Graded exercise evokes bronchovascular and lower airway smooth muscle constriction in sheep

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Exercise stimulus-response relationships for airway blood supply and dimensions have not been described in mammalian species including man. The data are vital for postulates concerning integrated reflex factors normally controlling the smooth muscle of airways and which underlie the asthma syndromes of exercise. This study defines airways stimulus-response relationships in exercising sheep. Ewes between 35 and 40 kg were instrumented at left thoracotomy under 15mg/kg thiopentone/2-3% isoflurane general anaesthesia. Pulsed Doppler ultrasonic transducers were mounted on the bronchial artery, and transit-time plus single crystal sonomicrometers on the left main bronchus. These recorded simultaneously and continuously bronchial blood flow (Qbr) and conductance (Cbr), bronchial circumference (Circbr) and wall thickness (Thbr). Aortic pressure (Pa), and central venous pressure (Pcv) catheters were placed in the superficial cervical artery and vein. In Protocol 1 (P1), four sheep ran duplicate 5 min protocols on a horizontal treadmill at continuous step-up-and-down speeds of 1min duration, namely, 0.8, 1.6, 2.2, 1.6 and 0.8 mph (moderate exercise), followed by 10 min recovery. In P2, four sheep ran duplicate 2 min protocols at constant 4 mph (strenuous exercise), and in P3, one sheep ran separate protocols each of 3 min at 2.2, 4.4 and 6 mph (severe exercise). Regression analysis and repeated measures ANOVA were used to assess differences between times, runs and exercise intensity. In P1, airway onset and offset effects were immediate, directly related to graded exercise effort, and sustained over 5 min. Peak effects occurred at 2.2 mph, except for Thbr. Heart rate and Pa rose (to 156% and 111% of resting, respectively), and Qbr and Cbr fell (to 83% and 75%; both $p<0.001$). Circbr fell to 96% ($P=0.02$), and Thbr rose at low speeds early and late, and thinned at the highest speed. In P2 and P3 for all variables the steady-state effects were systematically greater than for P1, and the exercise stimulus-response relationship was near linear (4.4mph: Cbr to 43%, Circbr to 93%; 6.6mph: Cbr 25%, Circbr 82%). There was no significant recovery hyperaemia, but there was residual post-exercise bronchoconstriction. The exercise stimulus-response relationships from rest to a maximal 6mph for sheep airway circumference and its bronchial circulation are therefore inverse and functionally constrictor, and not dilator. The results also suggest that the mammalian primary response of airway wall and vascular smooth muscle is reflex, and may be sustained post-exercise as part of central command-induced autonomic resetting in exercise. If these results hold true for man, they suggest that asthma syndromes represent respiratory incapacity due to a normal response exaggerated by variable environmental factors.

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