Reply to Böning, Maassen, and Pries

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TO THE EDITOR: We appreciate the comments made in the letter by Böning et al. (4). We reply to these point by point.

1) The main part of optimal hematocrit theory as we reviewed it in our paper (8) does not consider the diameters of blood vessels. Some calculations do consider this effect, such as those by Pries et al. (6), as we had mentioned. Of course, the theory can be extended and refined in various directions. However, to make the main point, that is, to explain the observed hematocrit value of ~40–45% in many animals, the effect of vessel diameter is not necessary.

2) The (basic) optimal hematocrit theory indeed says that the optimal hematocrit value would be independent of altitude. We are grateful for drawing our attention to the fact that Tibetan and Ethiopian highlanders have barely elevated hematocrit values. In fact, this is in agreement with that theory. These populations have other means of increasing oxygen uptake to adapt to high altitudes, such as a thin-walled pulmonary vascular tree (2). The question why Andean and European populations at high altitudes do have increased hematocrit values requires further studies.

3) Several factors such as physical exercise could not be covered in our paper (8) because of space limitations. The observations of increased erythrocyte counts mentioned by Böning et al. (4) are somehow similar to effects observed in blood doping, implying both physiological advantages and risks. Again, further studies are needed to elucidate these effects. The question arises in how far experiments in perfused muscle are meaningful for the in vivo situation. A further effect worth mentioning is the compression of blood vessels by muscle activity, which first reduces and, thereafter, increases the vessel volume in the muscle (1, 5). Still another effect may arise from domestication—the observation that horses and dogs are natural blood dopers mentioned in Böning et al. (3, 4) should be checked in wolves and Przewalski’s horses.

4) As we mentioned in (8), the increase in hematocrit at higher altitudes in mountainers is partly attributable to a decrease in the amount of blood plasma. This is caused by dehydration and a shift of intravasal fluid to the interstitial space (7). Similar effects can occur during physical exercise. Water loss from the whole body and the compression of blood vessels in the muscle may lead to the above-mentioned shift of intravasal fluid. Thus the concomitant increase in hematocrit does not necessarily imply that the human hematocrit value at rest would not be optimal for exercise.

5) We completely agree that systematic errors in blood sampling attributable to experimental conditions are a further cause for variations. This should be reduced in future measurements as much as possible. Thus the compilation of values in our paper (8) may be helpful in deciding in which species a validation is recommendable.

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS
Author contributions: H.S. and S.S. edited and revised manuscript; H.S. and S.S. approved final version of manuscript.

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