a characteristic of the acidosis or the form of exercise, 30 normal
male subjects performed exercise on a cycle ergometer at 50, 100
and 150 watts, and 3 work rates at comparable \( O_2 \) uptakes on a
treadmill. For the second and third levels of work, \( V_e \) was higher
for cycle ergometer than treadmill exercise. This was associated
with a larger lactate increase and bicarbonate and pH decrease in
the former. If \( V_e \) is related to \( V_o_2 \) at work rates which are not asso-
ciated with metabolic acidosis, the relationship is linear with \( V_e \) in-
creasing 25 liters for each liter increase in \( V_o_2 \). Any increase in \( V_e \)
above that predicted by this relationship ("excess" \( V_e \)) reflects the
influence of metabolic acidosis. The "excess" \( V_e \) was 4L/ min for
each mEq/L decrease in bicarbonate regardless of the form of exer-
cise. We therefore conclude that "excess" \( V_e \) is more closely rel-
ated to the degree of metabolic acidosis during exercise rather than
the disparate modes of ergometry, per se.

Supported by PHS Grants HL-11907 and RR00425.
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8:45 a.m.
VENTILATORY AND GAS EXCHANGE KINETICS IN MODERATE
EXERCISE
L. B. Diamond, R. Casaburi, K. Wasserman, S. N. Koyal and B.
J. Whipp. Div. of Resp. Physiol. and Med., Harbor Gen. Hospi-
tal-UCLA School of Med., Torrance, California

The response of \( V_o_2 \) in the transition from rest to moderate exer-
cise is characterized by first order kinetics with a halftime (\( T_{1/2} \)) of
30 sec. Similarly \( V_o_2 \) dynamics, as determined by sinusoidal vari-
ation between work rates, feature \( T_{1/2} \approx 30 \) sec (Fed. Proc.
34:431,1975). However, it has been reported that the kinetics of
\( V_o_2 \) is almost twice as rapid if the transition is between one work-
load and another (J.A.P.32:618,1972). In order to resolve this dispa-
ity, 7 normal subjects each performed 3 transitions, to a sub-
aerobic threshold work rate, on a cycle ergometer: 1) from rest,
2) to a low work rate (both at 06pm), and 3) from a low work
rate at 40 rpm to the high work rate at 80 rpm. \( V_o_2 \), \( V_c_o_2 \) and \( V_e \)
were computed breath-by-breath and response kinetics extracted.
The mean half-times for the seven subjects were:

<table>
<thead>
<tr>
<th>( V_o_2 )</th>
<th>( V_c_o_2 )</th>
<th>( V_e )</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>41</td>
<td>47</td>
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<tr>
<td>35</td>
<td>47</td>
<td>52</td>
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<tr>
<td>30</td>
<td>45</td>
<td>49</td>
</tr>
</tbody>
</table>

We conclude that the response kinetics of these variables are not
appreciably altered by the prior exercise or by variation of pedal
rate. The dynamics of \( V_e \) was highly correlated with \( V_o_2 \)
\((r=.94)\) providing further evidence that exercise hyperpnea is a
\( C_02 \) -coupled phenomenon.

Supported by NIH Grants HL-14967, HL-17107 and
HL-11907.

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9:00 a.m.
EFFECTS OF INSPIRATORY RESISTANCE AND A HYPOXIC
GAS MIXTURE ON AEROBIC WORK TOLERANCE
C. E. Wade, R. H. Dressendorfer, and E. M. Bernauer. Dept. of
P. E., Univ. of California, Davis

Effects of increasing inspiratory resistance, \( R_i > R_1 > R_2 > R_3 \),
where \( R_i \) is tube radius, \( R_1 = 35 \text{mm} \) and \( R_2 = 8 \text{mm} \) on aerobic work
tolerance were studied in seven well-conditioned subjects by con-
tinuously monitoring \( V_e \), \( V_o_2 \), \( V_c_o_2 \), and \( H_r \) every 15 sec during
incremental work tests to exhaustion on a cycle ergometer. \( V_e \) de-
creased with increasing resistance (\( R_1 = 178.3 \), \( R_2 = 100.5 \text{ L/min}
BTPS, \( P<.01 \)), but submaximal \( V_o_2 \) and aerobic threshold (\( A_T \))
were not affected. \( V_o_2 \)max decreased (\( R_1 = 4.28 \), \( R_2 = 3.74 \text{ L/min},
P<.01) \) parallel with peak \( V_e \) as resistance increased, and exhaus-
tion occurred earlier. \( V_e \) at \( V_o_2 \)max for each resistance remained
70-75% of the respective maximal voluntary ventilation, but \( V_o_2 \)
decreased (\( R_1 = 4.68 \), \( R_2 = 3.90 \text{ L/min}, \( P<.01) \). Peak \( H_r \), and cal-
culated \( O_2 \) deficit were reduced at the highest resistance, \( R_3 \), Re-
moval of \( R_3 \) at exhaustion abruptly increased \( V_e \) and \( V_o_2 \), and
permitted work to continue. Breathing 35% \( O_2 \) and \( N_2 \) against \( R_3 \)
resulted in significantly greater values \((P<.05)\) for \( A_T \), \( V_o_2 \)max,
peak \( H_r \), endurance, and \( O_2 \) deficit, but did not change \( V_e \) and \( O_2 \) def-
cit accumulation from \( A_T \) to exhaustion was of the same order of
magnitude for all conditions \((R_1 = 0.59, R_2 = 0.56 \text{ L/min})\). Aerobic
work tolerance, measured by \( V_o_2 \)max and endurance time, thus
seems dependent on ventilatory capacity, \( R_e \), during maximal exer-
cise, may limit pulmonary function before active extremes of
fatigue. Aerobic work tolerance reduced by high inspiratory resistance,
may be partly restored by hyperoxic gas mixtures.

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9:15 a.m.
CHEMORECEPTOR INFLUENCE ON HEART RATE AND BLOOD
PRESSURE RESPONSES TO BREATH-HOLDING IN MAN
P. M. Gross, B. J. Whipp, J. T. Davidson, S. N. Koyal and K.
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Harbor General Hospital, UCLA School of Medicine, Tor-
rance, California

The bradycardia and elevated blood pressure (BP) which occur
in most species during breath-holding (BH) and apneic diving have
been extensively studied in past years. For man, several possible
factors have been proposed to explain the mechanism of these car-
diovascular changes, but none has been as convincing as that which
links the carotid chemoreceptors to the diving response in avian
species and anesthetized dogs. To examine the role of che-
moreceptors in regulating apneic heart rate (HR) and BP in man, we
studied these variables continuously before and during prolonged
BH in 5 patients whose carotid bodies had been resected (CBR).
Seven normal subjects served as controls. BH experiments were
performed with single breaths of 100%, 21% or 12% \( O_2 \). During BH
with 21% \( O_2 \), normals displayed the typical cardiovascular re-
sponses; the bradycardia, however, was attenuated with 100% \( O_2 \)
and 12% \( O_2 \). In contrast, the CBR subjects manifested a progres-
sively increasing tachycardia which was inversely proportional to
the \( O_2 \) tension in each gas. BP also increased progressively, but
was not related to \( O_2 \) tension. Our data demonstrate that the HR
response to BH in man is influenced by chemoreceptors. The arterial
hypertension seen during BH does not appear to be aortic chem-
oreceptor-related, but may involve the carotid bodies and/or per-
ipheral constrictor reflexes arising from the lungs.

Supported by U.S. PHS Grants HL-11907 and HL-14967.

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9:30 a.m.
DIVING REFLEX DURING EXERCISE IN MAN
C. I. Williams and E. M. Bernauer. Human Performance Lab-
oratory, University of California, Davis

In order to examine persistence of the "diving reflex" response to
face immersion during exercise, heart rate (HR), blood pressure
(BP), body flow (BF), and alveolar \( P_O_2 \) and \( P_C_O_2 \) were measured
in 8 male subjects in response to nonanepic immersion (NAI) and
anepic immersion (AI) at rest (R), NAI and AI during steady state
exercise (SSE), and NAI and AI with exercise begun simultaneously
with immersion (SSI). Bicycle ergometer load was chosen to pro-
cduce a HR of 80% of the subject's maximum HR. The breath was
held at 90% of vital capacity, and water temperature was 10 C. At
R, NAI elicited a decline in HR from 60 to 58.5 beats/min. Mean
BP increased and peripheral BF decreased indicating an active pe-
ripheral vasconstriction. AI at R elicited a similar response, but
the reduction in HR was greater (99.4 to 39.8 beats/min) and oc-
curred at a more rapid rate. During both SSE and SSI, NAI failed