A COMPARATIVE STUDY OF TWO TYPES OF BACKSTROKE STARTS IN SWIMMING

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY
WILLIAM M. REA
1973

ABSTRACT

A COMPARATIVE STUDY OF TWO TYPES OF BACKSTROKE STARTS IN SWIMMING

By

William M. Rea

This study was conducted in an attempt to determine which of two backstroke starts is the more advantageous.

The subjects included eighteen high school swimming team members and five members of the Michigan State University swimming team. The coaches of these swimmers were asked to train each subject on the two specific starts. It was suggested that each of the starts be practiced for fifteen minutes after each training session. After a period of six weeks, each swimmer went to Michigan State University to be tested. Each subject performed both types of starts three times while being filmed. A camera was positioned thirty feet above the pool water level so that the swimmer, starter, markings on the pool deck, and starting block could be recorded on film. A cinematographic analysis was conducted to determine how much time, in seconds, it took the swimmer to reach a point twenty feet from the starting end of the pool. The swimmer's velocity also was calculated at that point.

One hundred thirty-eight starts were filmed and analyzed. A two-way mixed-model analysis of variance with equal cell

frequencies was applied to the data to determine if there was a significant difference between the mean elapsed starting times using the two types of starts. The same analysis was used to determine if there was a significant difference between the mean velocities at the twenty-foot mark using the two types of starts.

The following conclusions were drawn from the results:

1. The time it took to reach the twenty-foot mark from the sound of the gun was faster when the subjects performed the modified start.

2. The velocity at the twenty-foot mark was faster when the subjects performed the modified start.

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Health, Physical Education and Recreation

1973

ACKNOWLEDGEMENTS

The writer wishes to express his sincere appreciation to the following people whose invaluable guidance and assistance made this research possible.

Dr. W. W. Heusner

Mr. Richard Fetters

Mr. Scott Soth

Mr. Charles McCaffree

A grateful note is also sent forth to the Michigan State University swimming team and the volunteers from high schools across the state for their cooperation in this study.

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CHAPTER I

INTRODUCTION

Gary Dilley, of Michigan State University, introduced a new type of starting position for the backstroker at the 1966 National Collegiate Athletic Association Swimming and Diving Championships. Since then there have been a few changes in the rules which have made it easier for the backstroker to perform a start similar to Dilley's. Although several swimmers have modified their starts since the 1966 NCAA competition, the question has not been answered as to which type of start is of greater advantage to the backstroker. It is the aim of the writer to answer this question in the following thesis.

There have been few research projects devoted to the backstroke start. Swimming coaches have had to rely on empirical evidence to determine which type of start to teach their backstrokers. Conflicting data have been presented and published on the different types of starts; therefore, further investigation was warranted.

Statement of Problem

This study was conducted in an attempt to determine which of two backstroke starts is the more advantageous.

Hypothesis

The following hypothesis was tested: There is no significant difference between the conventional and modified backstroke starts with respect to velocity and time taken to reach a point twenty feet from the starting end of the pool.

Significance of the Study

The findings of this study should be of considerable value to athletes and coaches concerned with improving the racing start in the backstroke. The writer also hopes to stimulate further study in this area.

Limitations of the Study

1. The writer was not able to be present at all training sessions.

2. All coaches may not have interpreted the instructions as intended by the writer.

3. The findings of the study were limited to the use of only male high school and collegiate swimmers.

4. The use of cinematography for measuring speed and velocity was limited because water splashing hindered the writer in the analysis of the film.

5. The start types were not tested in random order.

Definitions

1. Conventional Start - This starting method is in the form of a deep crouch with the swimmer's feet on the gutter, his hands on the bar attached to the starting block, and his head between his hands. Most of the swimmer's weight is

distributed evenly between his feet and his arms, with his arms flexed and his head and body close to the block. At the sound of the starting gun, the swimmer throws himself backward, releasing his hands and throwing them to the side and overhead, and at the same time extending his legs vigorously into the wall. The body is completely extended with a slight arch as it travels over the water (see Figure 1).

2. Modified Start - This starting method begins with the swimmer standing on the gutter facing the starting block and leaning forward slightly with his hands placed on the front edge of the block. His fingers point to the back of the block, and the heels of his hands are over the front edge of the block. At the sound of the gun, the hands are thrust into the front edge of the block while the knees are slightly bent causing the hips to drop. As his body approaches a position parallel to the water, the swimmer's legs thrust against the gutter to carry him over the water. At the same time, his arms are thrown out to the side, remaining straight and then extending over the head just before entry (see Figure 2).

3. Velocity - The velocity is the speed at which each subject is traveling, measured in feet per second, at the twenty-foot mark.

4. Time - The time used in this study is the elapsed time in seconds from the starting stimulus to the moment at which the subject reaches the twenty-foot mark.

5. Dilley Start - The Dilley start is the same as the modified start with the exception of the hand position before

Figure 1. Starting position for the conventional start.

Figure 2. Starting position for the modified start.

the sound of the gun. The swimmer places his hands on the starting grips provided instead of on the top of the blocks.

6. FINA Start - The FINA start is the same as the conventional start with the exception of the position of the feet before the sound of the gun. The swimmer places his feet against the wall just below the water level. The feet may not be placed on the gutter.

7. NCAA Start - The conventional and the NCAA starts are synonymous.

8. Stand-Up Start - This starting method begins with the swimmer standing on the front edge of the block with his large toe and second toe curled over the edge. He is bent forward from the waist with his hands hanging loosely perpendicular to the water level. At the gun the swimmer swings his arms in a circular motion, drops his head, and dives forward. The arms are swung forward with the legs thrusting into the block forcing the body to extend parallel to the water. Upon entering the water, the swimmer takes one arm pull while turning over on his back (see Figure 3).

9. Rea and Soth Start - The modified and the Rea and Soth starts are synonymous.

Figure 3. Starting position for the stand-up start.

CHAPTER II

REVIEW OF LITERATURE

There have been few articles written which are directly related to the backstroke start in question. The Official National Collegiate Athletic Association Swimming Guide of 1973 (7) dictates the procedure to be followed in performing the backstroke start. Rule 2, Section 1, Article 2, states:

> "In the backstroke start, each swimmer shall line up facing the starting mark with both hands grasping the starting grips (this to include the end of the pool or any part of the starting block) and with both feet in contact with the end of the pool. Upon the command 'Take Your Mark!' he shall assume any desired position which does not remove him completely from the water, nor his hands, nor his feet from contact with the end of the pool. When the starter sees that the swimmers are completely motionless, he starts the race with the Pistol Shot."

Rea and Soth (8) reported on the Gary Dilley start at the 1966 National Collegiate Athletic Association Championship Swimming and Diving Meet. They also conducted a study shortly after the meet using Dilley as a subject. Rea and Soth collected data on four starts of each of the conventional and modified types. Cinematography was used to measure Dilley's elapsed time from the wall to the twenty-foot mark and his velocity at the twenty-foot mark. Data on the four starts of each type are as follows (Table 1).

TABLE 1

DATA IN REA AND SOTH STUDY

	Average time to the twenty-foot mark	Average velocity at the twenty-foot mark
Conventional	2.695 seconds	5.067 ft/sec
Modified	2.519 seconds	5.676 ft/sec

From these data, Rea and Soth concluded that the modified start was faster for Dilley. The authors stated that because of the single subject used and the amount of data collected, the study should not be considered conclusive.

Stratten (10) compared three types of backstroke starts. The experiment tested the hypothesis that the National Collegiate Athletic Association backstroke start is the fastest start. Specifically, the experiment compared the speed with which a swimmer reaches a point twenty feet from the starting block using each of the following three starts: the international rules (FINA) start, the National Collegiate Athletic Association (NCAA) start, and the Dilley start. Thirteen subjects were used in the study with the timing done by stop watches which could time to the 1/100 of a second. Stratten concluded that the NCAA start is faster than the FINA and Dilley starts.

A different type of backstroke start, called the "stand-up start", was introduced by Decker (5) in 1971. This type of start does not comply with any rules for backstrokers at the present time. The author attempted to show that the stand-up start is faster with the hope of possibly influencing the rule makers to change the rules to permit this type of start. A statistical evaluation of the times obtained indicated the existence of a highly significant difference in favor of the standing start in all but the first timing situation. That is, the standing start is not significantly faster until a minimal distance has been covered, at which point the difference in favor of the standing start becomes highly significant. This type of start would eliminate the present controversy over varying types of backstroke start hand grips.

Joseph Scheuchenzuber (9) filmed, with a high speed motion picture camera, 200 time trials of four backstroke start styles (Figure 4). The swimmers were tethered to a timer in order to record their times electronically over a four-meter distance from the starting wall. The total time period for each trial began with the shot of the starting gun and ended as the swimmer reached the four-meter mark. The object of Scheuchenzuber's study was to evaluate the four starts to see if they were equally effective. He concluded that the NCAA start was fastest with the FINA start being the slowest. The two modified positions proved to be slower by .04 seconds. One of these two starts was reported

Figure 4. Starting position for the Scheuchenzuber study.

to be the Rea and Soth start but in viewing Figure 4, the reader can see that the starting techniques are not the same as for that start.

CHAPTER III

PROCEDURES

Selection and Nature of Subjects

Letters were sent to the coaches of the top twenty Michigan high school backstrokers asking for their help and cooperation in a study of the relative effectiveness of two different starts. The modified start was explained in detail and methods of training were outlined. Post cards were enclosed so that each coach could indicate if he would participate and list the swimmers that could be tested. Twenty names were returned and eighteen actually participated.

Five Michigan State University swimming team members also participated. Only two subjects had used the modified start in competition previous to this study. Those two men favored the modified start. The remaining subjects were not sure as to the effectiveness of the new start. All of the subjects were volunteers and all had experience swimming backstroke in competition previous to the study.

Description of the Testing Apparatus

For this cinematographic study, a Bell and Howell 16mm movie camera, a wide angle lens, and tri-X negative Kodak film were used. The speed of the camera was set at 48 frames per second, with the camera stationed thirty feet directly

above a mark twenty feet from the starting end of the pool. The starter was also in the picture so that the flash of the gun, indicating the start of the race, could be photographed. Tape was placed at the edge of the pool at six-inch intervals for a distance of eighteen inches on each side of the twenty-foot mark. All markings were located so as to be recorded on the film.

Preliminary Preparation

Each high school coach was given instructions in the correct way to perform each start. The swimmers were asked to practice the conventional backstroke start for fifteen minutes and the modified start for fifteen minutes three days a week at the end of their daily training sessions. The swimmers practiced both starts for six weeks. The eighteen high school subjects were neither supervised nor observed in practice by the writer. However, the writer did supervise the five college swimmers and was able to correct any problems or misunderstandings about the start.

Administration of the Trials

The study lasted for six weeks. All of the time spent, except the last day, was devoted to training the athletes in performing both the conventional and modified starts. The last day was utilized in testing each subject to obtain the time in seconds it took him to reach a point twenty feet from the starting end and the velocity he had attained at that point. All subjects met at one site and were given as much time as needed to warm up for the testing period. The

subjects performed three conventional starts in random subject order and then in the same order performed three modified starts. Movies were taken of each start for analytical purposes.

Description of Experimental Conditions

The final testing period was performed at Michigan State University's Indoor Intramural Pool. The water temperature was seventy-nine degrees Fahrenheit. The air temperature was a constant eighty-two degrees Fahrenheit. The subjects were provided towels with which to dry off between starts. A thirty-two caliber starting pistol was used to initiate each start. The starter was positioned so that the flash of the gun was recorded by the camera.

Method of Data Analysis

A ball drop was made with an eight-pound rubber diving brick from a height of nine feet. The formula $s = \frac{1}{2}at^2$ (s is distance, a is acceleration due to gravity, and t is time) was used to find the time taken for the ball drop. The value used for acceleration due to gravity was 980.498 centimeters per second, which is the value at the front of the Physics Math Building on the Michigan State University campus. The conversion factor of .03281 was used to change centimeters per second to feet per second.

$t = \sqrt{2s/a}$ (s is 9 feet, a is 32.1661 ft/sec)

$t = .748129$ seconds

It took thirty-four frames for the ball drop; therefore, by dividing t by the number of frames used, it was possible to calculate the number of seconds used per frame of film:

.748129 seconds ÷ 34 frames = .0220 seconds per frame

.0220 seconds per frame = 45.446 frames per second

The time it took each subject to reach the twenty-foot mark was calculated by counting the number of frames from the flash of the gun until the subject's head reached that point. The subject's velocity at the twenty-foot mark was calculated by using the formula velocity is equal to distance divided by time. In this case, the time equals the number of seconds per fram times the number of frames taken to cover a specified distance (eighteen inches on each side of the twenty-foot mark for a total of three feet).

$$v = s \times \frac{1}{\text{seconds per frame}} \times \frac{1}{\text{number of frames}}$$

$$v = \frac{136.338}{\text{number of frames}}$$

A two-way, mixed-model analysis of variance with equal cell frequencies was applied to the data to determine if there was any significant difference between the elapsed starting times of the two types of starts. The same analysis was applied to determine if there was any significant difference in the velocities at the twenty-foot mark between the two types of starts.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The purpose of this study was to determine which of two backstroke starts is the more advantageous. Each of the twenty-three subjects in the study performed three backstroke starts of both types. All one hundred thirty-eight starts were filmed for analysis with a 16mm camera.

Data Analysis

The mean time required for each subject to reach the twenty-foot mark, by start type, was calculated by the use of a CDC 3600 computer. These data are presented in Table 2, which also shows the overall mean time for all starts by type (start 1 - Modified, start 2 - Conventional). The subjects averaged .199 seconds less time to reach the twenty-foot mark when using the modified start than they did when using the conventional start.

The mean velocities by subject and start type are presented in Table 3. The subjects had an average velocity of .907 feet per second faster at the twenty-foot mark when using the modified start than they did when using the conventional start.

A two-way, mixed-model analysis of variance with equal cell frequencies was applied to the data of Table 2 to

TABLE 2

MEAN TIMES IN SECONDS TAKEN TO REACH THE TWENTY-FOOT MARK BY SUBJECT AND START TYPES (1-MODIFIED, 2-CONVENTIONAL)

Subject	Start	
	Modified 1	Conventional 2
1	2.552	2.698
2	2.508	2.632
3	2.640	2.801
4	2.786	2.720
5	2.383	2.691
6	2.412	2.654
7	2.544	2.852
8	2.556	2.845
9	2.552	2.742
10	2.588	2.852
11	2.588	2.882
12	2.383	2.632
13	2.456	2.823
14	2.515	2.742
15	2.662	2.918
16	2.376	2.562
17	2.625	2.632
18	2.500	2.889
19	2.434	2.662
20	2.338	2.596
21	2.508	2.742
22	2.640	2.860
23	2.390	2.706
	2.516	2.716
	$\bar{X}_1$	$\bar{X}_2$

TABLE 3

MEAN VELOCITIES AT THE TWENTY-FOOT MARK BY SUBJECT AND START TYPE (1-MODIFIED, 2-CONVENTIONAL)

Subject	Start	
	Modified 1	Conventional 2
1	5.643	5.259
2	5.616	4.896
3	5.686	4.557
4	5.113	5.248
5	6.205	5.248
6	6.295	5.552
7	6.010	4.656
8	6.305	5.761
9	5.406	5.123
10	5.686	4.596
11	5.762	4.449
12	6.403	4.058
13	6.107	5.080
14	6.123	4.989
15	5.789	4.670
16	6.609	5.844
17	5.541	5.686
18	5.789	4.547
19	6.205	5.434
20	6.600	5.313
21	6.295	5.258
22	5.724	4.547
23	6.205	4.728
	5.957	5.050
	$\bar{X}_1$	$\bar{X}_2$

determine if the observed difference between the average elapsed starting times, using the two types of starts, was statistically significant. The same type of analysis was applied to the data of Table 3 to test the significance of the difference in mean velocities at the twenty-foot mark between the two types of starts.

The analysis of variance table for starting time is given in Table 4. The obtained F-ratio for type of start is highly significant. The null hypothesis is clearly rejected in favor of the modified start. Similarly, the analysis of variance table for velocity is given in Table 5. Again, the obtained F-ratio is significant. The observed mean difference in velocity is significant and in favor of the modified start.

TABLE 4

ANALYSIS OF VARIANCE TABLE (TIME ANALYSIS)

	ss	df	ms	f	p
Type of start	1.3776	1	1.3776	25.44	<.0005
Start x Subject	1.1914	22	.0542		
Subject	1.8096	22	.0822	2.31	.003
Error	3.2733	92	.0355		

TABLE 5

ANALYSIS OF VARIANCE TABLE (VELOCITY ANALYSIS)

	ss	df	ms	f	p
Type of start	28.403	1	28.4013	90.3284	<.0005
Start x Subject	6.9173	22	.3144		
Subject	15.0198	22	.6827	5.1893	<.0005
Error	12.1035	92	.1315		

CHAPTER V

SUMMARY, DISCUSSION AND CONCLUSIONS

Summary

The purpose of this study was to determine which of two different types of backstroke swimming starts is more advantageous. Eighteen high school and five Michigan State University varsity swimming team members participated in the study. Each subject practiced for fifteen minutes three times per week on each of the two starts after their regular workout sessions. At the end of a six-week period, tests were conducted.

Each subject performed both types of starts three times while being filmed. A camera was positioned thirty feet above the pool water level so that the swimmer, starter, markings on the pool deck, and starting block could be recorded on film. A cinematographic study was conducted to determine how much time, in seconds, it took the swimmer to reach a point twenty feet from the starting end of the pool. Also, each swimmer's velocity was calculated at that point.

One hundred thirty-eight starts were filmed and analyzed. A two-way, mixed-model analysis of variance with equal cell frequencies was applied to the data to determine if there was a significant difference between the mean

elapsed starting times using the two types of starts. The same type of analysis was used to determine if there was a significant difference between the mean velocities at the twenty-foot mark using the two starts.

Discussion

The superiority of the modified backstroke start in swimming has been demonstrated in this study. From the review of literature, it is found that seven different backstroke starts have been tested and analyzed. One researcher concluded from his data that the Rea-Soth, or modified, start was slower than the NCAA, or conventional, start. From viewing Figure 4 it can be seen that the true modified start was not used in Scheuchenzuber's study. One difference between the modified start and all other backstroke starts (except the stand-up start) is that the backstroker does not have to change from a pulling action with his arms to a pushing action. The pulling action which holds the backstroker in a position close to the starting block is eliminated in the modified start.

With swimmers becoming faster and faster each year, races in championship meets have become closer. Automatic timers calibrated to .001 seconds and place pickers calibrated to .0001 seconds are required at national and world-class competitions in swimming. State meets and even local A.A.U. swimming meets have used automatic timers with great success. Any start which allows a swimmer to modify his time by even a small amount could make the difference

between success and failure in many championship meets. Therefore, the relatively large observed difference of almost .2 seconds between the conventional and modified starts in this study becomes highly significant.

Conclusions

Within the limitations of this study, the following conclusions can be drawn from the obtained data:

1. The elapsed time it takes to reach the twenty-foot mark is less when performing the modified start than when performing the conventional start.

2. The velocity at the twenty-foot mark is greater when performing the modified start than when performing the conventional start.

Recommendations for Further Study

Further study in this area might be accomplished by the following:

1. Different age groups and members of both sexes should be included in future studies.

2. The heights of the subjects should be included in the data to determine if there is any correlation between the height of the subject and the speed of the modified or conventional starts.

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APPENDICES

APPENDIX A

RAW DATA--ELAPSED TIME OF EACH SUBJECT FROM THE STARTING BLOCK TO THE TWENTY-FOOT MARK*

Subject	First column - start type; second column - start number 1 - Modified; 2 - Conventional 11	12	13	21	22	23
01	2.706	2.332	2.618	2.662	2.750	2.684
02	2.420	2.530	2.574	2.684	2.597	2.618
03	2.706	2.596	2.618	2.794	2.860	2.750
04	2.816	2.794	2.750	2.662	2.728	2.772
05	2.420	2.332	2.398	2.662	2.684	2.728
06	2.398	2.442	2.508	2.728	2.596	2.640
07	2.508	2.530	2.596	2.772	2.860	2.926
08	2.574	2.332	2.464	2.816	2.838	2.882
09	2.376	2.618	2.662	2.816	2.750	2.662
10	2.596	2.662	2.508	2.684	2.904	2.970
11	2.728	2.530	2.508	2.904	2.904	2.838
12	2.376	2.464	2.310	2.574	2.640	2.684
13	2.508	2.486	2.376	2.772	2.816	2.882
14	2.530	2.552	2.464	2.728	2.750	2.750
15	2.662	2.794	2.530	2.860	2.926	2.970
16	2.354	2.442	2.332	2.596	2.574	2.518
17	2.662	2.596	2.618	2.596	2.640	2.662
18	2.664	2.508	2.530	2.882	2.838	2.948
19	2.398	2.464	2.442	2.662	2.750	2.574
20	2.330	2.354	2.330	2.618	2.596	2.574
21	2.486	2.530	2.508	2.750	2.706	2.772
22	2.552	2.574	2.794	2.838	2.882	2.860
23	2.398	2.354	2.420	2.596	2.640	2.882

* All data in seconds

APPENDIX B

RAW DATA--VELOCITY OF EACH SUBJECT AT THE TWENTY-FOOT MARK*

Subject	First column - start type; second column - start number 1 - Modified; 2 - Conventional 11	12	13	21	22	23
01	5.243	4.869	6.817	5.680	5.049	5.049
02	5.927	5.680	5.243	4.398	5.049	5.234
03	5.453	5.927	5.680	4.869	4.260	4.544
04	5.049	5.243	5.049	5.049	5.243	5.453
05	6.197	6.492	5.927	5.243	5.453	5.049
06	6.492	6.197	6.197	5.680	5.927	5.049
07	5.927	6.492	5.608	4.701	4.869	4.398
08	6.492	5.927	6.197	4.869	4.701	4.544
09	5.927	5.243	5.049	5.453	4.869	5.049
10	5.927	5.453	5.680	4.544	4.701	4.544
11	4.869	5.927	6.492	4.260	4.544	4.544
12	6.816	6.197	6.197	5.680	5.680	5.927
13	6.197	6.197	5.927	5.243	5.453	4.544
14	6.197	5.680	6.492	5.049	4.869	5.049
15	5.927	6.197	5.243	5.049	4.260	4.701
16	6.816	6.816	6.197	5.927	5.680	5.927
17	5.927	5.243	5.453	5.927	5.453	5.680
18	6.197	5.927	5.243	4.701	4.398	4.544
19	6.197	6.492	5.927	5.453	5.243	5.608
20	6.816	6.492	6.492	5.243	5.453	5.243
21	6.492	6.197	6.197	5.453	4.869	5.453
22	6.197	5.927	5.049	4.701	4.398	4.544
23	6.492	6.197	5.927	5.243	4.544	4.398

* All data in feet per second

APPENDIX C

NUMBER OF FRAMES CONVERTED TO TIME IN SECONDS

Frames	Seconds	Frames	Seconds
105	2.310	121	2.662
106	2.332	122	2.684
107	2.354	123	2.706
108	2.376	124	2.728
109	2.398	125	2.750
110	2.420	126	2.772
111	2.442	127	2.794
112	2.464	128	2.816
113	2.486	129	2.838
114	2.508	130	2.860
115	2.530	131	2.882
116	2.552	132	2.904
117	2.574	133	2.926
118	2.596	134	2.948
119	2.618	135	2.970
120	2.640	136	2.992

APPENDIX D

RAW DATA--FRAMES CONVERTED TO VELOCITY IN FT/SEC

Frames	Velocity
20	6.816
21	6.492
22	6.197
23	5.927
24	5.680
25	5.453
26	5.243
27	5.049
28	4.869
29	4.701
30	4.554
31	4.398
32	4.260

APPENDIX E

LETTER SENT TO HIGH SCHOOL COACHES

February 14, 1967

Dear Coach,

I hope your boys have been practicing the new backstroke start. If you were here at MSU during the Michigan meet you would have seen Gary Dilley get beat on the start. I hope this did not discourage you because Gary was not performing the start as stated in the paper you received. He was leaning too far back before the gun was fired. Against Indiana Dilley beat Hickocks by about one and a half feet on the start. For this reason and with your cooperation I hope to prove that the start is faster, the same speed or slower.

The date and time that we will be able to use the Men's Intramural pool in the Men's I.M. building has been set at 9:30, Sunday, March 5th, the day after the Big Ten Championships. The building will be closed at that time but you will be able to get in the southwest door by the outdoor pool. Please indicate on the enclosed post card if you foresee any problems with the date and time set aside for the filming of the start. Also, please indicate the names of the boys that will be coming and send the card to me as soon as possible.

Thank you,

William M. Rea III
1619-C Spartan Village
East Lansing, Michigan

P.S. You can read the paper you received in this month's "Swimming Technique." The starting block pictured in that article has been since improved upon to fully comply with the rules.

APPENDIX F

POST CARD RETURNED TO THE AUTHOR BY THE COACHES

Time and Day OK _____

Not OK _____

Backstrokers

1. _____
2. _____
3. _____

Coach _____