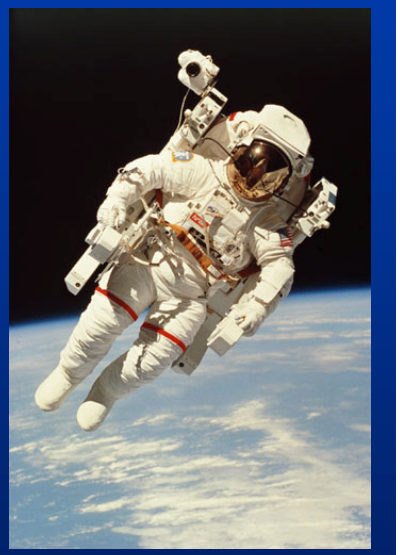
COMPARISON OF V-4 AND V-5 EXERCISE/OXYGEN PREBREATHE PROTOCOLS TO SUPPORT EXTRAVEHICULAR ACTIVITY IN MICROGRAVITY



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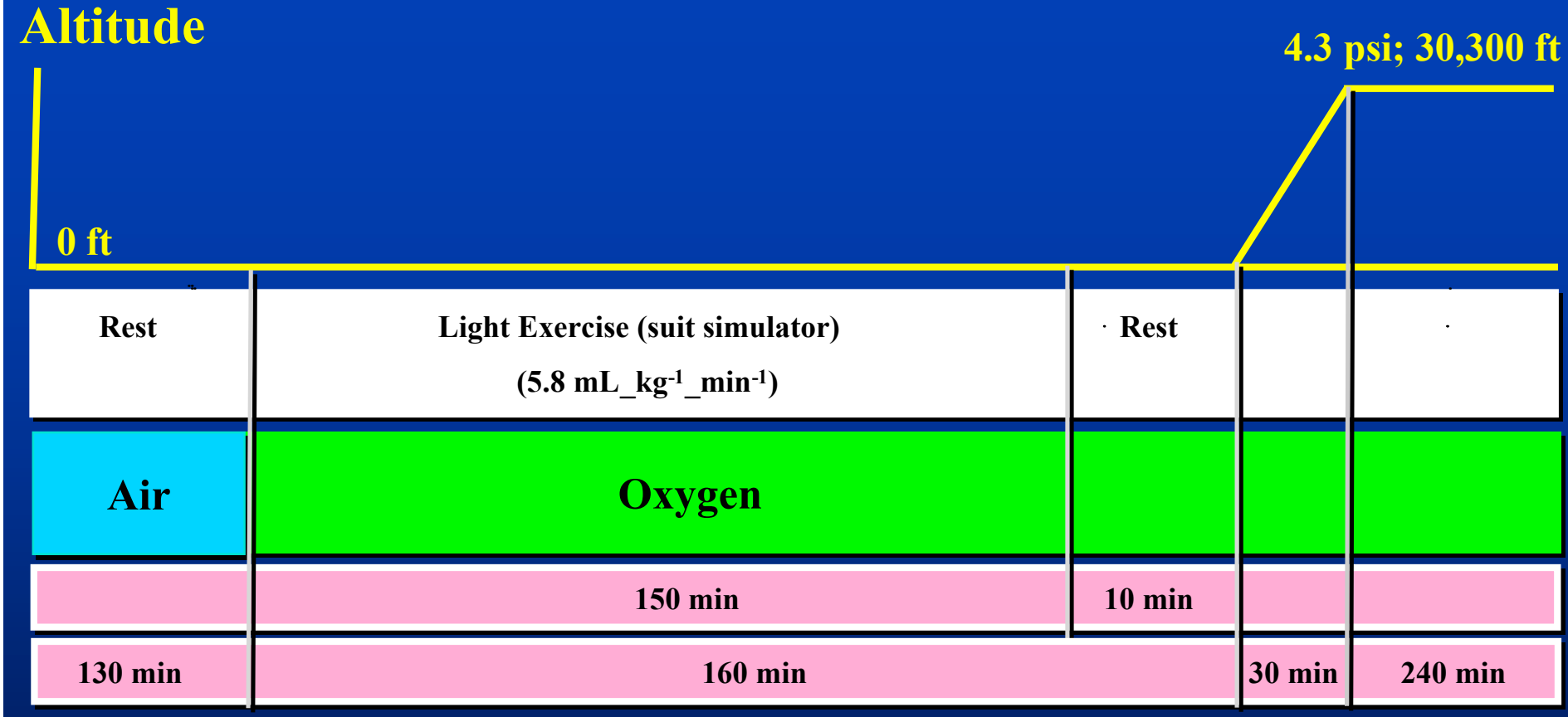
INTRODUCTION

- Extravehicular activity (EVA) requires decompression from 14.7 psi ambient pressure to a 4.3 psi spacesuit pressure
- Standard NASA protocols required a 4 h resting oxygen prebreathe preceding decompression to eliminate inert gas and avoid DCS
- The Prebreathe Reduction Program (PRP) incorporates exercise during oxygen prebreathe to reduce the necessary prebreathe time
- Initial testing produced an ergometer-based protocol
  - used successfully for 42 spacewalks
  - ergometer failures on orbit have threatened effectiveness

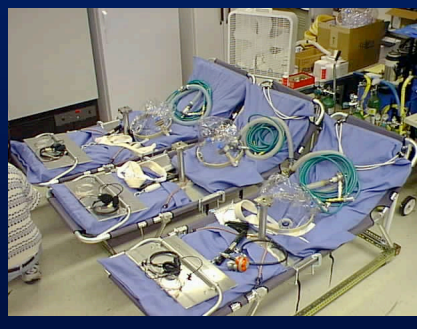
PRP PHASE V GOAL

- To develop an exercise protocol to be carried out within the spacesuit, eliminating the need for an exercise ergometer

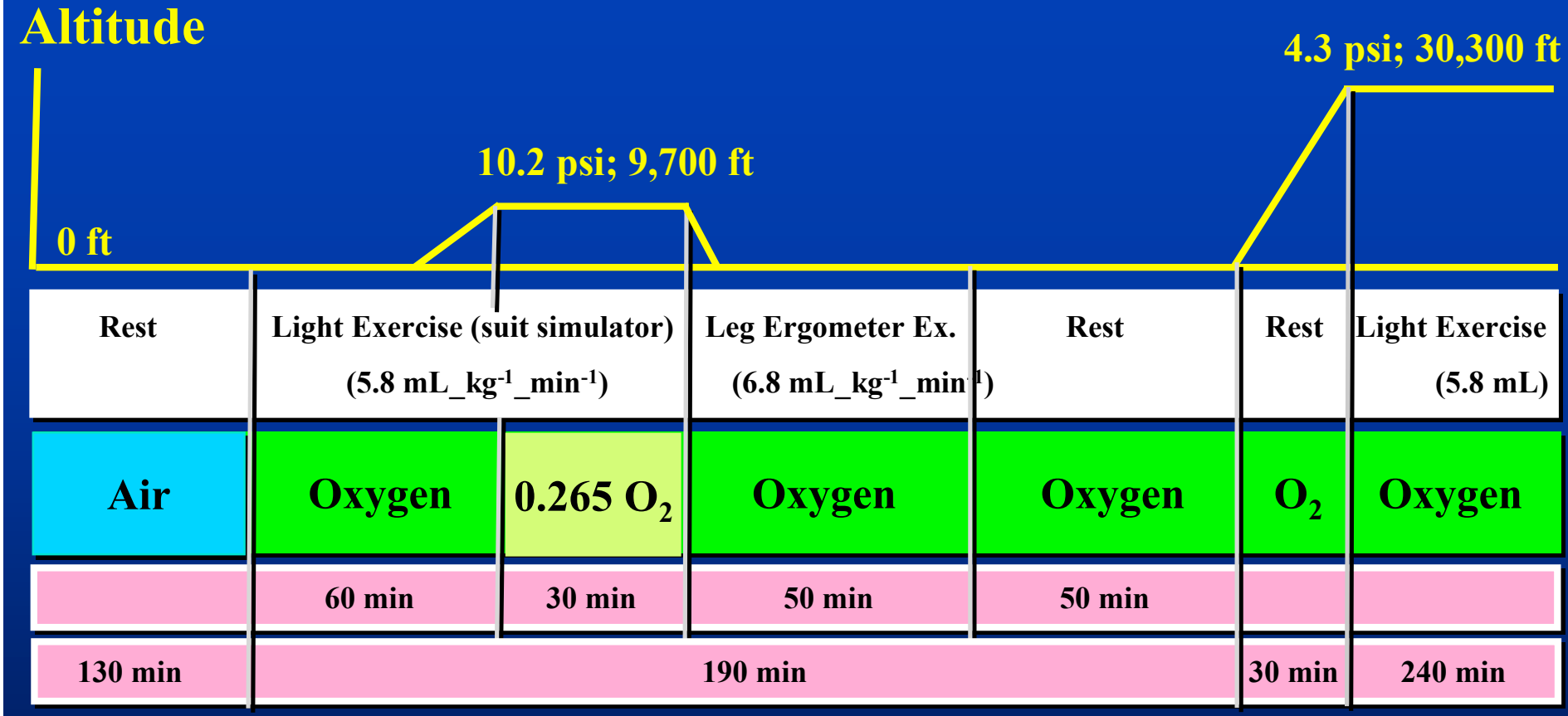
PRP PROTOCOL V-4



- 160 min prebreathe with 150 min of continuous ILE
- Entire protocol completed at 14.7 psi
- Total VO_2 905 mL·kg^{-1}; all upper body exercise
- 10 min of rest preceded depress to 4.3 psi



PRP PROTOCOL V-5



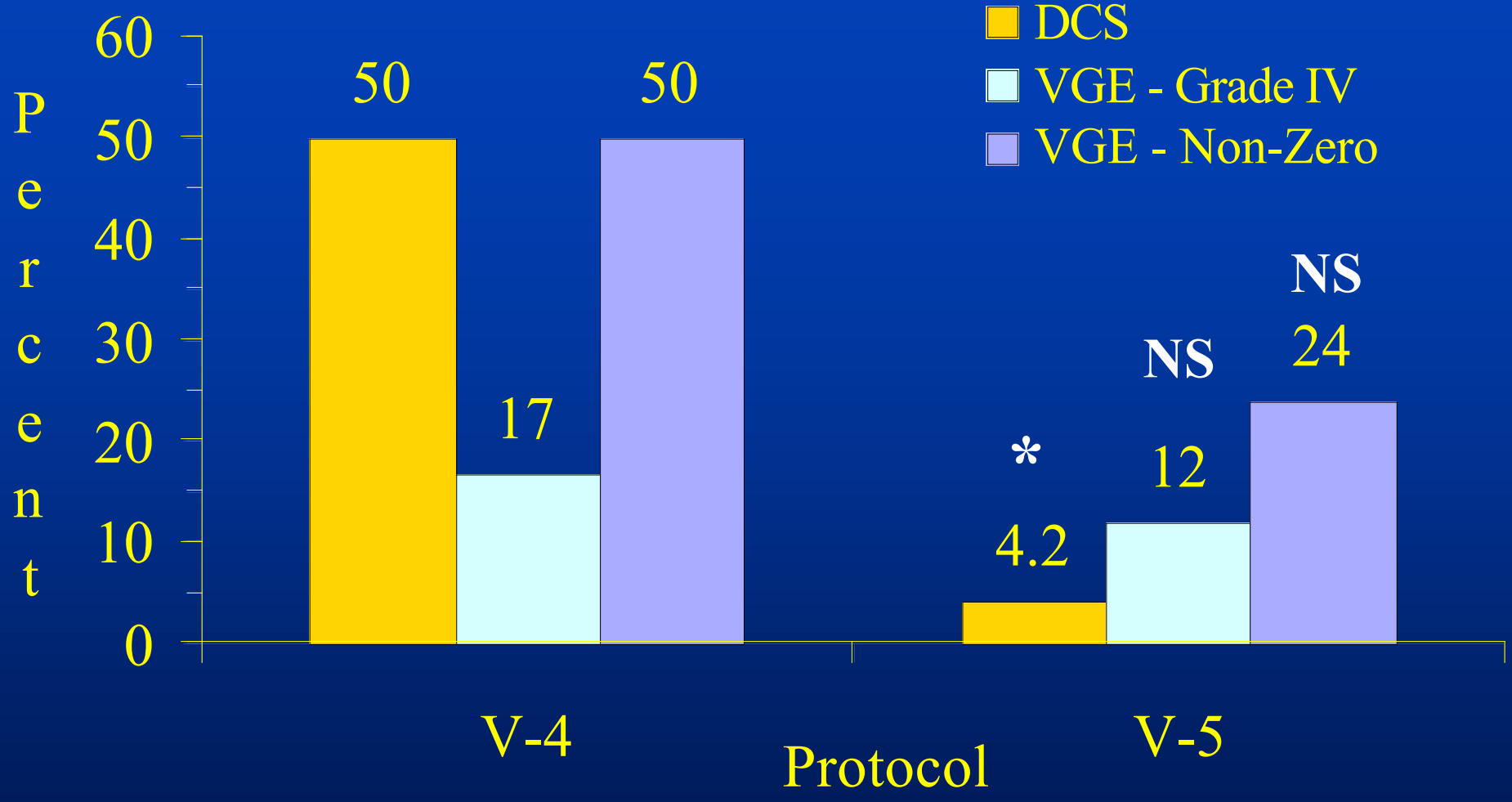
- 160 min prebreathe with 140 min of ILE
- Included transient depress to 10.2 psi
- Total VO_2 863 $mL \cdot kg^{-1}$; 51% upper / 49% lower body exercise
- 50 min of rest preceded depress to 4.3 psi

METHODS

- Accept/Reject criteria for protocol testing
  - **Accept if**
    - DCS ≤15% and Spencer Grade IV VGE ≤20%, at a 95% confidence level
      - minimum 50 person-trials
  - **Reject if**
    - DCS >15% or Grade IV VGE >20%, at a 70% confidence level; any neurological DCS

- Differences in DCS and VGE incidence were assessed through non-parametric Fisher Exact test statistics
  - significance accepted at $p<0.05$

RESULTS



Percent of DCS and Grade IV VGE in V-4 (n=6) and V-5 (n=24) trials (statistical contrasts between protocols: Fisher Exact * = $p<0.05$; NS = non-significant)

DISCUSSION (1)

- V-5 differed from V-4 in several ways
  - 10.2 psi depress component vs. all at 14.7 psi
  - 49% intentional lower body exercise vs. 0%
  - 50 min post-exercise rest prior to final depress vs. 10 min
- V-5 produced less DCS than V-4
  - despite a 5% lower total VO_2
    - 863 vs. 905 $mL \cdot kg^{-1}$
- Factors other than total oxygen consumption are necessary to explain these observations

DISCUSSION (2)

- Logistic regression analysis of all PRP data shows that both the 10.2 psi depress/repress and post-exercise rest significantly improve model predictions and reduce decompression stress
- Involvement of gas phase or nucleation-related mechanism(s) beyond inert gas elimination kinetics is likely
  - microbubble expansion/compression effect?
  - rest effect?
  - lower body exercise is a confounder

CONCLUSIONS

- The V-5 protocol produced significantly less DCS than the V-4 protocol during human trials in a hypobaric chamber
- Our data suggest that the difference could be attributable to a gas phase or nucleation mechanism, although the use of lower body exercise is a confounding variable
- Trials will continue until point of acceptance or rejection is reached