In a previous paper we pointed out that while it was often assumed that the iron enzymes were "inviolate" in iron deficiency, this view was unsupported by any acceptable experimental evidence. Indeed, it was possible to demonstrate that in rats rendered iron deficient by a combination of bleeding and iron-poor diet, the cytochrome C content of the liver and kidneys was diminished markedly (1). As yet, these studies have not been extended to human subjects because of the difficulty in obtaining sufficiently large samples of cytochrome-containing tissues. However, another iron enzyme, the heme-protein complex catalase, is readily available for study in the red blood cells of patients, and it seems surprising that more attention has not been paid to this easily obtained and easily measured enzyme in the iron-deficiency state. A few measurements have been made of catalase activity in the organs of iron-deficient experimental animals and these have yielded contradictory results (2, 3). Studies in man have been limited in scope and have yielded difficult-to-interpret and inconclusive results. It is usually unclear whether the patients who were studied were iron-deficient or not (4-11). Furthermore, in nearly all instances the method of catalase estimation is clearly invalid; a catalase index was calculated by dividing the number of milligrams of peroxide destroyed in a fixed period of time by the red blood cell count. Since the destruction of \( \text{H}_2\text{O}_2 \) by catalase is a first order reaction, the quantity of \( \text{H}_2\text{O}_2 \) that has been decomposed at any given time is not a linear function of the amount of enzyme present. In addition, the incubation times used, up to two hours, were so long that virtually all the peroxide was destroyed, and the quantity of enzyme was no longer an important limiting factor in the reaction.

The study described in this paper was undertaken to clarify the effect of iron deficiency on catalase activity in the red blood cells of man.
lase activity of normal red cells was $65.9 \pm 2.5$ Kat $F_{(V)}$ units while that of iron-deficient red cells was $64.0 \pm 3.2$ Kat $F_{(V)}$ units. When expressed as catalase activity per $10^9$ red cells, however, the catalase activity of the red cells of the iron-deficient subjects was somewhat reduced. The degree of reduction of catalase activity was related to some extent to the severity of the iron deficiency as judged by the patient's hemoglobin level (correlation coefficient equals $+0.20$). This is simply a reflection of the microcytosis of the red cells in iron deficiency. The mean catalase of normal red cells was $60.4 \pm 2.1$ Kat $F_{(B)}$ units while that of iron-deficient cells was $54.8 \pm 3.0$ Kat $F_{(B)}$

units. When the catalase activity was expressed as activity per Gm. of hemoglobin, a substantial increase in catalase activity in the iron-deficient as compared with the normal group was observed. The increase was inversely proportional to the hemoglobin level of the patient's blood (correlation coefficient equals $-0.60$). This finding is a reflection of the reduction of hemoglobin concentration of the red cells which occurs in iron-deficiency anemia. The mean catalase activity of normal red cells was $198.2 \pm 6.8$ Kat $F_{(H)}$ units while that of iron-deficient red cells was $241.4 \pm 13.0$ Kat $F_{(H)}$ units.

No significant sex difference in red cell catalase activity of normal red cells was $65.9 \pm 2.5$ Kat $F_{(V)}$ units while that of iron-deficient red cells was $64.0 \pm 3.2$ Kat $F_{(V)}$ units. When expressed as catalase activity per $10^9$ red cells, however, the catalase activity of the red cells of the iron-deficient subjects was somewhat reduced. The degree of reduction of catalase activity was related to some extent to the severity of the iron deficiency as judged by the patient's hemoglobin level (correlation coefficient equals $+0.20$). This is simply a reflection of the microcytosis of the red cells in iron deficiency. The mean catalase of normal red cells was $60.4 \pm 2.1$ Kat $F_{(B)}$ units while that of iron-deficient cells was $54.8 \pm 3.0$ Kat $F_{(B)}$ units.

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activity was observed in the small number of samples that was studied.

**DISCUSSION**

It is apparent from these studies that even under conditions of severe iron need, the concentration of catalase in human red cells remains normal. If it is true, as has been suggested by Theorell, Beznak, Bonnichsen, Paul, and Akeson (13), that catalase and hemoglobin derive their heme groups from a common source, then it would appear that the catalase synthesizing mechanism has more success in competing for the limited amount of available heme than has the hemoglobin synthesizing mechanism. This would appear to be the reverse of the situation with cytochrome C, where it has been shown that the hemoglobin of iron-deficient animals returns to normal values while the cytochrome C content of liver and kidney is still very low (1).

**SUMMARY**

The catalase activity of the red cells of 9 normal subjects and 11 subjects with iron-deficiency anemia has been determined. Iron deficiency produced no change in the catalase activity per milliliter of red cells. Therefore, there was a slight decrease in catalase activity per $10^{10}$ red cells and a well marked increase in catalase activity per Gm. of red cell hemoglobin, reflecting the microcytosis and hypochromasia which occur in iron-deficiency anemia. These findings indicate that the mechanism synthesizing red cell catalase is more successful in competing for a limited quantity of iron than is the hemoglobin synthesizing mechanism, when only a small quantity of iron is available.

**REFERENCES**