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Comments on 'The Effect of Training Type on Oxidative DNA Damage and Antioxidant Capacity during Three-Dimensional Space Exercise'

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Dear Sir,

In a recent edition of *Medical Principles and Practice*, Kim et al. [1] presented data about the effect of orbotron training on plasma malondialdehyde and lactate content, and erythrocyte superoxide dismutase (SOD) activity. The findings about SOD activity changes are most surprising. Results presented in table 2 and figure 1c show that erythrocyte SOD activity more than doubled (212–251% increase) when the participants in the study were subjected to intense orbotron exercise, even after 9 months of training. Those values rapidly dropped after only 30 min of recovery. Such dynamics are highly unexpected in view of the fact that SOD activity is expressed in units per gram of hemoglobin, which accounts for hematocrit changes; CuZnSOD, the only isoform present in mature erythrocytes, is not post-transcriptionally regulated [2], and mature erythrocytes cannot synthesize new proteins. The modest increase in erythrocyte SOD activity after 9 months of training can be explained by hemolysis of the older red blood cells (RBCs), which have lower SOD, and their replacement with younger ones containing more SOD [3, 4]. Investigations show that older RBCs are more prone to hemolysis [5, 6], and lyse more during exercise [7]. This, however, does not explain why an exercise after 9 months of training more than doubled RBC SOD activity, and even less, why 30 min later, SOD activity drops so dramatically. Activation of erythrocyte SOD by micromolar H_2O_2 concentrations, which could eventually explain the increase in SOD activity during exercise, has been reported earlier [8], but this report contradicts other investigations [9] and data obtained in vivo [10–12]. Furthermore, the procedure used to prepare the erythrocyte samples for the SOD activity assay [1] rules out the presence of H_2O_2. Unfortunately, the 'Subjects and Methods' section does not describe what method was used to determine SOD activity. The 'Discussion' in turn does not address the surprising dynamics of the SOD activity. On the contrary, it contains statements that are completely wrong. For example, 'However, because it is dismutated by the antioxidant defense system, SOD is present in tissue to convert O_2^- to H_2O_2 and H_2O_2 to H_2O and O_2'. First, 'dismutation' is the conversion of $O_2^{\cdot -}$ to H_2O_2 and O_2. Second, SOD does not convert H_2O_2 to H_2O and O_2 [9, 13]. In fact, CuZnSOD displays modest peroxidase activity [14], but this does not mean that it decomposes H_2O_2 to H_2O and O_2. Third, reference 14 in the paper by Kim et al. does not support the above-listed statements of the authors.

Performing experiments in vivo and interpreting data requires knowledge and understanding of the processes at the molecular level. Lack of such knowledge and understanding leads to publications containing results, which if not absurd, should be classified at least as paradoxical. Such publications, lacking critical analysis and logical explanation of the data, mislead the scientific community and open the door for the publication of other erroneous results.

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Reply

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We would like to express our heartfelt thanks to Prof. L. Benov for his interest in and comments on our paper, 'The Effect of Training Type on Oxidative DNA Damage and Antioxidant Capacity during Three-Dimensional Space Exercise' [1]. First, he questioned the increase in erythrocyte superoxide dismutase (SOD) activity, which increased at least twice immediately after Orbotron exercise and dramatically decreased just 30 min after recovery. As a matter of fact, we never expected such a result, and thus do not clearly understand its mechanism. In any case, we frankly admit that our study was a limited preliminary one and that selection bias might have affected the outcome. Nevertheless, it was our view that, given the fact that all subjects who participated in Orbotron exercise showed a similar trend in the changes of SOD activity, it may not be advisable to dismiss the results as a chance effect, and hence it was thought that there must be a cause for the changes in SOD activity. As Prof. Benov mentioned, it is illogical to relate such changes to gene expression, inasmuch as erythrocytes' nuclei are removed by denucleation after they have matured. What should not be overlooked is that the study pertained to subjects who were aviation cadets receiving special military training and three-dimensional space exercise, which is quite unlike the two-dimensional exercise that has been dealt with in previous studies [2]. Based on these facts, a hitherto unknown physiologic change may have occurred. Although we do not know of a clear mechanism, we assume that some form of allosteric changes might have occurred at the protein level, or SOD activity might have changed due to a post-translational modification that has so far been unknown [3]. To find the mechanism that changes SOD activity, a further study needs to be conducted on more subjects, in which the effect of chance may be minimized. In addition, the study should be performed at the molecular level in order to find out why SOD activity has changed. The plain fact is that well-trained aviation cadets can cope very well with oxidative stress caused by three-dimensional space exercise and become physiologically adapted to it.

Prof. Benov wondered how we measured erythrocyte SOD activity. Put simply, first, the whole blood collected from the peripheral veins of subjects was placed into a heparinized Vacutainer and the amount of hemoglobin was measured and recorded. Then, 1 ml of whole blood was mixed with 0.85% sodium chloride (NaCl), centrifuged at 3,000 rpm for 10 min, and the supernatant was separated. This process was repeated 4 times. Next, cold distilled water was added to the mixture so that the total volume became 2.0 ml and this was then incubated at 4°C for 15 min. Finally, it was diluted 25 times using 0.1 mmol/l of the phosphate buffer, and analyzed using the autoanalyzer Cobas Mira (Roche Co. Ltd., Switzerland) [4].

Regarding the statement, 'CuZnSOD displays modest peroxidase activity, but this does not mean it decomposes H_2O_2 to H_2O and O_2' [5, 6], it is widely known that catalase is the enzyme that decomposes H_2O_2 into H_2O and O_2. We did not mean to suggest that SOD had catalase activity, but that SOD and catalase might be in the same region of the body. For example, it is known that both SOD and catalase are present in the liver [7].

Lastly, regarding in vivo experiments, Prof. Benov emphasized the importance of knowledge and understanding of the process at the molecular level. We are entirely in agreement with this observation, and this advice has made us review our study. However, our aim was to suggest that it might be advisable to perform a study of the physiological status, as its results could provide valuable insights that may lead to further studies. May we point out that there are many cases where physiological studies are more suitable than studies at the molecular level because of the expense and time involved, and thus we reckon that it would be appropriate to commence a study from the physiological perspective and later devise a study that would lead to an understanding of the molecular level. Of course, we do not mean to refute Prof. Benov's opinion that in the case of in vivo experiments, previous knowledge and understanding of the process at the molecular level are very important. As mentioned above, we are entirely in agreement with our colleague's advice, which is wise and merits consideration. We acknowledge that the remarks of Prof. Benov motivated us to review the limitations of our study and are grateful for his observations.

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