe (Transonic Systems) was placed on the terminal aorta for measurement of blood flow to the hindlimbs (HLBF). A 10-mm hydraulic vascular occluder (In Vivo Metrics) was placed on the terminal aorta just distal to the flow probe. All arteries branching from the aorta between the iliac arteries and the HLBF probe were ligated and severed. A catheter was advanced through a lumbar artery proximal to the HLBF probe for measurement of arterial pressure.

All cables, wires, occluder tubings, and the aortic catheter were tunneled subcutaneously and exteriorized between the scapulae at the end of each surgical session.

Experimental procedures. All experiments were performed after the animals had fully recovered from surgery; i.e., they were active, afebrile and were observed to have a good appetite. Before the experimental sessions, each animal was transported to the laboratory, allowed to roam freely for 15–30 min, and then led to the treadmill. The blood flow transducers were connected to the flowmeters (Transonic Systems). HR was computed by a cardiotachometer triggered by the CO signal. The arterial catheter was connected to a pressure transducer (Transpac IV, Abbott Laboratories). The LV implant was turned on, and the quality of the signal was verified. All data were recorded on a pen-chart recorder (model RS 3800, Gould) as well as computerized analog-to-digital recording systems for subsequent off-line analyses. For a given experimental session, data were collected at rest and then at a randomly selected workload: mild exercise (3.2 km/h at 0% grade) or moderate exercise (6.4 km/h at 10% grade). Steady-state data were recorded for 3–5 min at rest while the animal was standing on the treadmill, during exercise with unrestricted HLBF, and after MRA. The muscle metaboreflex was elicited by partial reductions in HLBF via step inflation of the terminal aortic occluder, as shown in previous studies (32–34, 36, 54, 55). Each dog completed several experiments at both workloads and, thus, served as its own control.

Data analysis. During the experiments, MAP, HR, LVP, CO, and HLBF were measured continuously. Later, off-line data analyses yielded LV systolic pressure (LVSP), R-R interval (RRI), and stroke volume (SV; Advanced CODAS, Dataq Instruments). Data were collected for 3–5 min so that the recording period spanned multiple respiratory cycles. The data were averaged at each condition (at rest, during mild or moderate exercise with unrestricted blood flow to the hindlimbs, and after MRA) across all experiments for each animal. These mean values were then averaged across animals to obtain the mean values for the population studied. Thus each animal contributed only once to the overall averages, and each animal served as its own control.

As shown in Fig. 1, SBRS was dynamically assessed by the sequence analysis technique (3, 41). Since LVSP is nearly identical to systolic pressure in the aortic arch, we used LVSP as the input to the arterial baroreflex. The beat-to-beat time series of LVSP and HR were searched for three or more consecutive beats in which the LVSP and HR of the following beat changed in the opposite directions (i.e., −HR/+LVSP and +HR/−LVSP). These sequences were identified as baroreflex sequences. A linear regression was applied to each individual sequence; only those sequences with $r^2 > 0.85$ were accepted, and the slope was calculated. The mean slope of the LVSP-HR relation, obtained by averaging all slopes computed within a given test period, was calculated and taken as a measure of SBRS for that period. The same analysis was performed on the time series of LVSP and RRI, which were searched for three or more consecutive beats in which the LVSP an RRI of the following beat changed in the same directions (i.e., +RRI/+LVSP and −RRI/−LVSP).

Statistical analysis. Averaged responses for each animal were analyzed with Systat software (Systat 11.0). $P < 0.05$ was set to determine statistical significance. One-way analysis of variance for repeated measures was used to compare hemodynamic data obtained at rest and during exercise under free-flow conditions and during MRA at mild and moderate workloads. If a significant effect was found, a post hoc test for simple effects was performed to determine significant group mean differences. Values are means ± SE.

RESULTS

Table 1 shows the average values of LVSP, CO, SV, HR, RRI, and number of spontaneous baroreflex sequences (SBRS incidence) at rest and at each workload before and during MRA.
elicit via partial reduction in HLBF. In accordance with previous studies (32, 55), from the standing position (rest) to mild exercise, we observed a significant increase in CO, HLBF, and SV and a substantial tachycardia; LVSP remained unchanged. MRA at this workload significantly elevated LVSP compared with the free-flow condition. Considerable tachycardia and an additional rise in SV occurred, and, as a result, CO significantly increased. As also shown in Table 1, moderate exercise generated a significant rise in CO, HLBF, SV, HR, and LVSP. In addition, with MRA, CO, SV, LVSP, and HR increased further, and, as expected, a significant decrease in RRI was observed. In addition, there was no significant change in SBRS incidence from standing rest to mild or moderate exercise with or without MRA. In agreement with previous studies (2, 31, 32, 64), the elevation of MAP was the result of the increases in vascular conductance (ml·min⁻¹·mmHg⁻¹) to all nonischemic areas: 44.6 ± 3.1 vs. 44.2. ± 2.8 (P > 0.05) and 57.9 ± 3.3 vs. 54.1 ± 3.3 (P > 0.05) during mild and moderate exercise, respectively.

Figure 2 shows RRI-SBRS and HR-SBRS at each setting (rest, mild exercise, MRA during mild exercise, moderate exercise). Figure 3 shows the prevailing HR or RRI and LVSP at each setting, with its corresponding SBRS mean slopes. As shown in Figs. 2 and 3A, from rest to mild exercise, the HR-LVSP relation shifted upward and SBRS decreased significantly (i.e., the mean slope became flatter). MRA shifted the HR-LVSP relation upward and rightward and further decreased SBRS. Similar results were observed during moderate exercise. As shown in Figs. 2 and 3B, at this workload, the HR-LVSP relation shifted upward and rightward and SBRS significantly decreased. In addition, MRA elicited a further shift of the HR-LVSP relation (upward and rightward) and an additional significant reduction in SBRS. As expected, compared with the HR-LVSP relation, the RRI-LVSP relation shifted in the opposite vertical (downward) direction.

As shown in Fig. 4, the relations between HR and HR-SBRS and RRI and RRI-SBRS were nonlinear. Although SBRS decreased with progressive increases in HR, the reduction in baroreflex gain was greater when HR rose in situations where baseline HR was lower (i.e., rest or mild exercise).

Our conclusions were unaffected regarding the changes in SBRS when HR or RRI was used in the analysis.

**DISCUSSION**

To our knowledge, this is the first study to investigate the effects of MRA on SBRS during mild and moderate dynamic exercise. The major findings of our study were that from rest to either workload and, moreover, with MRA, there is a progres-

![Image](http://ajpheart.physiology.org/)

**Table 1. Average HLBF, LVSP, CO, SV, HR, RRI, and SBRS incidence at rest and at each workload before and during MRA**

<table>
<thead>
<tr>
<th>Workload</th>
<th>HLBF, l/min</th>
<th>LVSP, mmHg</th>
<th>CO, l/min</th>
<th>SV, ml</th>
<th>HR, beats/min</th>
<th>RRI, ms</th>
<th>SBRS Incidence, sequences/min</th>
</tr>
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<tbody>
<tr>
<td>Rest</td>
<td>0.85 ± 0.04</td>
<td>137.5 ± 5.3</td>
<td>4.6 ± 0.2</td>
<td>44.3 ± 2.0</td>
<td>105.2 ± 3.7</td>
<td>591.7 ± 20.4</td>
<td>9.7 ± 1.4</td>
</tr>
<tr>
<td>Mild</td>
<td>1.32 ± 0.07*</td>
<td>136.1 ± 5.5</td>
<td>6.2 ± 0.3*</td>
<td>47.5 ± 2.2*</td>
<td>131.4 ± 2.7*</td>
<td>462.6 ± 9.3*</td>
<td>8.2 ± 1.0</td>
</tr>
<tr>
<td>Mild + MRA</td>
<td>0.67 ± 0.03†</td>
<td>180.6 ± 6.2†</td>
<td>7.5 ± 0.3†</td>
<td>49.2 ± 2.5†</td>
<td>153.7 ± 4.7†</td>
<td>396.4 ± 11.7†</td>
<td>9.4 ± 1.2</td>
</tr>
<tr>
<td>Moderate</td>
<td>2.77 ± 0.14*</td>
<td>152.5 ± 6.7*</td>
<td>9.1 ± 0.3*</td>
<td>49.9 ± 2.1*</td>
<td>182.7 ± 5.5*</td>
<td>332.1 ± 9.2*</td>
<td>10.6 ± 1.1</td>
</tr>
<tr>
<td>Moderate + MRA</td>
<td>1.90 ± 0.10‡</td>
<td>195.2 ± 7.9‡</td>
<td>10.3 ± 0.4‡</td>
<td>52.8 ± 2.6‡</td>
<td>196.4 ± 6.5‡</td>
<td>305.9 ± 9.6‡</td>
<td>11.3 ± 1.7</td>
</tr>
</tbody>
</table>

Values are means ± SE. HLBF, hindlimb blood flow; LVSP, left ventricular systolic pressure; CO, cardiac output; SV, stroke volume; HR, heart rate; RRI, R-R interval (pulse interval); SBRS incidence, number of spontaneous baroreflex sequences; mild exercise, 3.2 km/h at 0% grade; moderate exercise, 6.4 km/h at 10% grade; MRA, muscle metaboreflex activation. *Significantly different from rest (P < 0.05). †Significantly different from mild exercise (P < 0.05). ‡Significantly different from moderate exercise (P < 0.05).
sive resetting of the arterial baroreflex with a significant decrease in SBRS.

**Dynamic exercise and the baroreflex.** Previous animal (5, 44) and human studies (40, 45) have shown that the arterial baroreflex is reset to operate around the prevailing blood pressure generated during dynamic exercise. Furthermore, several investigations (4, 12, 39, 63) have shown that static and dynamic exercise reduce SBRS. On the basis of a series of studies (11, 12, 14), Iellamo et al. suggested that the effect of exercise on the direction of resetting (vertical and/or lateral) and/or decrease in SBRS is strongly dependent on the type and intensity of exercise, as well as the size of the muscle mass engaged. Our findings confirm previous results, in that whole body mild dynamic exercise resets the arterial baroreflex operating point upward and decrease SBRS. Moreover, during moderate exercise, we observed an upward and rightward resetting and further reduction of SBRS in the control of HR.

**Muscle metaboreflex and SBRS.** Underperfusion of active skeletal muscle during dynamic exercise evokes a powerful pressor response known as the muscle metaboreflex. In normal conditions and during submaximal exercise, the most important mechanism employed by this reflex is the increase in CO. In addition, the activation of this reflex is capable of eliciting significant increases in sympathetic nerve activity (SNA), HR, SV, ventricular contractility, and plasma levels of vasoactive hormones and inducing central blood volume mobilization and vasoconstriction in the peripheral vasculature to raise perfusion pressure (i.e., MAP) to help restore blood flow and reduce the O₂ deficit in the active skeletal muscle (1, 2, 6, 7, 17, 21, 25, 32–34, 36, 38, 50, 52, 55, 57–59, 61, 64).

It has been previously reported in humans that MRA by the postexercise muscle ischemia technique has no effect on SBRS (14). However, our results provide strong evidence that MRA in dogs during dynamic exercise evokes an upward and rightward resetting of baroreflex control of HR, with a concomitant decrease in SBRS. This discrepancy may be explained in part by the different methodology employed to perform the studies, which results in manifest differences in the balance of the autonomic nervous system, especially parasympathetic nerve activity. For example, HR and MAP increase substantially when the muscle metaboreflex is activated during exercise; however, when the muscle metaboreflex is activated in the recovery period from exercise, i.e., by postexercise muscle ischemia, MAP and SNA remain elevated, but HR declines toward resting levels (29). Dynamic exercise withdraws parasympathetic nerve activity to the heart in rough proportion to the exercise intensity (35). However, during postexercise muscle ischemia, while SNA to the heart is maintained at high levels, parasympathetic outflow also increases with the cessation of exercise (27, 29, 37). Thus, in this latter situation, despite elevated sympathetic outflow, bradycardia occurs as a result of an overwhelming effect of parasympathetic activation due to restoration of SBRS to the resting level and loss of central command (14, 29). As previously stated, during postexercise muscle ischemia, parasympathetic tone is elevated; this could obscure the inhibitory effect of MRA on SBRS. Interestingly, Iellamo et al. (13) found that the decrease in SBRS by dynamic bicycle exercise was maintained during postexercise muscle ischemia during spaceflight, which was accompanied by greater tachycardia and pressor responses than in the preflight condition. Their results suggest that greater activation of the muscle metaboreflex is necessary to decrease SBRS during postexercise muscle ischemia. Thus we may speculate that, in dogs and humans, MRA would work to

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**Fig. 3.** Group average prevailing HR or RRI and LVSP with corresponding mean slopes at rest (A–D, dotted lines) and during mild exercise (A and C, dashed lines), mild exercise + MRA (A and C, solid lines), moderate exercise (B and D, dashed lines), and moderate exercise + MRA (B and D, solid lines).
attenuate SBRS. With static exercise, during which central command, mechanoreceptors, and metaboreceptors are activated, Iellamo et al. (14) and Stewart et al. (60) observed decreased baroreflex control of HR.

One may argue that the imposed ischemia and resultant decrease in mechanical efficiency of the skeletal muscle would require more motor unit recruitment and, thus, an increase in central command. Increased central command would reduce parasympathetic tone to the heart (62) and reset the cardiac baroreflex (47). However, Kozelka et al. (19) and Pomeroy et al. (43) showed in dogs that blockade of skeletal muscle afferent activity by lesions of the spinal tracts carrying the afferent information or intrathecal morphine virtually abolished the cardiovascular responses to treadmill exercise with complete unilateral iliac artery occlusion. Thus, if the “feedforward” central command reflex was strongly activated because of the necessity to recruit more motor units to perform the exercise, then blockade of the afferents should not markedly reduce the response to skeletal muscle ischemia. Furthermore, whereas the increase in HR with strong activation of central command can be abolished by muscarinic receptor blockade and is unaffected by β-adrenergic blockade (62), the opposite is seen with MRA: little tachycardia occurs with MRA after β-blockade, and muscarinic blockade has little effect on the HR response (29). Therefore, we believe that the responses observed in the present study stem from activation of the muscle metaboreflex.

Muscle metaboreflex-baroreflex interaction. It is difficult to provide a definitive explanation of the mechanism(s) responsible for MRA-induced decrease in SBRS during dynamic exercise. Direct action of the muscle metaboreflex on parasympathetic pathways seems unlikely, because the metaboreflex appears to operate mainly via increases in SNA, with little control over parasympathetic activity (37). It has been previously shown that high plasma norepinephrine concentration attenuates parasympathetic control of HR (26). Therefore, it is possible that the decreased SBRS is a result of the high plasma norepinephrine concentration induced by the MRA during dynamic exercise (8, 28). Another possibility is the arterial baroreflex-muscle metaboreflex interaction within the central nervous system, for it has been demonstrated that the brain stem receives several peripheral inputs, including afferents from skeletal muscles and arterial baroreceptors (23, 46, 56). It is known that the arterial baroreflex in the normal animal mainly controls peripheral vascular resistance and buffers metaboreflex-mediated effects on the vasculature (18). On the other hand and as previously stated, the muscle metaboreflex exerts strong control over SNA to the heart (the main mechanism employed by the muscle metaboreflex in the normal animal is the increase in CO). Since it is known that the increase in CO is induced by an increase in HR and a stable or slightly increased SV, then it seems reasonable that MRA may influence the baroreflex control over HR to better control cardiac performance by modulating baroreceptor resetting and, concomitantly, lessening baroreflex opposition to HR increases. Hence, inhibition of the vagal-cardiac baroreflex modulation could have contributed to the MRA-induced increase in tachycardia during exercise. In the present study, after MRA at either workload, there was a significant upward and rightward shift of the HR-LVSP relation and, in addition, a significant reduction in SBRS. However, the precise mechanisms remain to be confirmed.

HR-SBRS vs. RRI-SBRS. There is a long-standing controversy as to which index, HR or RRI, should be used to evaluate the cardiac baroreflex sensitivity (30). Either method may be adequate, depending on the aim of a given investigation (20, 48, 49). Briefly, because RRI is the inverse of HR, for any given change in HR, the corresponding change in RRI decreases as the baseline HR increases (30). This is especially important when large changes in the baseline HR occur between different settings, as between rest and exercise. In addition, the cardiac component of the baroreflex regulates blood pressure by changing CO, which is determined by SV and HR. In this case, the use of HR seems more reasonable to estimate the strength of blood pressure regulation by this reflex. On the other hand, because the relation between parasympathetic stimulation and RRI is linear (the relation between HR and parasympathetic stimulation is hyperbolic), the use of RRI, rather than HR, could be argued to be more appropriate to

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Fig. 4. Relations between baseline HR and HR-SBRS (A) and between baseline RRI and RRI-SBRS (B). Group average data during each condition; solid line, regression line.
examine the reflex parasympathetic influence on the heart (42). In the present study, we used both indexes and reached the same qualitative conclusion by using HR or RRI in all conditions.

Limitations. The spontaneous baroreflex sequence technique has some inherent limitations. By the use of only spontaneous blood pressure and HR changes, the analysis is inadequate to evaluate the full stimulus-response curve of the arterial baroreflex (i.e., threshold, saturation, and linear operational range of the reflex). Therefore, the possibility that the decrease in SBRS observed during dynamic exercise and after MRA may have resulted from a shift to a nonlinear region of the baroreflex stimulus-response relation cannot be discounted. Eiken et al. (6) showed that lower body positive pressure during supine cycling exercise caused tachycardia and horizontal and vertical resetting of the baroreflex cardiac responses to rapid changes in carotid transmural pressure. Furthermore, the operating point of the carotid-cardiac baroreflex was shifted to a flatter part of the stimulus-response relation. Although we saw no difference in SBRS between increases and decreases in pressure, the reduction in SBRS seen with exercise and MRA may be due to a shift of the operating point to a lower-sensitivity portion of the entire stimulus-response relation (47). Another limitation is that the spontaneous baroreflex sequence technique examines HR responses to rapid, transient changes in arterial blood pressure that are parasympathetically mediated, whereas it does not enable us to investigate the slower sympathetic component of the baroreflex (37, 39). Therefore, our observations of the effect of dynamic exercise and MRA on cardiac baroreflex are most likely confined to the parasympathetic component of the baroreflex. However, the spontaneous baroreflex sequence technique has many advantages. It enables a qualitative and quantitative estimate of the integrated baroreceptor-cardiac response relations during the spontaneous blood pressure fluctuations that characterize the resting and exercise conditions. This is possible without pharmacological or mechanical interventions. This technique utilizes a dynamic and natural stimulus of physiological magnitude, i.e., the spontaneous blood pressure increases and decreases around the prevailing levels of blood pressure and HR with which the body must cope in any physiological or pathological situation.

In conclusion, our study confirms that dynamic exercise resets the arterial baroreflex to higher blood pressure and HR as exercise intensity increases and, in addition, reduces SBRS. Furthermore, we found that MRA evokes further upward and rightward resetting of arterial baroreflex from mild and moderate dynamic exercise and also decreases SBRS.

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