ATTEMPTS TO CORRECT SWIMMING ERRORS

by

S. M. Luria, Ph. D.

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R. A. Margulies, CDR MC USN
Commanding Officer
NavSubMedRschLab

THE PROBLEM:

To test procedures that will elucidate the cause of directional errors in swimming under conditions of low visibility and that may reduce swimming errors.

FINDINGS:

Adjustments in the swimfins did not reliably affect performance with a snorkel on the surface, and a rudder on the SCUBA tank did not reliably improve accuracy under water.

APPLICATIONS:

The results fail to support several proposed explanations of swimming errors.

ADMINISTRATIVE INFORMATION

This investigation was conducted under Naval Medical Research and Development Command Research Work Unit M0099-PN. 003-9016 -- "Improvement of Diver Orientation under Conditions of Poor Visibility in the Water". It was submitted for review on 8 November 1978, approved for publication on 5 January 1979 and designated as NavSubMedRschLab Report No. 886.

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ABSTRACT

Blindfolded divers, using either snorkels or SCUBA gear, when attempting to swim a straight line, tend to make a consistent error either to the right or to the left of their intended target. Attempts were made to correct for this veering tendency by (1) reducing the area of one of the swimfins, and (2) by attaching an adjustable rudder to the SCUBA tank. Swimming accuracy was not reliably improved in 5 subjects by either method. The results argue against several proposed explanations of swimming errors.

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INTRODUCTION

When SCUBA divers or swimmers snorkeling on the surface cannot see where they are swimming, most tend to veer off their intended course in a rather consistent manner (Luria, 1978). Although roughly half the divers tend to veer to the right and half to the left, the same direction of error tends to be exhibited by a given diver in a variety of maneuvers. What causes the turning error is not clear. The errors do not correlate with either preferred hand or foot, or with the relative strength of the legs (Luria, 1978). Other explanations that have been proposed include differences in the length of the legs, and the tendency of the diver to favor one leg for kicking. Whatever the explanation, since a given individual tends to make a consistent error, it would seem to be possible to correct for that error by introducing some variable which would tend to induce an error in the opposite direction.

Two attempts are described in this report. In addition to attempting to correct the swimming errors, they also have a bearing on the validity of several of the proposed explanations for the errors. The first was to equip the swimmer with unequal swimfins so as to produce unequal thrusts in the two legs. Second, a rudder was attached to the SCUBA tank.

METHOD

Apparatus - The subjects began their trials wearing standard swimfins, about 45 cm long from heel to tip, and about 23 cm at the widest part, with three "Venturi" holes just beyond the end of the foot. To reduce the force exerted by a fin, about 3.5 cm was cut from the end of one of the fins, and a 3.5 cm square was cut from the center of that fin as well. The trimmed fin could be worn on either foot, of course. The trimmed fin is shown with its standard mate in Figure 1.

The rudder which was attached to the SCUBA tank is shown in Figure 2. Its overall length is 62 cm, and its maximum height is 25 cm. The adjustable section at the rear measures 20 x 25 cm. That section could be set at an angle of 0, 10, or 15° to either side with respect to the fixed portion.

The divers wore a standard facemask which was completely blacked out.

Procedure - The experiment was conducted in an indoor swimming pool, 10 x 25 m. The subjects, wearing the opaque facemask, attempted

to swim a straight line the length of the pool. Each subject was first tested with standard swimfins and a snorkel to determine the direction and consistency of his swimming error. Next a series of runs with snorkels was carried out on the surface with the trimmed swimfin. After the snorkel trials, the subjects donned SCUBA gear. Again they were first tested for accuracy and consistency, after which they swam with the rudder attached to the tank, wearing standard swimfins. The effect of unequal swimfins was tested primarily on the surface, and the effect of the rudder was tested only with SCUBA gear. In addition, however, one SCUBA diver was tested with unequal swimfins.

Subjects - Four Navy divers were tested in the snorkel runs on the surface. Three of these also had time for the SCUBA tests. Another diver then volunteered for the SCUBA tests to bring the number of subjects in each phase of the experiment to four, and the total number of subjects to five.

RESULTS AND DISCUSSION

Figure 3 shows the results of the various procedures which were attempted with the snorkelers on the surface. The first column shows the tracks made with the standard swimfins as the subjects tried to swim a straight line. The first 5 runs for Subject A were the initial determination of direction and consistency of error. In every case, A swam to his right. On the assumption that he was exerting too much force with his left leg, the trimmed swimfin was put on the left foot. In the first three runs in the second column, he now made errors to the left. Following this, four runs with the standard fins were repeated (6 to 9 in column one), but these were no longer consistent. Next, three runs made with the trimmed fin on the left foot resulted in two errors to the left and one to the right. Two more runs with the standard fins (10 and 11 in column one) resulted in one error to each side. Next, five runs were made with the trimmed fin on the left foot resulting in two errors to the left, two errors to the right, and one accurate run.

Next, three runs were made with the trimmed fin on the right foot, resulting in one accurate run, one slightly to the left, and one large error to the left. Since subject A tended to make errors to the right with standard fins, it was expected that with a trimmed fin on the right foot these errors to the right would be exaggerated. When they were not, one last run was made with the subject wearing one standard fin, only on the left foot. This resulted in an accurate run. The results of subject A lead to the conclusion that the swimfins have little effect on swimming accuracy.

The second subject, B, swam to his left on the initial trials, and he did so again regardless of whether the trimmed fin was on his right or left foot.

The same results were obtained for subject C, who also persisted in swimming to his left regardless of the placement of the fins.

Finally, subject D tended to swim to the right on most runs with standard fins or with a trimmed fin on either the right or left foot.

Figure 4 shows the results with SCUBA gear. Subject A swam to his left on three out of four attempts, although he had tended to swim to his right with the snorkel. (This conformed with his previous performance with SCUBA gear in the previous investigation.) When the rudder, with no angle, was attached to the SCUBA tank, he again swam to his left. With a 15° angle to the right on the rudder, he swam to his right three out of four times. With a 10° angle to the right, he was essentially accurate three out of four times. To ensure, however, that it was the rudder which was producing the accurate runs, he was again tested without the rudder and made two more accurate runs. It is, therefore, impossible to conclude that the rudder, and not practice, improved his performance.

Subject B again tended to swim to his left as he had done with the snorkel. A 0° rudder produced two runs which were much more accurate. A 15° right rudder produced two runs to the right following one accurate run and a run to the left.

Subject C tended to go to his right with the SCUBA gear. Three runs with a 0° rudder produced every possible result, indicating that the rudder was not reliably affecting his performance.

Finally, subject D consistently swam to his right. Neither a 0° rudder, a 15° left rudder, not any manipulations with the swimfins effected any changes.

These results indicate that neither the geometry of the swimfins nor the rudder has a reliable effect on performance. It is surprising that the performance of a diver swimming blind with only one swimfin is not appreciably different from the performance with both fins. One diver suggested that when one fin is trimmed or absent, the "feel" of that leg is so different from that of the other leg that the diver automatically compensates for the difference in force which he can exert with each leg. Yet presumably the "feel" cannot be experienced until the kick has been executed and the damage to performance done.

It is also somewhat surprising that the rudder had so little definite effect. The rudder is relatively as big for a man as the rudder of a sailboat, and the mass of the diver is far less than the mass of a boat. Little headway is required to steer a boat, yet the rudder seemed to have little or no effect on subjects A and E and no reliable effect on C. Apparently, whatever causes a diver to veer off course is strong enough to overcome whatever effects the fins and rudder may have.

These results seem to rule out some of the hypotheses which have been put forth to explain the veering tendencies. Lund (1930) has hypothesized that the consistent directional errors are caused by unequal length of the two legs. Since he found differences of only about .5 cm, and since the difference in length between the two swimfins in this study was 3.5 cm, this does not seem to be a likely explanation. Similarly, the hypothesis that the errors are caused by unequal strength in the legs (Thompson, 1942) does not seem likely, since more force can presumably be exerted with the untrimmed fin.

Christianson et al. (1965) have suggested that a diver may favor one leg for kicking independent of which leg is actually stronger. But the results when only one swimfin was worn argue against that interpretation as well. It is hard to image that a diver would favor the foot that had no fin - or that it would matter if he did.

Ross et al. (1970) have noted two other explanations of swimming errors. Howard and Templeton (1966) suggested that they may be caused by asymmetrics of vestibular functioning, and Gregory and Zangwill (1963) proposed as the cause an imbalance in the kinesthetic senses. These hypotheses are more difficult to test, but the cause of the veering tendencies may have to be better understood in order to correct it.

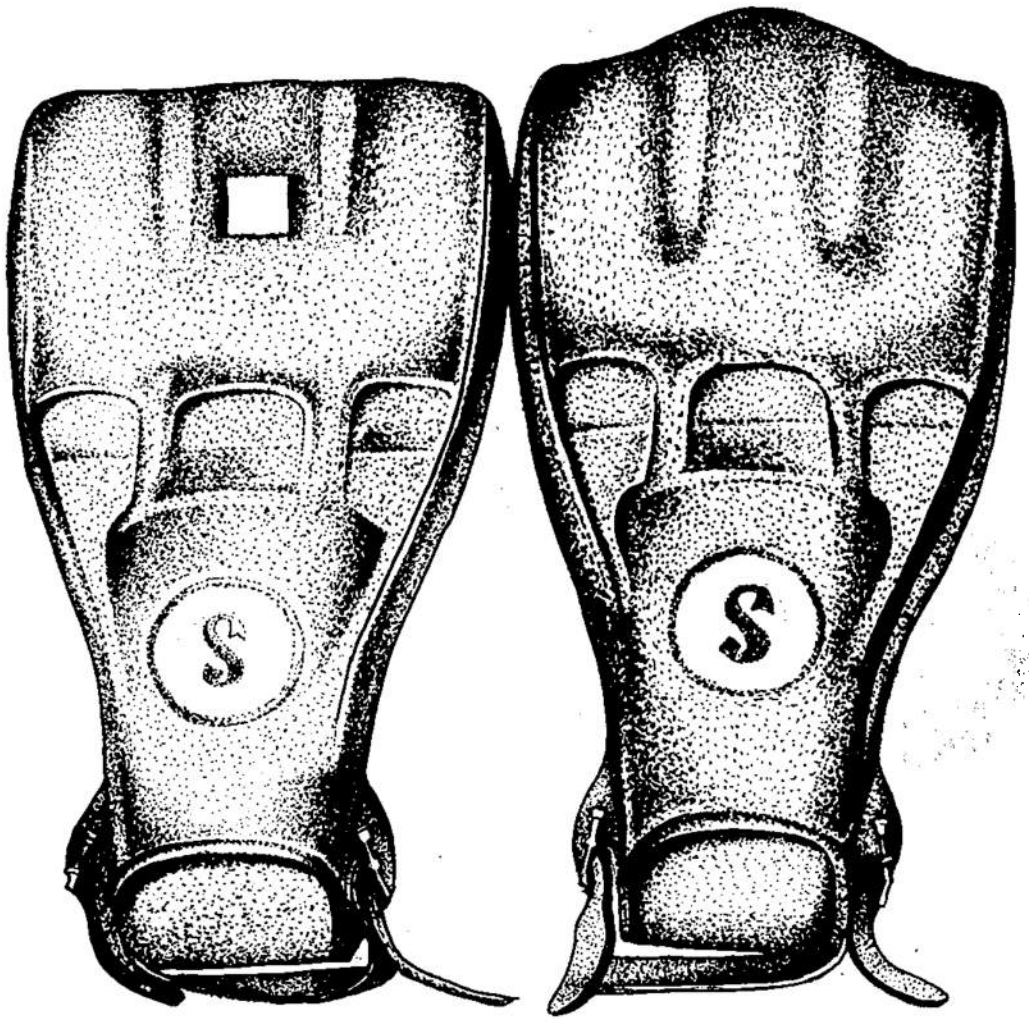

Figure 1

Trimmed swimfin with its untrimmed mate.

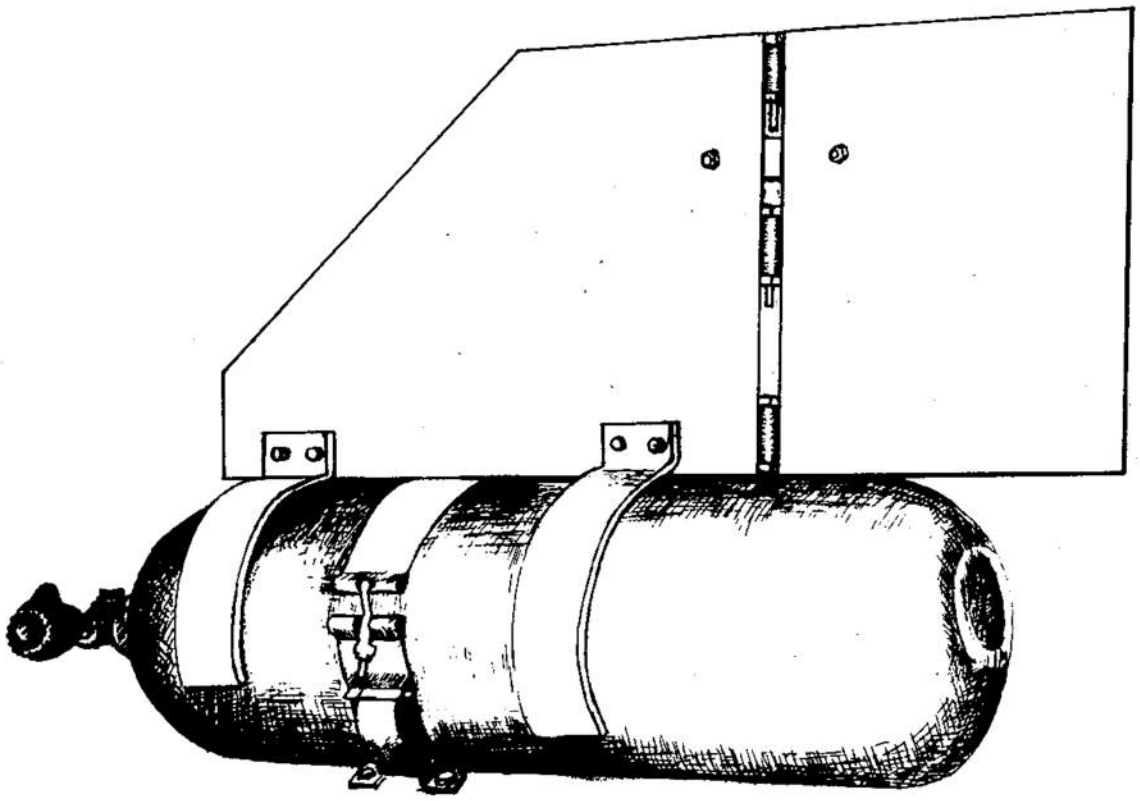

Figure 2

Rudder attached to SCUBA tank. The rear section can be fixed at any desired angle.

Figure 3. The performance of four divers swimming blind on the surface with a snorkel under various conditions. The first column shows their tracks in the swimming pool with standard swimfins. The second and third columns show their courses with the left and right swimfins trimmed, respectively. The fourth column shows the results with swimmer wearing only one standard swimfin.

Figure 4. The performance of four divers swimming blind with SCUBA gear under various conditions. The first column shows their performance with standard SCUBA gear. The second column shows their performance with the rudder, set at 0^{o} deviation, attached to the SCUBA tank. The other conditions are as labeled. (Note that there are seven diagrams for subject D and only two diagrams for subject C.)

SNORKEL

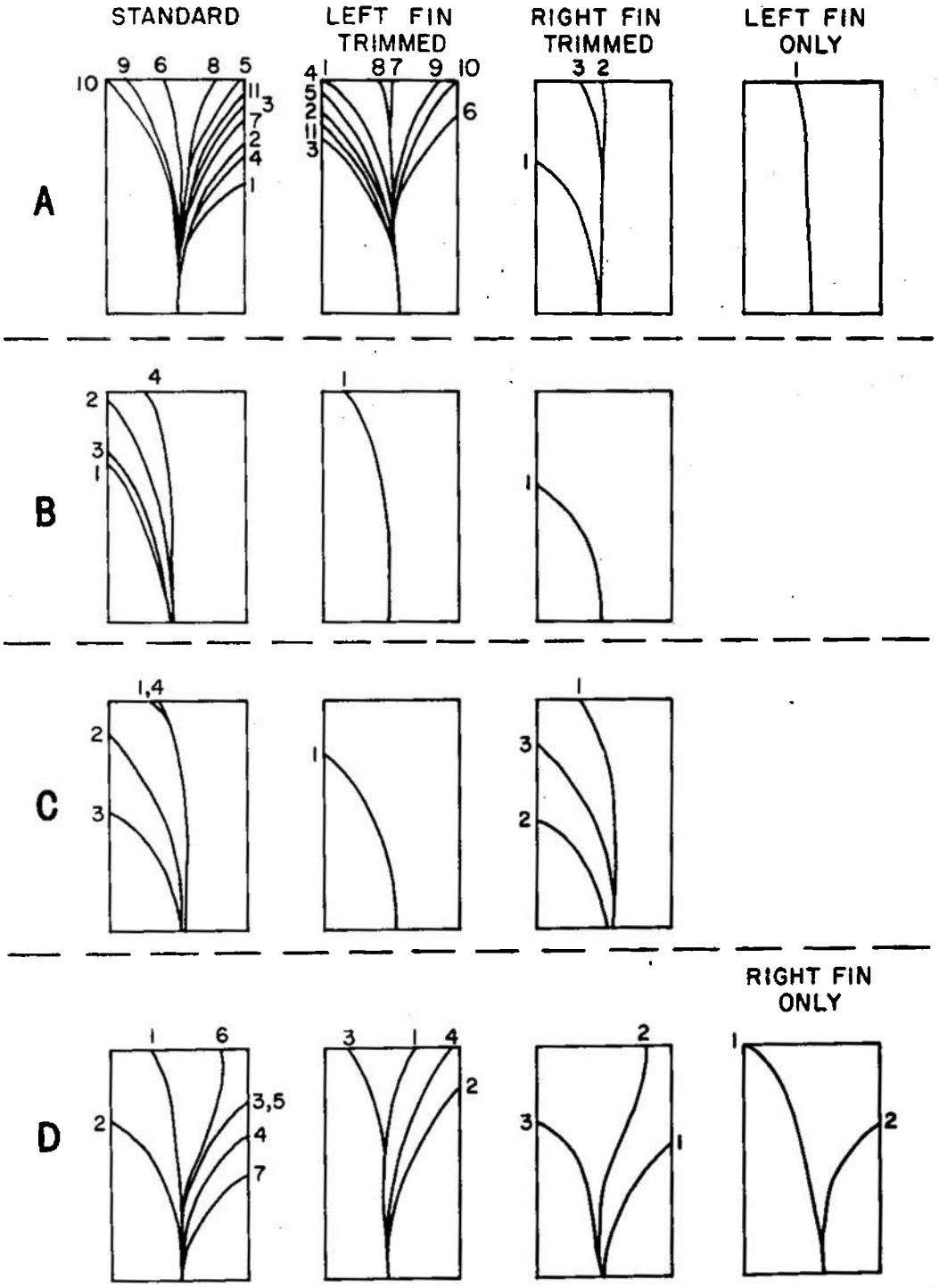

Figure 3

SCUBA

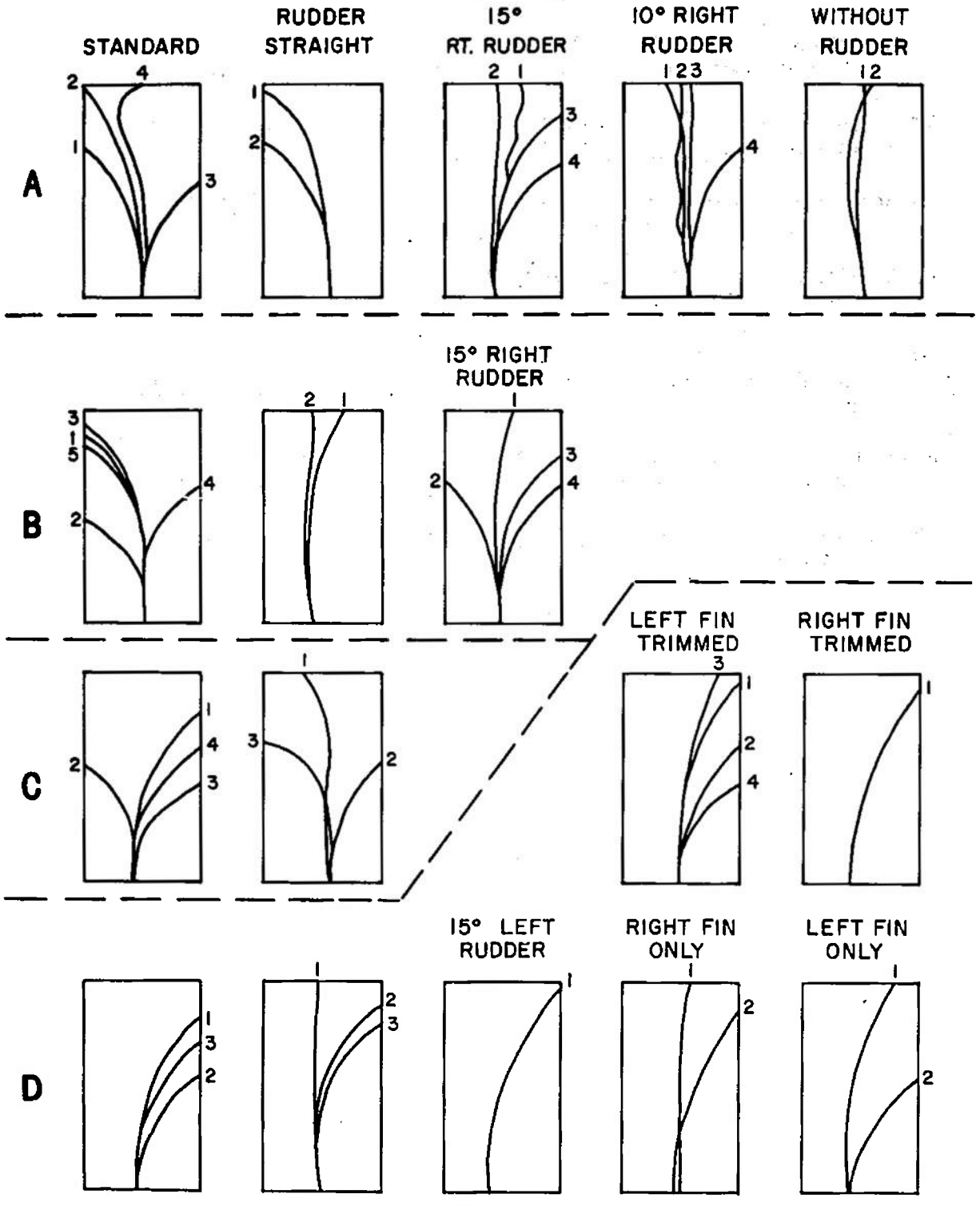

Figure 4

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Blindfolded divers, using either snorkels or SCUBA gear, when attempting to swim a straight line tend to make a consistent error either to the right or to the left of their intended target. Attempts were made to correct for this veering tendency by (1) reducing the area of one of the swimfins, and (2) by attaching an adjustable rudder to the SCUBA tank. Swimming accuracy was not reliably improved in 5 subjects by either method. The results argue against several proposed explanations of swimming errors.

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