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"Does anybody really know what time it is?"

Swimming is not really about knowing what time it is. Competitive swimming is, however, about knowing how much time it takes. And rather than estimating time as we do between lightning and a thunderclap (by counting one thousand one, one thousand two etc.), in swimming, we use sophisticated timing systems that cost several thousands of dollars. A generation ago, we used stopwatches to time a swim race. Today, we use stopwatches only as a back up to the electronic systems and then only when it is absolutely necessary. Can you really run a meet with stopwatches anymore?

The timing problems at FINA 2001 World Swimming Championships in Fukuoka, Japan, last July exemplifies the importance of accurate electronic timing systems. Faulty starting block sensors and touch-pads caused numerous relay disqualifications. This resulted in the removal of the timing system so that engineers could test and analyze how well it actually registered dive reaction times and relay take-offs. This fiasco prompted many swimming officials, coaches, and competitors to question whether or not our current technology is really much better than the trusty stopwatch.

In the vocabulary of science, we would refer to time as the dependent measure in any experiment pertaining to how long something takes. As such, time can be said to be the dependent measure in competitive swimming. Swim meets can be seen as science experiments on a grand scale, in that they are measures of how effective the training program is, a measure of an athlete’s adherence to the training program, and so on and so forth. Time is dependent upon all these variables during a swim race and probably a few thousand other factors as well. It should not, however, be dependent upon our ability to measure time accurately and precisely.

With time playing the most crucial factor in swim performance, it seems incumbent upon the sport governing bodies to initiate institutional changes that guarantee the sport utilizes the best combination of technologies to measure time. They should encourage innovation, and accommodate new technologies to bring the sport technically up to the same level as other sports that regularly use independent testing on all sport related equipment.

Needless to say, the ability to measure time is extremely important in competitive swimming. As the sport of swimming has matured, our athletes have gotten faster and faster as they approach the limits of human performance. World, Olympic, and national records continue to be broken by ever smaller margins. And as this has occurred, the necessary precision of our ability to measure ‘how long it takes’ has had to increase as well. As athletes approach these limits, the inter-individual differences in time become smaller and smaller. Our qualification events for such meets as the Olympic Games becomes increasingly more competitive and the margin of error any given athlete can afford becomes less and less.

Recently, coach Steven Selthoffer of Bonn, Germany (StevenSelthoffer@netscape.net), publicly called for the independent testing of swim timing equipment from all manufacturers. He poses the following questions: Is it possible that a world record on one timing system is not necessarily a world record on another timing system? Is it possible that swimmers missing the Olympic, NCAA, or USA Swimming qualifying times might have been able to achieve their goals had they been timed on a different timing system? Will records be “absolute” world records or “relative” world records, depending on which timing system was in use? The answers to these questions might be no or they might be yes. Who knows? Only time will tell.

Therein lies the problem for competitive swimming. Every scientific instrument needs to be calibrated before and after being used as a means to determine whether or not it is an accurate reflection of the dependant measure in question, namely, time. Oddly enough, there is no protocol for doing so in competitive swimming. Something needs to be done about this.

When records are broken (or not broken for that matter) at any competitive level, it should be a function of the athletes’ effort, training, and talent involved rather than a function of the inaccuracy or unreliability of the timing system. And yet, the one thing that matters most is the one thing we accept with complete blind faith. The next time one of your athletes struggles from the pool and turns to look at the results, perhaps both of you should wonder, “Does anybody really know what the actual time was?”

In this issue of the JSR, you will find a variety of topics. The article by Gould, et al reinforces what Johnny Weismuller’s coach once cautioned others to consider: “above all else, practice sessions should be enjoyable.” Tanner evaluates the claim that races can be won or lost by virtue of the racing start. The next article by Nicolaou, et al further quantifies the effect of wearing wet suits while swimming. Coast, et al describe the surprising benefits of drafting to those who choose to follow. And finally, Tanner again provides the latest installment of the “In Print” series. Thanks go out to all of the authors, editors, reviewers, secretaries, and ASCA for all of the hard work that goes into the JSR. This issue presents another collection of thought-provoking topics. As always, your comments are welcome.

J.M. Stager
Sources of Fun and Motivation In Age Group Swimmers

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The purpose of the article, “Sources of fun and motivation in age group swimmers”, is to provide specific strategies to help motivate young swimmers. The psychological component of performance often touted as important, however specific strategies to address the psychological and emotional components of swimming are not scientifically examined. This article surveys and analyzes one of the main motivators for participating in swimming by describing specific factors that swimmers describe as fun and non-fun. Coaches can use this information to design season plans and practice plans that will enhance the swimming experience for age group swimmers.

Abstract

This investigation had three purposes: (1) to determine specific sources of fun and non-fun in age group swimmers; (2) to identify factors influencing perceived fun and non-fun sources of the swimmers; and, (3) to explore how achievement motivational goal orientations are related to overall levels of swimming enjoyment and specific fun and non-fun sources. Participants were youth swimmers taking part USA Swimming age group programs throughout the continental United States. Stratified by geographical location, gender, and age, 600 surveys and parental consent forms were randomly mailed to participants. Two hundred and seventy-seven completed surveys were returned (46%); with swimmers ranging in age from 7-19 with a mean age of 13.03 years. Descriptive statistics revealed that “being with my friends” and “when coaches compliment and encourage me” were the items rated as the most important fun components. The most important sources of non-fun included “getting slower times than my goals” and “getting lapped in races”. Responses to fun and non-fun sources were found to differ based on gender, age, future participation, perceived ability, and stress. The achievement goal orientations of the young athletes were also found to influence fun and non-fun sources. Implications for improving motivation are discussed.

Key words: Fun, Swimming, Enjoyment, Motivation, Youth Sports

In a recent USA Swimming study of motivation in youth participants (16), fun was identified as a major factor contributing to continued involvement and motivation to swim. Conversely, not having fun contributed to the cessation of organized swimming involvement. However, while athlete fun ratings discriminated between active swimmers and swimming dropouts, the study was not designed to determine what specifically was and was not fun for age group swimmers. Moreover, when the first study’s results were presented to USA Swimming coaches, they indicated that identifying what makes swimming fun was a major factor of importance and a high priority research question. This study is designed to respond to this need and focus on the specific factors in swimming that children perceive as fun and not fun.

For the purposes of this manuscript, fun is defined as a general positive feeling and cognitive state that is more specific than affect or mood, but more general than a specific emotion (11; 22). Sometimes fun is confused with intrinsic
motivation. While fun is different from intrinsic motivation, it is certainly a component of motivating young athletes (9). This research will identify the impact fun and non-fun factors have on a swimmer's participation motivation.

Not only are fun and enjoyment major factors in swimming participation, but youth participation in sport in general (22). The enjoyment that a young athlete feels is related to positive team interactions and support, effort and mastery of a sport skill, positive coach support, and satisfaction with season performance (13), as well as the amount and type of parental involvement (18). Based on the body of sport enjoyment literature, Scanlan and her colleagues (14) describe sport enjoyment as a major predictor of motivation in their sport commitment model.

In the youth sport literature, there are several factors that influence a child's participation motivation. General participation motives include achievement, team atmosphere, fitness, skill development, friendship, and fun. In a recent literature review, it is clear that fun is a major reason for participation. Kim (9) concludes, “lack of enjoyment is a particularly important predictor of withdrawal from sport” (p. 25). Therefore, he indicates that it is important to understand the specific components of fun that may relate to young athletes’ decisions to drop out or stay in a sport. Based on this literature, a major purpose of this study was to identify specific sources of fun as perceived by age group swimmers. It was also deemed important to examine components of swimming that were non-fun, as these have not been previously examined in the youth sport literature.

Previous studies (21; 12) have shown that a variety of background factors, such as gender and age, influence fun. However, few consistent findings have emerged as to how they impact fun. So, not only is there a need to examine specific sources of fun and non-fun in youth swimming, but demographic factors, such as gender and age, need to be re-examined.

Besides these demographic factors, sport psychology research suggests that a number of personality orientations or dispositions might influence a young athlete's sport enjoyment. One factor of particular importance is the young athlete’s motivational goal orientation (a disposition where a child adopts predominantly task or ego goals)(15). Goal orientation theory states that there are two basic perspectives or dispositions that people have in varying degrees when they are in achievement situations. One perspective is task orientation, where a performer focuses on judging success based on personal, self-referenced comparison with themselves (e.g. did my times get better, has my stroke improved). The other perspective is ego goal orientation, where a performer focuses on judging success based on a direct comparison (e.g. beating an opponent in a sprint) (23). Goals orientation researchers such as Nicholls (10) and Duda (7) predict that task and ego goal orientations are related to perceptions of ability, enjoyment, stress, and commitment/involvement in sport. Specifically, predominately task oriented swimmers are expected to most enjoy self-referenced fun sources such as skill or fitness improvement, while ego oriented swimmers most enjoy beating others in races.

The motivational goal orientation theory was especially relevant to use in this study for several reasons. First, it has been the dominant theoretical explanation used for studying athlete motivation for over a decade, having been shown to predict both athlete performance and motivation (4). Second, in the sport of swimming emphasis can be easily placed on improving relative to one's own ability (e.g., decreasing time) or judging ability in reference to others (e.g., winning/placing). It would help coaches to know which of these orientations facilitate swimmer fun and motivation. In fact, several researchers (16, 25) have found that creating specific motivational climates by stressing task or ego goals can influence athletes' motivation.

Based on the motivational goal theory tenant that only one child can actually win a contest, but all can improve relative to their own ability, it is predicted that those swimmers who adopt a task rather than an ego orientation will experience greater enjoyment. It was also hypothesized that motivational goal orientations would be related to a child’s perception of enjoyment and specific factors that are fun and non-fun. Specifically, it was predicted that fun sources that are outcome oriented and social evaluation (e.g., winning) would be rated as more important by swimmers with high task and high ego goal orientations. Whereas, fun sources that focus on the enjoyment of the swimming process (e.g., trying to improve) would be rated as more important by swimmers with high task and low ego goal orientations.

Methodology

Participants

Participants were youth swimmers taking part in USA Swimming (USAS) age group programs throughout the continental United States. Since USA Swimming initiated and funded this study, only swimmers who were part of their network organization were contacted. In an effort to ensure that the results would be representative of USA Swimming programs from around the country 600 surveys and parental consent forms were randomly mailed to member swimmers, equally stratified by geographical location, gender, and age-group classification. To insure the highest possible return rate, USA Swimming merchandise prizes were offered via a lottery to a selected number of participants who returned completed surveys. In addition, if the survey was not returned within 5 weeks after the initial mailing, a reminder postcard was sent, and finally, if there was no response to the reminder postcard, the survey was remailed four weeks after the reminder card. Two hundred and seventy-six completed
surveys were returned (46%). A total of 123 males (44%) and 154 females (56%) completed the surveys. They ranged in age from 7 to 19 with a mean age of 13.03 years (SD = 2.63). Fifty-five athletes were in the following 4 USAS age group categories: 7 to 10 age group (26 males, 29 females), 11 to 12 age group (29 males, 42 females), 13 to 14 age group (41 males, 47 females), and 15 to 19 age group (26 males, 36 females). Male and female years of swimming experience were identical with a mean of 5.4 years (SD = 2.89) of swimming experience. Finally, 235 swimmers indicated that they planned to continue swimming, while 11 indicated they would not continue swimming, and 29 were undecided.

Swimming Fun Survey

A swimming fun survey was developed for use in this investigation. This survey was comprised of four parts described below.

Swimmer background information. A series of demographic and background questions (e.g., age, gender, years experience) were included in this portion of the questionnaire, as well as 5 point Likert scales assessing global swimming enjoyment (1 = not at all, 3 = average, 5 = very much), perceived stress of swimming (1 = not at all, 3 = average, 5 = very stressful), and swimming ability (1 = not good, 3 = average, 5 = very good). The swimmers were also asked if they planned to continue swimming next year (yes, no, or not sure). Single items were utilized to measure these constructs due to the wide range in ages of the swimmers and the need to keep the survey reasonable in length.

What is fun about swimming? Participants were asked to rate how much they agreed with 41 swimming fun items (e.g., I like the challenge, I like being with friends) on 5 point Likert scales with anchors 1 = “Not true for me”, 3 = “Sort of true for me”, and 5 = “Really true for me”. Ten of these items came from the existing youth sport enjoyment questionnaire of Wankel and Kreisal (19). Additional items were identified in open-ended interviews of 48 age group swimmers conducted by the authors. These interviews identified unique items specific to swimming such as “my relay team really comes together” or “trying to improve my times.” It was felt that these items were important to include, as they would provide more specific information for coaches and parents, as compared to the more global Wankel and Kreisal items.

What is not fun about swimming? Participants were asked to rate how much they felt 16 items related to not enjoying swimming (e.g., I do not like getting slower times than my coach says, I do not like wearing a skimpy swim suit) on 5 point Likert scales with anchors 1 = “Not true for me”, 3 = “Sort of true for me”, and 5 = “Really true for me”. These items came from open-ended interviews of 48 age group swimmers conducted by the authors.

Task and Ego Orientation in Sport Questionnaire (TEOSQ)

Part 4 of the questionnaire was only completed by swimmers 13 years and older (n = 150) and consisted of the TEOSQ (5). The TEOSQ consists of 13 questions that measure goal orientations, with six items loading on Task Orientation and seven items loading on Ego Orientation. These items were verified using confirmatory factor analysis. The TEOSQ scales have been found to be internally consistent (3). In the present study, the internal consistency for the Task and Ego subscales were consistent with earlier tests of the measure (Cronbach alpha for task = .84 and for ego = .85)(3).

Findings

Predictor Variables

Several items were used as predictor variables in the analyses. These variables were assessed on 5-point Likert scales that ranged from 1 “not at all” to 5 “very much/good”. These predictor items included the following: perceived enjoyment of swimming, perceived stress of swimming, and perceived ability at swimming.

There were two predictor variables that were created from other items on the survey. These included total swimming involvement and plans to continue swimming. Total involvement was determined by multiplying total years swimming, the number of months out of the year that each participant swam, the number of days per week spent swimming, and the number of minutes of each practice. The raw involvement score was divided by 100 to make it more manageable. Due to the high number of swimmers who plan to continue, the variable that described plans to continue was collapsed into two responses instead of three. When asked if they would continue swimming, the swimmers responded with a “yes”, “no”, or “I am not sure”. The “no” and “I am not sure” items were put into one group of “no/not sure”. Combining the responses like this was done due to the inequity in respondents who were continuing and those that were not. This change also allowed us to review the results with a preventative tone because the athletes in the category of “no/not sure” are in danger of dropping out of swimming. Total sample means for these variables can be seen in Table 1.

Sources of Fun and Non-Fun

The total sample means were calculated for each of the 41 fun item ratings and were rank ordered to determine the most important fun items that were associated with being involved in swimming (see Table 2). The top five items included being with friends, being complimented and encouraged by the coach, being known as a good swimmer, winning races, and

1. The questionnaire used in this study is available upon request from the first author.
getting in shape (tied with varied workouts and when my relay team comes together).

Table 1
Mean Responses of Participants by Age Group

<table>
<thead>
<tr>
<th>Age Groups</th>
<th>7-10</th>
<th>11-12</th>
<th>13-14</th>
<th>15-19</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Swim Enjoyment</td>
<td>4.5(0.7)</td>
<td>4.4(0.8)</td>
<td>4.3(0.8)</td>
<td>4.2(0.9)</td>
<td>4.3(0.8)</td>
</tr>
<tr>
<td>Perceived Stress</td>
<td>2.0(1.0)</td>
<td>2.5(1.1)</td>
<td>2.5(1.0)</td>
<td>3.4(1.0)</td>
<td>2.7(1.1)</td>
</tr>
<tr>
<td>Perceived Ability</td>
<td>4.0(0.8)</td>
<td>4.0(0.8)</td>
<td>3.8(0.8)</td>
<td>3.9(0.9)</td>
<td>3.9(0.8)</td>
</tr>
<tr>
<td>Years Experience</td>
<td>3.4(1.4)</td>
<td>4.5(1.8)</td>
<td>5.4(2.4)</td>
<td>8.4(3.2)</td>
<td>5.4(2.9)</td>
</tr>
<tr>
<td>Days/Week of Practice</td>
<td>4.1(0.9)</td>
<td>4.4(1.0)</td>
<td>4.9(1.0)</td>
<td>5.5(0.7)</td>
<td>4.8(3.1)</td>
</tr>
<tr>
<td>Minutes/Day of Practice</td>
<td>79(20)</td>
<td>107(35)</td>
<td>133(46)</td>
<td>143(37)</td>
<td>118(48)</td>
</tr>
<tr>
<td>Month/Year of Practice</td>
<td>9.9(2.5)</td>
<td>10.3(2.0)</td>
<td>10.8(1.9)</td>
<td>10.2(2.4)</td>
<td>10.3(2.2)</td>
</tr>
<tr>
<td>Total Involvement Index</td>
<td>117.7(90)</td>
<td>243.8(196)</td>
<td>423.4(346)</td>
<td>683.2(618)</td>
<td>368(354)</td>
</tr>
</tbody>
</table>

Table 2
Top 15 Best/Top of Reported Fun Sources in Age Group Swimming

<table>
<thead>
<tr>
<th>Rating</th>
<th>Mean</th>
<th>SD</th>
<th>Fun Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.74</td>
<td>.68</td>
<td></td>
<td>Being with my friends</td>
</tr>
<tr>
<td>4.73</td>
<td>.62</td>
<td></td>
<td>When coaches compliment and encourage me</td>
</tr>
<tr>
<td>4.72</td>
<td>.60</td>
<td></td>
<td>To be known as a good swimmer</td>
</tr>
<tr>
<td>4.71</td>
<td>.61</td>
<td></td>
<td>Winning races</td>
</tr>
<tr>
<td>4.68</td>
<td>.69</td>
<td></td>
<td>Getting in shape</td>
</tr>
<tr>
<td>4.68</td>
<td>.71</td>
<td></td>
<td>When the workouts are varied – not just the same everyday</td>
</tr>
<tr>
<td>4.68</td>
<td>.73</td>
<td></td>
<td>Relays when my team really comes together</td>
</tr>
<tr>
<td>4.65</td>
<td>.67</td>
<td></td>
<td>Feelings of accomplishment</td>
</tr>
<tr>
<td>4.65</td>
<td>.76</td>
<td></td>
<td>Team cheering for each other and the team coming together</td>
</tr>
<tr>
<td>4.52</td>
<td>.69</td>
<td></td>
<td>Trying to improve my times</td>
</tr>
<tr>
<td>4.52</td>
<td>.77</td>
<td></td>
<td>Being on a team</td>
</tr>
<tr>
<td>4.56</td>
<td>.82</td>
<td></td>
<td>When we have fun time and not just swim laps</td>
</tr>
<tr>
<td>4.55</td>
<td>.80</td>
<td></td>
<td>Relays</td>
</tr>
<tr>
<td>4.51</td>
<td>.82</td>
<td></td>
<td>When my parents support, cheer and encourage me</td>
</tr>
<tr>
<td>4.48</td>
<td>.94</td>
<td></td>
<td>When we have relays in practice</td>
</tr>
</tbody>
</table>

Note: A rating of 5 equals "really true for me".
Note 2: For a full listing of the fun items, please contact the authors.

The items at the bottom of the fun list included advice from parents, comparing skills against others, being able to talk to coach about anything, hard work, and dryland training. It is important to note that none of the items reflecting swimming fun sources were rated below three on a five point scale, in fact, most of the items had a mean score of four or higher, showing that these participants found the swimming sources assessed to be fun.

Responses to the items that reflected things that young swimmers might not like about swimming were ranked ordered by mean scores (see Table 3). The five items that were ranked as most relevant and least liked about swimming included getting slower times than a swimmer’s goals, getting lapped in races, when other swimmers skip laps, when the coach yells or threatens, and swimmers who think they are good just because they are fast. Having too many meets did not seem to be a major factor for swimming not being fun for this sample of swimmers.

Table 3
Top 12 Ratings of Reported Non-Fun Sources for Age Group Swimming

<table>
<thead>
<tr>
<th>Rating</th>
<th>Mean</th>
<th>SD</th>
<th>Non-Fun Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.41</td>
<td>.89</td>
<td></td>
<td>Getting slower times than my goals</td>
</tr>
<tr>
<td>4.23</td>
<td>1.17</td>
<td></td>
<td>Getting lapped in races</td>
</tr>
<tr>
<td>4.12</td>
<td>1.19</td>
<td></td>
<td>When other swimmers skip laps or get in front of me in practice</td>
</tr>
<tr>
<td>4.10</td>
<td>1.32</td>
<td></td>
<td>When my coach yells at or threatens me</td>
</tr>
<tr>
<td>4.07</td>
<td>1.21</td>
<td></td>
<td>Swimmers who think they are good just because they are faster</td>
</tr>
<tr>
<td>4.01</td>
<td>1.20</td>
<td></td>
<td>When parents keep asking about bad races</td>
</tr>
<tr>
<td>4.01</td>
<td>1.24</td>
<td></td>
<td>When parents brag about only their swimmer</td>
</tr>
<tr>
<td>4.00</td>
<td>1.20</td>
<td></td>
<td>Getting beat by people I used to beat</td>
</tr>
<tr>
<td>3.95</td>
<td>1.25</td>
<td></td>
<td>When I have no time for other things like school, friends, shop</td>
</tr>
<tr>
<td>3.94</td>
<td>1.32</td>
<td></td>
<td>Being stuck in a lane with slower swimmers</td>
</tr>
<tr>
<td>3.41</td>
<td>1.47</td>
<td></td>
<td>Screaming/Yelling parents</td>
</tr>
<tr>
<td>2.79</td>
<td>1.47</td>
<td></td>
<td>When parents make you go to practice</td>
</tr>
</tbody>
</table>

Note: A rating of 5 equals "really true for me".
Note 2: For a full listing of the non-fun items, please contact the authors.

Fun Source Discriminant Analysis

Harmonic means were calculated for the fun items that had fewer than six missing responses, so that the discriminant analyses would have more power. The criteria for using harmonic mean calculations on missing item data was that less than 3% of the sample was missing for an item. Exploratory factor analyses of the fun items using both orthogonal and oblique rotations were conducted to determine if there were groupings of similar "fun" sources. However, these analyses
failed to find clear factors, so the fun items were examined separately.

In order to determine how ratings on the fun items might be influenced by swimmers in different groups, discriminant function analyses followed by univariate analysis were completed using gender, age groups, plans to continue, perceived ability, perceived stress of swimming, and swimming involvement as discriminating variables. If the overall discriminant function was significant, the contribution of specific fun items to the overall significant discriminant functions was carried out as follows. The items judged to have displayed the strongest discriminating power had both a relatively high standardized discriminant coefficient and a significant univariate F score. Items that only displayed relatively high standardized discriminant scores were judged as important, but not as important as those with both high standardized discriminant function coefficients and significant univariate mean differences.

Gender differences. Gender was a discriminating factor for the 41 fun items in swimming, Wilk's Lambda = 0.72, p < 0.001 (see Table 4). An inspection of those items with high standardized discriminant coefficient scores and significant univariate analysis indicated that females found rewards and medals, having a coach tell them what they need to improve on, and the excitement of winning to be more important fun sources than for the males. High discriminant coefficient results also suggested that males found winning races, competing with friends, and having parents give them advice to be more important sources of fun than females.

Table 4

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-test p</th>
<th>Standardized Discriminant Coefficient</th>
<th>Fun Source Rating Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Coach telling me what to</td>
<td>0.001</td>
<td>0.47</td>
<td>4.28</td>
</tr>
<tr>
<td>improve on</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Getting rewards/medals</td>
<td>0.05</td>
<td>0.49</td>
<td>4.19</td>
</tr>
<tr>
<td>Excitement of Swimming</td>
<td>0.05</td>
<td>0.47</td>
<td>4.16</td>
</tr>
<tr>
<td>Winning races</td>
<td></td>
<td>0.47</td>
<td>4.78</td>
</tr>
<tr>
<td>Competing with friends</td>
<td>-0.45</td>
<td>2.97</td>
<td>3.97</td>
</tr>
<tr>
<td>When parents give me advice</td>
<td>0.41</td>
<td>3.23</td>
<td>3.23</td>
</tr>
</tbody>
</table>

The discriminant function analysis reached significance, Wilk's Lambda = 0.72, X²(41) = 79.5, p(0.001)

Age differences. The age of swimmer fun items discriminating analysis was significant, Wilk's Lambda = 0.36, p < 0.001. Furthermore, an inspection of the standardized discriminant coefficients and significant univariate analysis results (receiving rewards discriminant coefficient = 0.70, p < .001, team

cheering discriminant coefficient = 0.42) indicated that receiving rewards and medals is a more important source of fun for younger swimmers and that its importance decreases for older swimmers (Age 7 – 10 M = 4.86; age 13 – 14 M = 4.7; age 13 – 14 M = 4.33; age 15 – 19 M = 3.48). While not as strong a factor, based on comparison of standardized discriminant coefficient scores, it appears that having teammates cheer each other on is a very important source of fun for the youngest age groups (age 7 – 10 M = 4.53; age 11 – 12 M = 4.69), which decreases in importance for the 13-14 year old age group (M = 4.53), and then regains its importance in later adolescence (age 15 – 19 M = 4.70).

Plans to continue swimming. The decision to continue with swimming was found to discriminate the 41 fun items, Wilk's Lambda = 0.57, p < 0.001. While there was a large disparity between the cell sizes (235 continuing and 40 not sure or not continuing), it is of note that the participants in the not continuing group doubled in size after a second, follow-up, mailing of surveys was sent.

All of the fun item ratings that were found to be significantly related to remaining involved in swimming, based on standardized discriminant coefficient scores and significant univariate F-scores, were rated as more important for the participants who had decided to continue their swimming involvement (see Table 5). Specifically, the fun items involved were related to the swimmers' relationship with the coach and enjoying the skills needed to improve their swimming.

Table 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-test p</th>
<th>Standardized Discriminant Coefficient</th>
<th>Fun Source Rating Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relays</td>
<td>0.001</td>
<td>0.35</td>
<td>4.60</td>
</tr>
<tr>
<td>Trying to improve times</td>
<td>0.001</td>
<td>0.33</td>
<td>4.73</td>
</tr>
<tr>
<td>Excitement of swimming</td>
<td>0.001</td>
<td>0.31</td>
<td>4.53</td>
</tr>
<tr>
<td>Improve skills</td>
<td>0.001</td>
<td>0.21</td>
<td>4.45</td>
</tr>
<tr>
<td>I can talk to coach about anything</td>
<td>0.05</td>
<td>0.34</td>
<td>3.75</td>
</tr>
<tr>
<td>My coach knows me as a person</td>
<td>0.44</td>
<td>4.20</td>
<td>3.90</td>
</tr>
</tbody>
</table>

The discriminant function analysis reached significance, Wilk's Lambda = 0.57, X²(41) = 134.34, p(0.001)

Perceived stress of swimming. Perceived stress of swimming was not found to be a discriminating variable for swimming fun items, Wilk's Lambda = .65, p > 0.05).
**Perceived ability.** Perceived swimming ability was determined by a 5 point Likert Scale that required the swimmers to compare their swimming ability to that of other swimmers in their age-group from poor to very good. Due to the number of responses, Poor, Below Average, and Average responses were grouped together for the discriminant analysis. Discriminant analysis results using the three levels of swimming ability as the discriminating factor and the fun items as the dependent variables were significant, Wilk's Lambda = 0.62, \( p < 0.01 \) (see Table 6). Inspection of the standardized discriminant coefficient and univariate analysis results indicated a general trend that swimming tended to be more fun for swimmers with higher perceived ability. Specifically, the most significant of these items were the challenge and the excitement of swimming. With higher perceived ability swimmers rating these as more fun. The exception to this trend was that having the team cheer for each other and coming together as a team, while important for all levels of perceived ability, was more important for swimmers with lower perceived ability.

**Table 6**

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-test p</th>
<th>Standardized Discriminant Coefficient</th>
<th>Fun Source Rating Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Post-Ave.</td>
<td>Above Ave.</td>
</tr>
<tr>
<td>Perceived Ability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The challenge</td>
<td>0.001</td>
<td>0.39</td>
<td>4.00</td>
</tr>
<tr>
<td>Excitement of swimming</td>
<td>0.001</td>
<td>0.31</td>
<td>4.12</td>
</tr>
<tr>
<td>Team cheering for each other and coming together</td>
<td>0.59</td>
<td>4.72</td>
<td>4.66</td>
</tr>
<tr>
<td>When my coach tells me what I must improve on</td>
<td>-0.56</td>
<td>4.51</td>
<td>4.42</td>
</tr>
<tr>
<td>My coach knows me as a person</td>
<td>0.47</td>
<td>3.91</td>
<td>4.23</td>
</tr>
<tr>
<td>Knowing that my parents are at my meets</td>
<td>0.41</td>
<td>4.31</td>
<td>4.23</td>
</tr>
<tr>
<td>Traveling to new places</td>
<td>0.40</td>
<td>4.28</td>
<td>4.45</td>
</tr>
<tr>
<td>Being on a team</td>
<td>0.33</td>
<td>4.59</td>
<td>4.56</td>
</tr>
</tbody>
</table>

The discriminant function analysis reached significance, Wilk's Lambda = 0.62, \( \chi^2 (32) = 113.44, \ p(0.01) \)

**Non-Fun Source Discriminant Analysis**

Harmonic means were calculated for the non-fun items using the same criteria as the fun items. Exploratory factor analyses of the non-fun items failed to display conceptually sound factors, so the non-fun items were examined separately.

As was the case with the fun item results, discriminant function analyses followed by univariate analysis were conducted using gender, age groups, plans to continue, perceived ability, perceived stress of swimming, and swimming involvement as discriminating variables and the non-fun item ratings as the dependent variable.

**Gender.** Gender was not found to significantly discriminate between the groups, Wilk's Lambda = 0.93, \( p > 0.05 \).

**Age.** Age was a discriminating factor for items that were considered not to be fun in swimming, Wilk's Lambda = 0.75, \( p < 0.005 \). Standardized discriminant coefficients and univariate analysis (see Table 7) indicated that younger swimmers found being stuck in the slow lane a major source of non-fun feelings in swimming. This feeling decreased progressively in the later age groups. Another, similar, trend was the dislike for not having an off-season. While, in absolute terms this was not a major factor, all scores were below 2 (\( M = 1.70, 1.58, 1.57, \) and 1.17 from youngest to oldest age group), this was more of a factor for younger swimmers than older swimmers in not enjoying swimming.

**Table 7**

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-test p</th>
<th>Standardized Discriminant Coefficient</th>
<th>Fun Source Rating Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Post-Ave.</td>
<td>Above Ave.</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snack in lane with slow swimmers</td>
<td>0.001</td>
<td>0.61</td>
<td>4.46</td>
</tr>
<tr>
<td>Dislike no off-season</td>
<td>0.001</td>
<td>0.54</td>
<td>1.70</td>
</tr>
<tr>
<td>Getting lapped in races</td>
<td>-0.49</td>
<td>2.37</td>
<td>2.75</td>
</tr>
</tbody>
</table>

The discriminant function analysis reached significance, Wilk's Lambda = 0.75, \( \chi^2 (48) = 76.9, \ p(0.005) \)

Another source of not enjoying swimming that demonstrated differences in responses based on age was being lapped in races. This was less important for young swimmers and became a larger factor for not enjoying swimming for the older swimmers.

**Plans to continue swimming.** The decision to continue with swimming was a discriminating category for non-fun items in swimming, Wilk's Lambda = 0.84, \( p < 0.001 \). Standardized discriminant coefficient (0.69) and univariate analysis \( (p < .01) \) indicated that swimmers skipping laps or getting in front of the swimmer was a more significant source of displeasure for swimmers who were not sure or were not continuing in competitive swimming \( (M = 4.05) \), as compared to swimmers who planned to continue \( (M = 2.59) \).

**Perceived stress of swimming.** The stress of swimming was found to discriminate between the two groups based on non-fun item ratings, Wilk's Lambda = 0.75, \( p < 0.001 \). An inspection of the standardized discriminant coefficient and
univariate analysis revealed that higher levels of perceived stress of swimming concerning swimming were significantly related to the relevance of two non-fun items. Specifically, getting beat by people that a swimmer used to beat (discriminant coefficient = 0.57, \( p < 0.001 \)) and wearing skimpy suits (discriminant coefficient = 0.33, \( p < 0.001 \)) were rated as more relevant to not enjoying swimming for high stress swimmers than for low stress swimmers (Getting beat low stress \( M = 3.5 \), average stress \( M = 4.22 \), high stress \( M = 4.39 \); Skimpy suit low stress \( M = 2.73 \), average stress \( M = 2.90 \), high stress \( M = 3.28 \)).

**Perceived ability.** Perceived ability was a discriminating category for non-fun items in swimming, Wilk's Lambda = 0.82, \( p < 0.001 \). Standardized discriminant coefficient and univariate analysis (see Table 8) indicated that several non-fun items were more important for swimmers with low perceived ability and this relevance increased with a swimmers' perceived ability. Specifically, 'parents bragging about their child's swimming' and 'getting slower times than their goals' became more of a factor as swimmers' perception of ability increased.

**Table 8**

**Perceived Ability Discriminant Non-Fun Sources Analysis**

<table>
<thead>
<tr>
<th>Variable</th>
<th>t-test p</th>
<th>Standardized Discriminant Coefficient</th>
<th>Fun Source Rating Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Post-Ave.</td>
<td>Above Ave.</td>
</tr>
<tr>
<td>Getting beat by people I used to beat</td>
<td>0.001</td>
<td>0.54</td>
<td>4.09</td>
</tr>
<tr>
<td>Stuck in lane with slow swimmers</td>
<td>0.05</td>
<td>0.43</td>
<td>4.24</td>
</tr>
<tr>
<td>Screaming/Yelling parents</td>
<td>0.05</td>
<td>0.39</td>
<td>2.07</td>
</tr>
<tr>
<td>Swimmers who think they are good just because they are fast</td>
<td>0.05</td>
<td>0.31</td>
<td>4.20</td>
</tr>
<tr>
<td>Getting slower times than my goals</td>
<td>-0.37</td>
<td>4.26</td>
<td>4.43</td>
</tr>
<tr>
<td>When parents brag about their swimmer</td>
<td>-0.36</td>
<td>3.85</td>
<td>3.89</td>
</tr>
<tr>
<td>No time for other things</td>
<td>0.33</td>
<td>4.34</td>
<td>4.26</td>
</tr>
</tbody>
</table>

The discriminant function analysis reached significance, Wilk's Lambda = 0.82, \( \chi^2 (32) = 52.31, p(0.001) \)

Screaming and yelling parents and swimmers who think they are good just because they are fast were non-fun items that were rated as more important for low perceived ability swimmers than high perceived ability swimmers.

**Motivational Goal Orientation Analysis**

Goal orientation researchers such as Nicholls (10) and Duda (6) predict that task and ego goal orientations are related to perceptions of ability, enjoyment, stress and commitment/ involvement in sport. Although much of the goal orientation research has focused on simply examining the task and ego orientations' main and interaction effects, the theoretical work of Nicholls (10) emphasized the importance of the interaction effects of three factors — task goal orientation, ego orientation, and perceived ability. That is, task and ego orientation differences should be maximized in low versus high perceived ability athletes since theoretical predictions are expected to be accentuated in low perceived ability individuals. For this reason, separate 2 x 2 x 3 way (task goal orientation by ego orientation by perceived ability) ANOVAs were conducted using enjoyment, perceived stress of swimming, and commitment/involvement as dependent variables. Task and ego goal orientation scores for the swimmers over the age of 13 were divided into high and low categories based on median splits \( (\text{Ego} = 3.0 \text{ and Task} = 4.5) \). Finally, 2 x 2 (task and ego goal orientations) MANOVAs were conducted on the fun and non-fun items to determine if specific enjoyment sources were effected by those goal orientations. Unfortunately, for the fun and non-fun item analysis full 2 x 2 x 3 MANOVAs could not be conducted because of difficulties filling all cells with adequate numbers of participants.

Perceived ability was organized into 3 categories. Category 1 was composed of all the swimmers who rated themselves as average or below ("1-3" on a Likert Scale) \( (n = 86) \). Category 2 was all of the swimmers who rated themselves as above average (a rating of "4" on a Likert Scale) \( (n = 121) \). Category 3 was composed of all the swimmers who rated themselves as very good ("5" on a Likert Scale) \( (n = 70) \).

**Enjoyment analysis.** Swimmers rated their overall enjoyment using a 5 point Likert scale, with 1 signifying low enjoyment and 5 signifying very high enjoyment. The 2 x 2 x 3 ANOVA indicated a significant task goal orientation main effect \( (F(1,132) = 10.31, p < .002) \) with the enjoyment levels of high task swimmers \( (M = 4.44) \) rated higher than the enjoyment ratings of low task swimmers \( (M = 3.97) \). There was also a significant perceived ability main effect \( (F(2,132) = 5.29, p < .05) \). Post hoc Tukey analysis indicated that all three groups significantly differed \( (p < .05) \) with enjoyment being higher for higher levels of perceived ability \( (M_1 = 3.9, M_2 = 4.26, M_3 = 4.57) \).

**Perceived stress of swimming analysis.** Swimmers rated their perceived stress of swimming using a 5 point Likert scale, with 1 signifying low enjoyment and 5 signifying very

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2. Only swimmers in the 13 to 14 and 15 to 18 age groups were asked to complete the TEOSQ used in the goal orientation analyses because the scale had not been validated for younger age groups.
high enjoyment. The 2 x 2 x 3 ANOVA indicated a significant task goal orientation main effect ($F (1, 132) = 6.27, p < .05$), with the perceived stress of swimming of high task swimmers ($M = 2.82$) lower than the perceived stress of low task swimmers ($M = 3.26$). There were no other significant effects or interactions.

**Involvement analysis.** There was no significant effect of task goal orientation, ego goal orientation, or perceived ability on total involvement in swimming ($p > .05$).

**Fun item analysis.** A task by ego goal orientation (2 x 2) MANOVA was conducted on the fun items. The 2 x 2 MANOVA results revealed a significant task goal orientation main effect ($F (41, 93) = 1.04, p < .001$) and a significant ego goal orientation main effect ($F (41, 93) = .80, p < .01$). Subsequent univariate and discriminant function analysis indicated that swimmers who had a high task goal orientation found more varied workouts (high task $M = 4.89$; low task $M = 4.54$), working hard (high task $M = 4.17$; low task $M = 3.48$), getting in shape (high task $M = 4.83$; low task $M = 4.60$), being on a team (high task $M = 4.66$; low task $M = 4.43$), parents giving advice (high task $M = 3.19$; low task $M = 2.48$), and liking swimming as more enjoyable (high task $M = 4.62$; low task $M = 4.02$) than the low task oriented swimmers. Based on the examination of the follow-up univariate analysis and standardized discriminant function coefficients, swimmers with high ego goal orientations had higher ratings for enjoying rewards and medals (high ego $M = 4.25$; low ego $M = 3.59$), winning races (high ego $M = 4.83$; low ego $M = 4.32$) and doing the skills needed for swimming (high ego $M = 3.87$; low ego $M = 3.59$). Swimmers with low ego goal orientations indicated that having the coach know the swimmer as a person was a greater source of enjoyment than for swimmers with high ego orientation (high ego $M = 3.69$; low ego $M = 4.13$). The interaction effect was not significant.

**Non-fun item analysis.** A task by ego goal orientation (2 x 2) MANOVA was conducted on the non-fun items. The 2 x 2 MANOVA results revealed a significant task goal orientation main effect ($F (16, 125) = .29, p < .01$) and a significant ego goal orientation main effect ($F (16, 125) = .34, p < .001$). Subsequent univariate and discriminant function analysis indicated that swimmers who had a high task goal orientation did not like it when their parents made them go to practice (high task $M = 4.28$; low task $M = 3.60$), being stuck in the slow lane with slow swimmers (high task $M = 4.12$; low task $M = 3.57$), or when they made slower times than their goals (high task $M = 4.53$; low task $M = 4.27$). Swimmers with low task goal orientations found wearing the skimpy suit to be a major factor for not enjoying swimming (high task $M = 2.47$; low task $M = 3.07$). Based on the examination of the follow-up univariate analysis and standardized discriminant function coefficients, swimmers with high ego goal orientations did not like having slower times than their goals (high ego $M = 4.63$; low ego $M = 4.12$), not having time for other activities (high ego $M = 4.61$; low ego $M = 3.92$), having so many meets (high ego $M = 4.20$; low ego $M = 3.62$), and having their coach yell or threaten them (high ego $M = 4.30$; low ego $M = 3.49$). The interaction effect was not significant.

**Discussion**

The purpose of this exploratory study was threefold. The first purpose was to determine specific sources of fun and non-fun in age group swimmers. The second purpose was to determine specific factors influencing the perceived fun of age group swimmers. The third purpose of this study was to further explore how achievement goal orientations are related to overall levels of swimming enjoyment, participation, and specific fun and non-fun sources. This study furthers swimming participation information by focusing on specific factors of enjoyment in a single sport and how these factors relate to the theoretical constructs of Nicholls goal orientation theory (10).

Previous studies examining enjoyment in youth sport have found sport enjoyment to be influenced by such things as perceived competence, skill development, social reasons, competition, and health and fitness (2). This study (see Table 2) supported these findings with the top five reasons for enjoying swimming being related to social reasons (being with friends), perceived competence (being complimented by the coach and being known as a good swimmer), competitive reasons (winning), and health and fitness reasons (getting in shape).

While most attention has been paid to fun sources in youth sport literature, less attention has been paid to non-fun factors. In discussing their participation motivation model, Gould and Petlichkoff (8) stated that it is “imperative that youth sport leaders learn to recognize which aspect of their program are perceived by children to be most beneficial and which incur the greatest costs.” (p.175). This study described specific situations (costs) that are not fun for young swimmers. Moreover, results indicated that non-fun sources were not always the opposite of fun factors. (see Table 3) For example, not meeting personal goals (getting slower times than goals), coach factors (the coach yelling at the swimmer), and parental reasons (when parents keep asking about bad races and when parents brag about only their swimmer) were important non-fun sources. Coaches should be aware of specific fun and non-fun factors in swimming to better understand the specific cost-benefits of participation.

In addition, differences in the sources of fun and non-fun items were noted based on gender, age, future participation in age group swimming, perceived ability, and perceived stress of swimming. The major difference in the responses of males and females was that females found receiving rewards and medals to be more fun than males. Both genders enjoyed winning, but the focus was slightly different for males and females. Females found the excitement of winning to be
important for enjoyment while males enjoyed the competition
between friends and winning their races. Females also
reported that they enjoyed getting specific feedback from their
coach more than males. This is similar to gender difference
findings reported by coaches of both male and female colle-
giate athletes, although it is important to note that there are
more differences within genders than there are between
genders (17).

Swimmers who were going to continue swimming were
more likely to find swimming fun than swimmers who were
planning on discontinuing. While this is not a surprising
finding, it does underline the importance of understanding
specific aspects of swimming involvement that are fun and
non-fun for children. This is also important when combined
with the information that swimming was rated as more fun for
those swimmers with high perceived ability. Perceived ability
also had an insulating effect for screaming and yelling parents
and swimmers who think they are good just because they are
fast. However, parents bragging about their swimmer and
getting slower times than goals were found to be greater
factors of not enjoying swimming for swimmers with high
perceived ability. These findings support the importance of
perceived ability in understanding motivation factors involved
in youth sport (8).

The motivational orientation of the swimmer also appears
to be influential in the perceptions of enjoyment and stress as
well as specific reasons for enjoying and not enjoying
swimming. Overall, swimmers with high task goal orienta-
tions, where their focus is on the process of task improvement
and self-comparison, had higher levels of enjoyment with
swimming than swimmers with low task goal orientation.
This same pattern was seen for the swimmers with high
perceived ability. Perceived stress from swimming was also
lower for those swimmers with high task goal orientations.
These findings are important for two reasons. First, the
independence of task and ego goal orientations as orthogonal
constructs is supported by the lack of interaction between task
and ego on enjoyment and stress. Second, these findings
reinforce the necessity for coaches to emphasize the impor-
tance of a task-oriented focus for young swimmers. Recently
several researchers (16; 25) have studied the importance of
creating specific motivational climates for young athletes.
This research supports the importance of training coaches on
how to create task oriented goal orientations.

Motivational goal orientation did not appear to effect the
total amount of involvement, measured by length of season
and number of years of involvement, for the age group
swimmers. This may have occurred due to our construction
of the involvement variable, but it does help to confirm that
individual goal orientation does not effect the level of
involvement in sport. Athletes are involved in their sport
regardless of their primary motivational goal orientation.

The specific fun and non-fun items that were preferred by
high task oriented individuals are not surprising. High task
swimmers preferred activities that were focused on the
process of swimming such as working hard, getting in shape,
having varied workouts, and generally liking swimming.
Similarly predictable, the activities that were found to be most
fun for swimmers with high ego goal orientation scores were
outcome oriented such as enjoying rewards and medals.
Swimmers with low ego scores tended to want the coach to
know them as a person more than swimmers with high task or
ego scores. This is not surprising since swimmers with low
ego goal orientations may be participating more for social
reasons and not outcome reasons.

Applications

The results of this study have important implications for
coaching. First, coaches need to emphasize process-oriented
goals for swimmers. Many young swimmers are already
focused on making comparisons with peers and external
rewards. Based on the evidence in this study, focusing on a
child’s task goal orientation and downplaying the
outcome/reward focus of ego orientation, youth swimmers
will be more likely to enjoy swimming and feel less stress
from participation. For example, coaches may want to look
for swimmers who display frustration with other swimmers
who skip laps or get in front of them. This is one way of
targeting specific athletes who are likely to drop out of
swimming or who might benefit from a task focused view of
training.

Second, the importance of perceived ability in swimming
cannot be understated. Perceived ability influenced swimmer
enjoyment and their decision to continue or discontinue
swimming. This finding suggests that coaches must create
scenarios where children can feel success and competence in
their sport. This does not mean that coaches should give
children a false sense of self-esteem. It does suggest a de-
emphasis of inter-individual comparisons and an emphasis on
intra-individual comparisons. It also suggests that coaches
follow progressions that challenge children at the individual
level. For example, when teaching sprints to younger chil-
dren, have them keep track of the number of strokes they can
hold their breath. The object is to be able to focus on beating
their own records until they can go a full length.

The fun and non-fun items described in this research can be
used to help develop effective (and fun) practices. Some of
the non-fun activities, like wearing skimpy suits or having no
off-season, are currently a reality of competition, but these
items can be de-emphasized or counter balanced by focusing
on activities, such as varying workouts or focusing on
individual and team accomplishments, that are fun for young
swimmers. Other non-fun issues, such as having the coach
yell or threaten the swimmer, can (and should) be modified or
eliminated. One way to do this is to have a volunteer video-
tape several practices and meets. Watch the videos to see how the young swimmers see you. This same technique could also be a way to eliminate the screaming and yelling parents that the swimmers reported as not fun.

The age differences in the things young swimmers report as being fun and not fun are also important to keep in mind when creating practices. Keep in mind that younger swimmers in the 10 and under age group were more likely to rate receiving medals as fun than the older age groups. This does not mean that the older aged swimmers do not enjoy receiving awards and medals. It does mean that other forms of satisfaction are more important than external rewards. Cheering for teammates was also important for both the 11-12 year old age group and the 15-19 year old age group, while it is not as important for fun with the 7-10 year old and 13-14 year old swimmers. These specific fun factors become great strategies to refocus the energy and motivation of the swimmers that you work with.

Enjoyment in youth sport has been extensively studied, however the specific activities, such as having relays in practice, that make a sport like swimming enjoyable have not been examined. Most of the past research in youth sport enjoyment has been descriptive. It is time that we examine models with intervention studies. For example, researchers could train coaches to emphasize fun sources and measure patterns in participation, dropout, perceived stress, and perceived competence (1). By understanding specific reasons of swimming enjoyment, practitioners will be able to enhance the swimming experience for young athletes.

Author Notes

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Sprint Performance Times Related to Block Time in Olympic Swimmers

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Coaches often proclaim that a race can be won or lost on the start. This could certainly be the case in a close race, but this article attempts to illustrate that getting off the blocks quickly is no guarantee of winning the race. In fact, in Olympic 50 and 100 meter freestyle races, as much as 88% of the variability in performance can be attributed to factors other than block time. The range in block time among these swimmers is small, and finalists were not faster than those not making the finals. Although block time is easily measured with today’s technology, coaches should not dedicate an excessive amount of practice time towards reducing block time. Attention should also be focused on the other phases of the start (flight, entry, underwater, etc.) that contribute to reducing the time it takes the swimmer to reach ten meters.

Abstract

Due to the brief duration of the sprint events in swimming, an efficient start has been viewed as being essential for success. To test the hypothesis that performance time is related to the time interval from the start signal until the swimmer’s feet leave the starting blocks (block time), 225 performances from the 1996 Olympic 50 and 100 meter freestyle events were analyzed. Performance time and block time (BT), which is published in the official Olympic results, were used for analysis. Correlations between performance time and block time were weak but significant (p<0.05) for men in the 50 free (r=.35, N=63) and women in the 100 free (r=.29, N=48). Therefore, block time accounted for only 12% of the variability in performance time for men in the 50 free and only 8% for women in the 100 free. Men and women did not differ in BT for either event. Swimmers in the 50 were not faster off the blocks than swimmers in the 100. There were no differences in block time between finalists (top 16) and non-finalists for any event or sex. It is concluded that for sprinter swimmers at the Olympic level, the start is a minor factor in determining total performance time.

Index terms: swimming, Olympic swimming, start, reaction time

Introduction

The prevailing belief among swimmers and coaches is that a 50 m or 100 m sprint race can be won or lost on the start (6,21). Therefore, considerable effort has been devoted to improving the mechanics of the swimming start in hopes of achieving improved performance in sprint events. Consequently, it would be of importance for both coaches and swimmers to know if the start is really a significant factor in performance? Do the fastest swimmers have the fastest starts?

The start has been a popular subject for swimming research. Numerous studies have been conducted to compare types of starts, such as the conventional arm swing, the grab, and the track start. A comprehensive review of 15 studies up to 1978 is presented by Sue Lewis in Swimming Technique (18). At least another 12 studies have been conducted since 1978 (1,2,7,8,9,11,12,15,16,22,25,26). Methods used to collect data on start performance include analysis of 16 mm film or videotape, measurement of forces by transducers in the starting block, and measurement of time to a fixed distance.
using a thin line of a given length. Some of the studies using film or video were conducted during actual competition. However, all the studies requiring instrumentation for recording data from the starting blocks were conducted under laboratory conditions.

The studies reported in this paper defined block time as the time from the start signal until the swimmer's feet leave the block. A summary of the literature dealing with block time is presented in Table 1. In each of these studies, film or video were analyzed to determine block time. The study by Kollias et al. (16) was excluded from review because the observed block times are very fast compared to the other studies. When viewed as a composite, the block times in the rest of the studies examined were within 0.23 second from the slowest to the fastest. This is a surprisingly narrow spread, considering the wide variation in ability of the swimmers tested, from age groupers to Olympians. This would suggest that getting off the starting block is a fairly simple task to master and/or that block time is not an important factor in overall performance. Interestingly, the fastest block times were reported in a study which used untrained college students with no swimming experience (18).

The time taken to perform a movement can be broken down into two parts, reaction time (RT) and movement time (MT) (20). RT is the interval of time between the onset of the starting signal and the initiation of a physical response. MT is defined as the interval of time between the initiation and completion of movement. Block time can be partitioned into two segments, the time from the start signal to the initiation of the start (reaction time), and the time from the initiation of movement until the toes leave the block (12). Reaction time and movement time have been shown to be independent factors in total block time of a swimming start (10).

Selected studies reported women having slower reaction times and movement times when compared to men (13, 14, 23, 24). However, none of the studies reviewed in this paper that compared men with women found a statistically significant difference in block time by sex (16, 22). In addition, Wilson et al. (25) found no difference in movement time for 12 men and 12 women Canadian Olympic swimmers, although the men had faster horizontal velocity at takeoff (4.94±0.19 m/s versus 4.25±0.37 m/s) and longer flight distance (4.10±0.27 m versus 3.39±0.17 m) than the women. Kollias et al. (16) also found that men leave the block with a faster takeoff speed than women.

The relationship between start time and the time required to complete the entire event was investigated by Arellano et al. (1) during the 1992 Olympics in Barcelona. For this study, start time was defined as the time to reach 10 meters, determined by film analysis. Event time was significantly correlated with start time for both men and women in the 50 meter freestyle, r=0.91 and r=0.62, respectively. These relationships were also significant for men and women in the 100 meter freestyle, r=0.89 and r=0.90, respectively. The relationship between block time and event time has yet to be investigated.

From the above studies, we therefore conclude that men and women do not differ in block time and that performance in sprint events is related to block time. To test these hypotheses, the results of the 1996 Olympic 50 and 100 m freestyle events were analyzed. The purpose of the paper is therefore to review the existing data from the Olympic events and to stimulate further discussion and research on the importance of the start in determining performance in sprint events.

Table 1: Summary of studies reporting block time (BT) for a swim start.

<table>
<thead>
<tr>
<th>Author</th>
<th>Subjects</th>
<th>BT (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arellano et al. (2)</td>
<td>69 boy swimmers</td>
<td>0.90±0.09</td>
</tr>
<tr>
<td>Bloom et al. (4)</td>
<td>30 untrained college women</td>
<td>0.99±0.08</td>
</tr>
<tr>
<td>Gibson (9)</td>
<td>11 A class boys and girls</td>
<td>0.89</td>
</tr>
<tr>
<td>Havriluk (12)</td>
<td>3 college men swimmers</td>
<td>0.81 to 0.91</td>
</tr>
<tr>
<td>Kollias et al. (16)</td>
<td>6 men swimmers</td>
<td>0.62±0.04</td>
</tr>
<tr>
<td>Lewis (18)</td>
<td>6 women swimmers</td>
<td>0.64±0.07</td>
</tr>
<tr>
<td>Miller et al. (22)</td>
<td>10 untrained college men</td>
<td>0.76±0.04</td>
</tr>
<tr>
<td></td>
<td>8 Commonwealth men finalists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 free</td>
<td>0.82±0.04</td>
</tr>
<tr>
<td></td>
<td>200 free</td>
<td>0.83±0.05</td>
</tr>
<tr>
<td></td>
<td>8 Commonwealth women finalists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 free</td>
<td>0.78±0.05</td>
</tr>
<tr>
<td></td>
<td>200 free</td>
<td>0.82±0.03</td>
</tr>
<tr>
<td>Zatsiorsky et al. (26)</td>
<td>60 men swimmers</td>
<td>0.93±0.08</td>
</tr>
</tbody>
</table>
Methods

Subjects for the study were participants in the 50 and 100 meter freestyle events at the 1996 Olympic Games held at the Georgia Tech Aquatic Center in Atlanta, Georgia, July 20-26, 1996. A total of 225 performances from the preliminary heats of the men's and women's 50 and 100 freestyle events were included in the study.

Instrumentation

Block time was measured using an Omega OSB7SW Starting Block with Relay Takeover Monitoring Platform connected to an Omega ARES21 timing console (Swatch Timing, Biel, Switzerland). This starting platform has a mechanical contact switch mounted between the top of the starting block and the base. The switch is closed when a swimmer is standing on the platform and opens when the swimmer's feet leave the block following a start. The timing console reads the output of the platform to a resolution of 0.0003 second, although times are printed to the nearest 0.01 second.

Statistical Analysis

The official results from the Atlanta Olympics listed the time from the start signal until the swimmer's feet left the starting platform for every individual in every event. These times, and the corresponding finish time for that competitor, were entered into an SPSS for Windows, Version 9.0 data file (SPSS, Inc., Chicago, IL) for analysis. An independent groups t-test was used to test the significance of differences in performance time and BT between men and women for the 50 m and 100 m freestyle events. The top 16 finishers were compared to the other participants in each event to determine whether or not the faster swimmers differ in BT from the slower swimmers. Pearson product moment correlation was calculated to determine the relationship between block time and performance time for each event and sex. Significance was determined at the 0.05 level.

Results

Mean performance times and the number of swimmers in the 50 m and 100 m freestyle events are listed in Table 2. Mean block times for each event and sex are listed in Table 3. Mean BT for the 225 starts analyzed was 0.78 ± 0.06 second. Mean BT was not different between men and women in either event. Likewise, there was no difference in BT between the two events, i.e., the 50 m freestyle was not faster than the 100 m freestyle. BT of the top 16 finishers did not differ from the other participants for either event or sex.

Table 2: Mean performance time and number of swimmers in the 1996 Olympic 50 and 100 meter freestyle events.

<table>
<thead>
<tr>
<th></th>
<th>Women (n=102)</th>
<th>Men (n=123)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Free</td>
<td>26.83 ± 1.41 (n=54)</td>
<td>23.89 ± 1.89* (n=63)</td>
</tr>
<tr>
<td>100 Free</td>
<td>57.49 ± 1.49 (n=48)</td>
<td>51.37 ± 1.65* (n=60)</td>
</tr>
</tbody>
</table>

* Men significantly faster than women in the same event. (p<0.05)

Table 3: Mean block time for swimmers in the 1996 Olympic 50 and 100 meter freestyle events.

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Free</td>
<td>0.79 ± 0.05</td>
<td>0.77 ± 0.06</td>
</tr>
<tr>
<td>100 Free</td>
<td>0.81 ± 0.05</td>
<td>0.78 ± 0.06</td>
</tr>
</tbody>
</table>

Performance time was significantly correlated with BT for women in the 100 m free and for men in the 50 m free, but not for women in the 50 m free and not for men in the 100 m free (Table 4). Figures 1 - 4 illustrate these correlations.

Table 4: Correlation between performance time and block time for swimmers in the 1996 Olympic 50 and 100 meter freestyle events.

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Free</td>
<td>0.22</td>
<td>0.35 *</td>
</tr>
<tr>
<td>100 Free</td>
<td>0.29</td>
<td>-0.19</td>
</tr>
</tbody>
</table>

* Significant correlation (p<0.05)

Discussion

The block times for men and women swimmers in the 1996 Olympic Games are similar to the range of block times found in previous studies (2,4,9,10,16,18,22,26). Likewise, the absence of a difference in block time between men and women is consistent with previous findings (16,22).

The correlations between event time and BT are much lower than those found by Arellano et al. (1) for time to 10 meters and event time at the 1992 Olympic 50 and 100 meter freestyle events. In fact, the coefficient of determination for the largest correlation (r=0.35 for the men's 50 m free) is only 0.12, meaning that only 12% of the variability in performance time for the 50 m free is determined by BT. Therefore, 88% of the variability in the 50 freestyle times can be attributed to other factors, such as takeoff speed, flight time/distance, and swimming speed. The low correlation between BT and event
Block time (s)

Figure 1. Performance time versus block time for 54 women in the 1996 Olympic 50 meter freestyle.

$\ r = 0.22$

$n = 54$

Block time (s)

50 m time (s)

64

62

60

58

56

54

.6

.7

.8

.9

.9

1.0

100 m time (s)

$\ r = 0.29^*$

$n = 48$

* Significant correlation ($p<0.05$)
Figure 3. Performance time versus block time for 63 men in the 1996 Olympic 50 meter freestyle. * Significant correlation (p<0.05)

Figure 4. Performance time versus block time for 60 men in the 1996 Olympic 100 meter freestyle.
time should be viewed in relation to the proportion of total performance time accounted for by the start. In the men’s 50 m free, for example, BT was only 3.2% of the total time. Therefore, an action that lasted only 3.2% of the event determined 12% of the variability. From this perspective the start takes on much more importance. Clearly, for longer events the start is a smaller percentage of total time. In the women’s 100 free, for example, the correlation of $r=0.29$ determined 8% of the variability, but the start constituted only 1.4% of the total performance time.

It must be noted that a group of Olympic athletes cannot be considered a random sample of all swimmers. Nevertheless, it is clear from the scatter plots (figures 1-4) that several competitors were considerably slower than the mean of the group. Removing performance times slower than 30 seconds from the women’s 50 m free does not affect the correlation, but removing the four performances slower than 28 seconds from the men’s 50 m free changes the correlation to $r=0.04$, no longer significant. Removing the two performance times slower than 57 seconds in the men’s 100 free yields a significant correlation of $r=-0.26$. This surprising result suggests that swimmers who were the slowest off the blocks had the fastest performance times! In fact, the slowest swimmer off the blocks in the 100 freestyle final (Popov, 0.88 s) won the race! Clearly this is contrary to the beliefs of most coaches and swimmers, and suggests that perhaps the start is not as crucial a factor in performance as expected.

It may be concluded that at this level, the start does not assume more importance in determining performance because the swimmers are elite and the variance in block time is small. There may be more important factors than block time that determine who wins and who loses. These factors might include strength, power, technique, and mental strategy.

The difference between men and women in block time was very small, only 0.02 second. The difference in performance time, however, was much greater, 2.94 seconds in the 50 free and 6.12 seconds in the 100 free. In general, male swimmers have more muscle mass and are stronger than female swimmers. The observed differences in performance times are probably a result of greater strength in the men. The women were 12.3% slower in the 50 free and 11.9% slower in the 100 free but only 2.6% slower off the blocks. This suggests that strength may be less important in getting off the block fast, than it is in the water. Reacting quickly to the start signal and correct starting technique may be more important than strength in reducing block time.

When the anthropometry of swimmers was considered, several studies have found significant correlations between body size and swim start performance measures. Disch et al. (7) found that reaction time was correlated with weight ($r=0.54$), height ($r=0.37$), and reach ($r=0.37$) and flight time to 10 feet was correlated to height ($r=-0.45$) and reach ($r=-0.53$) in 30 untrained college women taught to perform a swimming start. These relationships accounted for 26 to 37% of the variance in start performance, the rest being attributed to such factors as leg strength, power, and technique. Height was also found to be important in determining the final time of Olympic swimmers, accounting for 25 to 56% of the variability at the Barcelona Games (1). On the other hand, Zatsiorsky (26) found that block time was not correlated with body size or the jumping ability of the swimmer.

It has been suggested that a longer block time may be advantageous for gaining distance off the block, in that the swimmer has more time to apply force with the legs (8, 18). Havriluk (11) states that “As predicted by the impulse-momentum equation, a longer block time could result in a higher takeoff velocity and ultimately a shorter time to a distance that represented an adequate criterion measure.” Nevertheless, Kollas (16) found no relationship between flight time and block time.

There are other factors besides block time and flight time that influence the success of a start. The “hole” entry, entering through a small hole in the water as opposed to flat, reduces form drag and has been shown to produce faster times to a given distance than the flat entry (25). The glide has also been shown to be an important phase of a fast start (15).

It is clear that a standard method for comparing starts should be adopted by swimming researchers. Reaction time, movement time, block time, flight time, takeoff velocity, and glide angle have been used with varying degrees of success. The most successful approach has been to record the duration from the start signal to a fixed distance, but this distance has not been standardized. Distances of eight feet (17), 12 feet (18), 5 meters (3), 5.5 meters (26), 8 meters (18, 15), 10 yards (5), 20 feet (19), 25 feet (9), and 30 feet (18) have been used in studies to date. Likewise, there is no agreement on which part of the body should be used to determine distance from the end of the pool: feet, hips, head, or hands. Havriluk (11) has suggested that 9.7 meters is a “defensible criterion measure for the swimming start” because this distance was one meter past the point where all members of the sample tested surfaced from the dive (30 men high school and college swimmers). The crown of the head was used to determine distance from the end of the pool. Arellano (1) found very high correlations between start time to 10 meters and event time at the 1992 Olympics in Barcelona. The time for the head to reach a distance of 10 meters should be adopted for future research on swimming starts.

In summary, men and women in the 1996 Olympic 50 and 100 m freestyle events did not differ in block time. Swimmers in the 50 m free were not faster off the blocks than swimmers in the 100 m free. The correlations between block time and total performance time were weak and their interpretation is equivocal. It therefore appears that at the elite Olympic level, the start plays a minor role in deciding the winner of sprint races.
Applications

Based on data obtained from the 1996 Olympic 50 and 100 m freestyle events, elite sprint swimmers, both men and women, leave the starting block in approximately 0.78 seconds after the start signal. Coaches can use this time as a standard against which to compare their own swimmers. However, for elite level swimmers, the time it takes to leave the starting block is not highly correlated with performance time for the entire event. Therefore, to improve start performance, coaches should place more emphasis on reducing the time to reach 10 meters than trying to lower block time by hundreds of a second.

It is suggested that the time for the crown of the head to reach a distance of 10 meters from the end of the pool be used to measure start time in future research on the swim start.

Note:

Block time and performance time for the men’s and women’s 50 and 100 meter freestyle events at the 9th FINA World Swimming Championships held in Fukuoka, Japan were obtained from the FINA web site (www.fina.org/fukuoka_SwimmingResults.html). Results of statistical analysis are presented in Tables 5 and 6. For comparison with the 1996 Olympic data, men who were slower than 28 seconds in the 50 or one minute in the 100 were eliminated from the analysis. Women slower than 30 seconds in the 50 or 1:05 in the 100 were eliminated.

Block time did not differ between the Olympics in 1996 and the World Championships in 2001, for either sex or event. In 2001, men were faster off the blocks in the 100 meter freestyle than women. Block time was correlated with performance time in the 50 meter freestyle for both men and women.

Acknowledgments

Official results were supplied by Rafael Escalas, competition manager for swimming at the 1996 Atlanta Games. Technical information concerning the Omega timing system used at the 1996 Olympic Games was supplied by Bill Fischer of Adolph Kiefer and Associates, Zion, Illinois.

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The Effect of Wetsuits on Swim Performance

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The primary aim of the article “The effect of wetsuits on swim performance” is to quantify the impact of, and illustrate the possible advantages obtained from, using a wetsuit while swimming. The reported performance-enhancing effects that may be realized while wearing any of the various models of wetsuits or bodysuits shows the need for conduction of laboratory-based research to examine the true, measurable, effect. It was found that by slightly minimizing the level of water-induced drag, the total energy expenditure of a swimmer during a race can be substantially reduced. This is a pure case of putting science into practice by examining what is already being done in the pool, and then applying a solid research design to determine if the perceived technological improvements can be translated into a true enhancement in the water.

Abstract

The use of a wetsuit during the swim portion of a triathlon has increased in popularity over the past few years. The purpose of this study was to quantify the impact of both the full-body and sleeveless wetsuits on 800m swim performance. Nine collegiate female swimmers swam three counterbalanced and randomized trials of 800m. Velocity, distance per stroke, swimming efficiency index, heart rate, ratings of perceived exertion, and perceived comfort were recorded for all trials, full-body wetsuit, sleeveless wetsuit, and bodysuits. No significant difference between the trials was found in distance per stroke, ratings of perceived exertion, heart rate, or swimming efficiency index. No significance was found among three different comfort levels between the two wetsuits. Inhibition in kicking occurred in 50% of subjects with the full-body wetsuit and 27.7% with sleeveless wetsuit. However, significant differences were found in velocity between both swimsuits (1.28 ± 0.059 m/sec) and full-body wetsuits (1.31 ± 0.033m/sec), and the sleeveless wetsuit (1.36 ± 0.065 m/sec) and the full-body wetsuit (p < 0.004). These results suggest that the use of a wetsuit compared to a swimsuit can increase velocity while maintaining a constant heart rate.

Index Terms: Swimming, Wetsuits, Triathlon

Introduction

Due to the anecdotal evidence of their benefits, the use of wetsuits for the swimming portion of triathlons is becoming a common practice among participants. Currently the typical tri-athlete comes from a single-event background, usually running or biking, and they often begin the sport with mastery of only one-third of the skills required for success in the triathlon. The transition to the multi-sport event is a demand-
and consequently, may have little competitive swimming experience. Numerous factors are required to improve swimming performance at this age, and the inherent difficulties associated with learning any new skill need to be minimized as much as possible. In some other sports, there exists the possibility of improving the skill through technological and biomechanical aids. During cycling a technologically advanced racing bike can be used, as well as an aerodynamic helmet, or even performance-enhancing clothing as a means to increase cycling efficiency. However, during swimming, there is minimal applicable equipment that can be utilized to create similar performance advantages. One technological edge used to improve swim performance is a wetsuit (4,14). They have been shown to create a reduced level of friction through the water, increase glide, and aid buoyancy by increasing hydrostatic lift (16).

It is well documented that people with higher percentage body fat have a decreased body density, thus causing them to float higher while swimming (4,5). The person with a higher percentage body fat spends less energy staying on the surface of the water and more energy can be utilized for direct propulsion (2). Wearing a wetsuit can also increase buoyancy and decrease surface drag which “frees-up” energy that can then be used for direct propulsion through the water. In 1996, Chataird and Millet (2) showed that for male tri-athletes with lower percentages of body fat (thus higher body density) and little swimming experience, the wetsuit improved swimming performance by over 7%. Additionally, the use of a full wetsuit has been shown to increase swimming performance on both the 400 meter and 1500 meter swim in trained females who presumably have more fatness and better natural buoyancy (5). Chatard, et al. (4) proposed that more highly skilled and less dense swimmers should not benefit as much from wetsuits as do less skilled but more dense swimmers. This raises the possibility that permitting wetsuit use when they are not needed for cold protection would provide a greater boost to poorer and denser swimmers relative to more highly skilled and buoyant swimmers.

Maximum swimming velocity (m/sec) is achieved when the swimmer increases stroke rate but decreases the distance per stroke (7, 8). The help that skilled swimmers get with the use of a wetsuit might translate into a higher distance per stroke and faster times (6,17). Toussaint, et al. (16) found a decrease in drag when a wetsuit was used while swimming. A decrease in drag could be translated into a higher distance per stroke and therefore mimic the swimming mechanics utilized by elite-level swimmers. Additionally, Costill et al. (6) concluded that distance per stroke is one of the major determinants of successful performance in swimming events of 400 y or longer.

The water temperature in which the athletes are going to compete is the determining factor as to whether or not wetsuit usage is allowed. Table 1 shows the guidelines, based on water temperature, used by all events sanctioned by the governing body of triathlon competitions, the International Triathlon Union (ITU) (9). Heat losses need to be minimized to ward off hypothermia, whereas heat gain is also monitored in order to avoid hyperthermia while wearing a wetsuit (18, 19).

Based upon the existing literature, the use of a wetsuit may offer an advantage to tri-athletes. The extent of this advantage over the impact of different wetsuit styles is unknown for skilled, buoyant, female swimmers. It is hypothesized that the use of the full body wetsuit will produce the most improvement in swim performance when compared with the long wetsuits and the swimsuits.

The purpose of this study is to quantify the impact of full suits and sleeveless wetsuits on performance when trained female swimmers use different models of wetsuits compared to common swimsuits when a distance of 800m is covered.

**Methodology**

**Subjects:** Nine young, apparently healthy, female volunteers from the University of Alabama swim team were recruited for this study. Physical characteristics were as follows (mean±SD): age 19.6±1.7 (yr), body mass 63.5±8.13 (kg), height 170.3±5.3 (cm). Before giving written consent to participate, subjects received thorough verbal and written information on the purpose and potential risks of the study. All experimental procedures received approval from the University of Alabama Institutional Review Board.

<table>
<thead>
<tr>
<th>Swim Length</th>
<th>Forbidden above</th>
<th>Mandatory below</th>
<th>Max. stay in water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500m</td>
<td>20°C</td>
<td>14°C</td>
<td>30 min</td>
</tr>
<tr>
<td>1501-3000m</td>
<td>23°C</td>
<td>15°C</td>
<td>1:40 min</td>
</tr>
<tr>
<td>3000 - 4000m</td>
<td>24°C</td>
<td>16°C</td>
<td>2:15 min</td>
</tr>
</tbody>
</table>
Wetsuit characteristics: The wetsuits used in this study were the VÒ2Max Stealth full-body wetsuit and the Elite Sleeveless Longjohn suit (Ironman Triathlon Wetsuits®, New Zealand). These were both compared to the common swimsuits (SS) (Nike Aquatics, Beaverton, OR). The wet suits had varying thickness of neoprene of 5mm at the chest and torso, 3mm for the sleeves and lower legs, 2mm across the back and 3mm incorporated into the X5 material located in the trapezius area. The back of both wetsuits was constructed from a trademark fabric developed by Ironman called X5 Blue Back, which is a material that is described as an ultra-stretch elastic knit with a thin neoprene micro-membrane under it, that is reported to provide a snug fit and flexibility in movement. Different sizes of wet suits were used to ensure that proper fit occurred during the trials.

Pre-Testing Assessment: It was visually determined which swimmers were active kickers (n = 5), and which were passive kickers (n = 4). An active kicker is one that uses a six-beat kick per cycle stroke and a passive kicker is one who uses a two-beat kick. A passive kicker is a more economical swimmer because of less use of the legs, which reduces oxygen usage, but is typically a slower swimmer in terms of velocity (3). Additionally, a familiarization session preceded all the trials in order to get the swimmers accustomed to getting in and out of the suits, and to get a feel of how the suit fits in water to minimize any learning effects.

Testing Procedures: The study utilized a randomized, counterbalanced wetsuit order across each of the three trials. All the tests took place during a three-week plateau in training during the aerobic development portion of their season. Rest interval (72 hrs), time of testing, pretest meal, temperature of water (27°C), warm-up (1000m), and test site (50m indoor pool), remained constant across all three trials. Time to completion of the swim (in seconds) for the 800m swim was recorded, along with time and stroke rate per 50m. Distance per stroke (m/sec) was also calculated. From these measures, a swimming efficiency index, (velocity x distance per stroke) was calculated with higher swimming efficiency index values being interpreted as more optimal swimming efficiency (6). In addition, average heart rate (Polar Vantage XL, Finland), and ratings of perceived exertion (1) were also recorded.

Questionnaire: An interval response scale was utilized to assess both the whole-body comfort, as well as specific body part (chest, neck, and shoulders) comfort. The body parts that were examined for comfort were the shoulder area - important for arm rotation per stroke, the neck area - important for rotation of the head for breathing, chest - important for expansion of the lungs for breathing, and the general overall feel of the wetsuit. This section was used to provide qualitative data regarding which wetsuit offered the greatest level of comfort, regardless of performance. Another questionnaire was designed to analyze whether or not the wetsuit inhibited kicking technique and whether it improved horizontal position in the water. This questionnaire had two subcategories; one section which was completed by the observer and one completed by the swimmer after the end of each trial.

Statistical Analysis: Data analysis was carried out using the Statistical Package for the Social Sciences (SPSS/PC 5.1, Chicago, IL). Results are presented as mean ± SD. A two-way analysis of variance (ANOVA) with repeated measures was used to test for significant differences among the three treatments: full-body wetsuit, sleeveless wetsuit, and swimsuit. An a priori p < 0.05 was taken to be the level of significance.

Results

The mean time required for the swimmers to cover the 800m in the swimsuit was 625.34±24.96 sec, with full-body wetsuit 603±16.8 sec, and with sleeveless wetsuit 585.6±28.8 sec. This translates into a mean velocity of 1.28±0.059 m/sec with the swimsuit, 1.31±0.033 m/sec with the full-body wetsuit, and 1.36±0.065 m/sec with the sleeveless wetsuit (Figure 1). There was a significant difference in velocity among all three conditions (p < 0.05). There was no statistical significant difference among the three suit conditions in distance per stroke (p > 0.05), ratings of perceived exertion, (p > 0.05) or heart rate (p > 0.05). The stroke efficiency index did not show any statistical significant differences between the suits, however the sleeveless wetsuit showed a tendency towards being more efficient when compared with the swimsuit (p = 0.074), between the sleeveless wetsuit and full-body wetsuit (p > 0.05) and full-body wetsuit and swimsuit (p > 0.05). The values for swimming efficiency index were sleeveless wetsuit = 1.68 m²/sec, full-body wetsuit = 1.60 m²/sec, and swimsuit = 1.53 m²/sec.

In Table 2 the comfort scale with different suits for three body parts is depicted along with the percentages rating for comfort for each suit. The Chi Square statistical test that was done had three different comfort levels (very comfortable, moderate, uncomfortable), and among those levels, no significance was found when the swimsuit was used (p > 0.05). A dependent paired t-test was done to compare the differences in percentages between suits and comfort levels. No significant difference was found between the percentage of people who felt very comfortable with full-body wetsuit and sleeveless wetsuit (p > 0.05). No significant difference was found between the percentages of swimmers that felt moderately comfortable (p > 0.05), and uncomfortable (p > 0.05). Anecdotally, the vast majority of the subjects complained during the trials that the full-body wetsuit was too hot.

The results of the questionnaire data for the inhibition of kicking and enhancement of horizontal positioning show that 50% of the subjects experienced inhibition in kicking with the full-body wetsuit and, 27.7% reported inhibition with the
sleeveless wetsuit. In regards to horizontal position, 83.2% percentage of swimmers felt that both the sleeveless wetsuit and full-body wetsuit enhanced horizontal positioning relative to the swimsuit.

Figure 1. Mean velocity (m/sec) of swimmers in each of the suit styles (n=9).

**TABLE 2: Reports of comfort scale with the two different wetsuits.**

<table>
<thead>
<tr>
<th></th>
<th>VC = Very Comfortable</th>
<th>M = Moderate</th>
<th>U = Uncomfortable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Suit</td>
<td>Shoulder Comfort</td>
<td>Neck Comfort</td>
</tr>
<tr>
<td></td>
<td>VC</td>
<td>M</td>
<td>U</td>
</tr>
<tr>
<td>Shoulder Comfort</td>
<td>22.2</td>
<td>33.3</td>
<td>44.4</td>
</tr>
<tr>
<td>Neck Comfort</td>
<td>22.2</td>
<td>44.4</td>
<td>33.3</td>
</tr>
<tr>
<td>Chest Comfort</td>
<td>55.5</td>
<td>22.2</td>
<td>22.2</td>
</tr>
<tr>
<td>Overall Comfort</td>
<td>11.1</td>
<td>67.0</td>
<td>22.2</td>
</tr>
<tr>
<td>*Mean Comfort Score</td>
<td>27.7</td>
<td>41.7</td>
<td>30.5</td>
</tr>
</tbody>
</table>

*Mean comfort score is the average score of all questionnaire items.
Discussion

Contrary to the proposed hypothesis that the full-body wetsuit would provide the greatest increase in performance, the sleeveless wetsuit was shown to give the greatest improvements in swimming velocity. With the velocity increasing 0.08 m/sec, the practical distance advantage in an 800m race is 50.8 meters, or 39.7 seconds faster.

A study done by Trappe et al. (19) concluded that the wetsuits gave a more economical "ride" in terms of oxygen consumption when compared to swimsuits. Oxygen consumption and heart rates are directly related (13) and in our study the heart rates were not significantly different throughout the three trials. The finding that velocity was statistically significant with approximately the same mean heart rates indicates that the swimmers were able to maintain the same utilization of oxygen and increase their velocity.

As reported in previous studies (5), the increase in velocity with the sleeveless wetsuit and full-body wetsuit is likely an effect of the increased buoyancy that swimmers experienced. This increased buoyancy means that the swimmer is able to move through the water with less effort due to the fact that a larger portion of the body was raised out of the water where the density of air has a lower drag coefficient than water (4). The use of both types of wet suits did not show significant difference in distance per stroke when compared with the swimsuit.

The increased buoyancy and hydrophobic material (neoprene) that causes the wetsuit to glide through the water with limited interference explains why both wet suits tended toward having higher distance per stroke values versus the swimsuit, and why a higher horizontal position was obtained. This finding is in agreement with the Toussaint et al., (16) who also found increases in buoyancy due to decreased levels of friction and drag found when wearing a wetsuit as evidenced by an enhanced horizontal position in the water.

Another question exists regarding the effects of different styles of wetsuits on swimming performance at different distances. Cordain and Korpiva (5) noted that their subjects registered complaints of being too hot in the pool water (27°C) while wearing the full-body wetsuit. Although this has been shown not to cause any decrements in performance in the subsequent two events of the triathlon, this remains an issue of relative comfort and perceived psychological success. Studies by both Trappe et al. (18) and Kerr et al. (11) concluded that when the water temperature was at 25.6°C or lower, there is no increase in core body temperature for the male swimmers tested, thus not posing any heat stress threat for the athlete in the later parts of the race. However, the water temperatures in those studies exceeded the limits as set forth by the International Triathlon Union (9). An additional consideration in relation to water temperature is that with longer races, more attention needs to be given to strategies implemented in avoiding heat gain or loss issues with the use of a wet suit. The distance of the swim portion and the temperature of the water should be evaluated before a wetsuit is used (20).

The results in Table 3 show that with the use of a swimsuit, 60% of the active kickers reported an inhibition in kicking and 40% did not. The same results were reported in the trials using the full-body wetsuit. This shows that wetsuits were perceived to inhibit more than half of the active kickers, but due to individual variability in techniques from swimmer to swimmer, these results cannot conclusively be applied to all wetsuit users. Passive kickers using a full-body wetsuit produced mixed results (50% inhibition), but when a sleeveless wetsuit was used, 75% of the participants reported no inhibition. Consequently, for passive kickers, who were predominately distance swimmers, the sleeveless wetsuit apparently did not alter the kicking technique, allowing for a smooth glide with minimal kicking. We can speculate that at high kicking cycles, the wetsuit tends to slightly interfere with the natural mechanics, and at slower kicking cycles, it is less inhibitive, allowing the passive kickers to use their preferred technique without disturbance. These results suggest, again in agreement with Cordain and Korpiva (5), that the greater the amount of wetsuit material, the more inhibition of kicking that can occur.

<table>
<thead>
<tr>
<th>Active Kickers (n = 5)</th>
<th>Passive Kickers (n = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick Inhibition</td>
<td>No Kick Inhibition</td>
</tr>
<tr>
<td>Kick Inhibition</td>
<td>No Kick Inhibition</td>
</tr>
<tr>
<td>LS</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>40%</td>
</tr>
<tr>
<td>FS</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>40%</td>
</tr>
</tbody>
</table>
The increase in velocity when a wet suit was used perhaps was not of a greater magnitude in terms of m/sec due to the fact that the swimmers were already at a high level of swimming performance and there was very little room for improvement. The temperature of the water may also have prohibited the maximal performance of the full-body wetsuit and a study with lower water temperatures might give a different result that favors the full-body wetsuit.

Based on results obtained in this study, it appears that the use of a sleeveless wet suit by skilled female swimmers will produce the highest velocity. In today's highly competitive triathlon events, these increases in velocity can translate into significant practical advantages over those athletes not using a wetsuit.

**Application**

By slightly minimizing the level of water-induced drag, the total energy expenditure of a swimmer during a race can be substantially reduced. The smooth body surface obtained when the swimmer wears a wetsuit can mimic the performance advantage gained from "shaving-down" before a competition. This minor physiological enhancement can also work as a psychological factor and help the swimmer achieve faster times (14).

In the events where drafting is considered legal by the International Triathlon Union, when a female tri-athlete who is a skilled swimmer accomplishes an advantage of 50.8m in an 800m swim with the use of a sleeveless wetsuit she can perhaps get in the first pack of cyclists. The tri-athlete of the same fitness level that does not use the sleeveless wetsuit may miss the first pack of cyclists. During cycling, those competitors that are able to draft expend less energy than single cyclists and produce faster cycling speeds due to the fact that the front position is shared by all the athletes of the group. Because of this swim distance advantage, the first pack to exit the water will be at a distinct advantage over the second group, or second competitor that starts the cycling leg. This makes it imperative to finish the swim portion of the race and get in the leading pack as early as possible to gain the distance advantage. Even in non-drafting triathlons, the distance advantage between athletes may contribute to a win or loss of the event. As it was indicated this distance advantage (50.8m) can be obtained with the use of a sleeveless wetsuit.

**References**

Heart Rate and Lactate Responses to Swimming in Various Drafting Positions

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The article: “Heart rate and lactate responses to swimming in various drafting positions” examines the effect of drafting on indicators of energy expenditure during swimming. The authors showed that when swimming in a 4-person line, the swimmers behind the leader have lower heart rates and blood lactate concentrations. This is an indicator that they expend less energy than the lead swimmer. Being further back in the line of swimmers did not seem to provide more advantage. The importance of this work is in practice situations, where a swimmer often swims only a few meters behind the person in front of them. In such a case, they should be expending less energy than they normally would when swimming at the same pace. When put in a competition, where they are alone in the lane, their times might not be as fast as they had experienced before.

Abstract

This study examined the effects of drafting in swimming on heart rate and blood lactate in collegiate swimmers. Subjects consisted of two groups, one male and one female. Subjects swam eight 400m swims with the swimmers in a straight line. They swam in each position in the line (1,2,3,4) during swims where the subjects were separated by five or ten seconds (5-sec draft and 10-sec draft, respectively). Heart rates were measured immediately post exercise. Lactate levels were measured two min post-exercise. Heart rates were significantly higher in position one in both the 5-sec and 10-sec draft conditions (p=0.015), but were not different between positions two through four. Lactate levels were significantly higher in position one than in position three or four in both drafting conditions (p=0.001), but positions two through four were not different. Results indicate that whether a person is swimming in a 5-sec or 10-sec interval draft the leader of a multi-person draft appears to expend more energy based on heart rate and lactate data. It can be concluded that there is a drafting effect in swimming, but little apparent change in energy expenditure the further back in the draft the person is swimming. These results may have implications for training swimmers when pool conditions dictate that numerous people swim in the same lane.

Key Words: Energetics, Locomotion, Drag, Hydrodynamics

Introduction

One method by which athletes try to lessen the physiological demands of exercise is by drafting. Drafting has been defined as “following closely behind in the air flow, or wake of another athlete (1).” The result of drafting is a lowered air or water resistance, and thus a less demanding performance for the drafting athlete (6). When performed properly, drafting should result in lower energy expenditure at any given speed, conceivably allowing a less skilled athlete to keep pace with an athlete who is actually faster. Drafting has long been a part of cycling, and studies have shown that drafting does decrease the cost of this activity, as well as other activities,
such as running, cross-country skiing, and speed skating (2, 3, 5, 9-12, 14). The research on drafting in swimming has been limited (1, 4).

Swimmers are often put in crowded conditions during practices. Because of crowded pool conditions, six or more swimmers may occupy one lane, which will inevitably result in drafting. Drafting may decrease the energy expenditure during practice. During pool competition, though, the opportunity to directly draft is not present. Drafting during practice could reduce the physiological adaptations that should occur with training if some swimmers drafted more than others. This situation might be detrimental when the athlete must then compete as an individual, suddenly experiencing increased energy expenditure and possibly earlier fatigue. A recent study found that there was a significant reduction in all the measured variables including blood lactate, heart rate, and recovery \( \text{VO}_2 \), while drafting compared to swimming alone (1). Another study showed that swimming triathletes had faster swim times and lower lactate levels when drafting than not (4). These studies did not examine a situation common to the pool setting, however, where lines of swimmers may complete lap after lap in a direct line. The hypothesis tested was that drafting in swimming would decrease the physiological response to a constant speed. We also wanted to determine if the position in a draft line altered the effects seen with drafting.

**Methodology**

**Subjects**

Eight collegiate swimmers (4 male, 4 female) volunteered for the study after giving their informed consent. The study had been approved by the University’s Institutional Review Board for Human Subjects in Research. All were accomplished swimmers and used to swimming in a drafting situation. Subjects trained an average of 5500 meters per day, 5 days per week. Within each group, all were of a similar height (mean ± SD) (males 181.0±7.2 cm, females 164.6±6.4 cm), cross sectional area as measured by a photographic technique (13) (males 863.9±41.3 cm², females 774.8±50.3 cm²) and speed (males 1.34±0.04 m/sec, females 1.29±0.075 m/sec) as determined in the trial swim to ensure that an ideal drafting condition should occur and that one swimmer was not following behind another of greatly different size.

**Swim Trials**

Testing took place in a 50 meter indoor pool with the water temperature held constant at 80°F. On each test day the swimmers swam a standardized 1200 meter warm-up. On day one, each subject performed a 400 meter trial at 100% effort to establish an experimental best time (EBT). This was used to determine the speed at which the swimmers were asked to swim during the drafting trials. Ninety percent of the slowest EBT of the males and the females was the chosen swim speed for that group. Each group (male and female) then performed eight 400 m swims at a speed of 90% of the slowest EBT for that group. Each subject swam as the first, second, third, and fourth swimmer, using a blocked design, where on successive trials the swimmer moved forward one position. Then when they got to the first position in the line they moved to the back. Testing took place on four days, separated by at least 48 hours, with two trials each day. Pace lights (Pacer Products, Batavia, IL) were used to establish and control the speed. The lead swimmer followed lights that flashed in succession along the bottom of the pool, while the other swimmers visually maintained their drafting distance. Heart rates were obtained and blood was drawn for lactate analysis after each swim for each swimmer. During four trials, swimmers were instructed to begin five seconds after the swimmer before them (5-sec draft) and during the other four trials they were instructed to begin 10 seconds after the preceding swimmer (10-sec draft). At the speeds used, this resulted in a distance of approximately six and 12 meters between the swimmers in the 5-sec and 10-sec draft, respectively.

**Measurements**

During the trials, lactate and heart rate were monitored. Heart rate was measured using a heart rate monitor (Polar Accurex Plus HRM, Polar Electro Inc. Port Washington, NY). The swimmers wore the heart rate watch that displayed the heart rate. Heart rates were obtained immediately post (< 5 sec) exercise due to the difficulty associated with stopping the swim to check heart rate at each lap.

Blood was obtained from a finger stick sample two minutes post exercise. The samples were analyzed with a lactate analyzer (YSI 23L, Yellow Springs Inst, Yellow Springs, OH) that was located at poolside and calibrated with 0, 5, and 10 mM standards.

**Statistics**

Means and standard deviations were calculated for the dependent variables blood lactate and heart rate, at each drafting condition for each swimmer. The data were analyzed using a 2-way (position X draft distance) repeated measures ANOVA to determine if differences existed among the trials for any of the variables. Alpha was set at the 0.05 level of significance. When significant differences were found, a Tukey’s post hoc test was used to determine where the differences existed. Separate analyses were not performed for males and females since the target times were similar (see results section).

**Findings**

After performing the 400 m swim trial to determine the EBT, the eight subjects were split into groups of four, one
male group and one female group. The experimental best time for the female group was 5.16±0.13 min (5:10.0) while that for the male group was 4.99±0.14 min (4:59.4). This yielded a calculated target pace for the females of 5:28.5 and for the males of 5:21.3.

The average pace achieved by the two groups was within two seconds of the target pace. The males averaged 5:21.1 and 5:23.3 for the 5-sec and 10-sec draft trials, respectively, while the females averaged 5:28.3 and 5:28.5 for the trials. In no case was the trial more than 4.1 seconds different from the target pace. These differences were not significant based on T-test of the expected vs actual times.

Heart rate data were collected post-exercise for both the 5-sec and 10-sec drafting conditions and are shown in figure 1. There was no significant difference between the drafting conditions (5-sec and 10-sec), nor was there a significant interaction between the drafting condition and the position in the draft (1, 2, 3, or 4). There was a significant difference, however, in heart rate based on the position in the draft (p=0.015). Heart rates were nine beats higher in the first position in the 5-sec draft and four beats higher in the 10-sec draft compared to the other positions. Although there appeared to be a difference between the 5-sec and 10-sec drafting conditions, it was not significant. Post hoc analysis showed that there were differences between the first position and all other positions. There was not a significant difference between any of the other positions, however.

The lactate values taken 2 min post exercise are shown in figure 2. These data followed a similar pattern to that of heart rate, in that no significant differences were found between the 5-sec and 10-sec draft conditions and there was no interaction between the drafting condition and position. There was, however, a significant difference (p=0.001) based on the position within the drafting line. Blood lactate values were approximately 0.5 mM and 0.4 mM higher in the first position in the 5-sec and 10-sec draft respectively than in the other three positions. The post hoc analysis showed significant differences between the first and third and first and fourth positions. Again, the values appeared to be lower further back in the draft line, but the differences were not significant.

**Discussion**

The practice of drafting in some sports has been recognized as a means to lessen the stress placed on the body, thus delaying fatigue (8). Drafting allows for lower resistance to be placed on the body of the drafting athlete, creating a more economical performance (6). The present study attempted to verify that drafting effects occurred during swimming. We also wanted to determine whether the effects occurred at two different distances following the preceding swimmer, and whether the effect was different when following one, two, or three swimmers in a line.

This study used heart rate and lactate levels as measures of intensity of exercise. Results indicated that regardless of whether a 5-sec or 10-sec draft was used, there was a significant decrease in heart rate between the first position and the other positions. This indicates that it is more energetically demanding to swim in the first position in either condition. Even though there was not a significant difference in heart rate between the 2nd, 3rd, and 4th positions, the trend indicates that there was a slight decrease in heart rate in those positions in both drafting conditions. Similar trends, although not significant were seen between the 5-sec and 10-sec draft, with heart rates slightly lower during the 5-sec draft. Interesting was the fact that there was no difference between drafting conditions, indicating that the wave behind a swimmer will allow drafting even for someone 10 seconds behind.

These data agree with the heart rate results of Bilodeau, at al (2, 3) in cross country skiers, who showed a significant decrease in heart rate between the first skier and the drafting skier. Data from Rundell (12) also showed a significant decrease in the heart rate of a drafting speed skater, while similar results have been found in kayakers, as well (7). These results substantiate, but extend, those of Bassett, et al (1) on drafting in swimming. They studied only one person drafting, but found a decrease in heart rate in the drafting swimmer.

The only published study observing a multi-person draft was by McCane, et al (9) in cycling. They found that while energy expenditure was decreased for the drafting rider, there was no difference between drafting in a line behind one, two, or four riders, but drafting behind a pack of eight riders provided greater energy savings. While comparisons are difficult to draw between these studies due to the differences in speed, drafting distance behind the leading person, and the resistance of the medium, the results are similar to those of the current study. That is, drafting provided a significant energy savings, but drafting behind more than one swimmer in a line did not significantly improve on that energy savings.

Lactate levels showed similar results to the heart rate data. Again, the 5-sec and 10-sec conditions were not different. There was a significant decrease in lactate levels between position one and three or four. This decrease in lactate concentration was similar to the decrease seen in heart rate.

Our lactate data also corroborate the results from previous studies on drafting. Rundell (12) found a significant difference in lactate between the lead skater and one drafting. Bassett, et al, (1) and Chatard, et al (4) found similar results in swimmers, in that the trailing swimmer had a decreased lactate concentration compared to the leading swimmer. As mentioned, however, these studies used only a leading and a following swimmer, as opposed to a line of swimmers, and had swimmers following very closely behind the preceding one.
Figure 1: Heart rate values obtained during the five-second draft (●), the ten-second draft (■), and under the combined conditions (▲). * indicates difference of mean condition from position one (p<0.05).

Figure 2: Blood lactate concentrations during the drafting trials. Symbols are the same as figure 1.
The Final Piece ...

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In summary, drafting 5 seconds or 10 seconds behind a leading swimmer appears to decrease the energy requirements of swimming, as shown by lower heart rate and blood lactate data. It was shown that the heart rates in position one of a four-person line were significantly higher than in the 2nd, 3rd, or 4th positions, but the difference among the trailing positions was not significant. Lactate levels were lower in the 3rd and 4th position than in the 1st. No differences in the variables were seen between the 5-sec and 10-sec draft. This was surprising, as it was expected that the wake of the swimmer directly ahead of the drafter would not be large enough to span the distance covered in a 10-sec draft, approximately 12 m.

Applications

The applicability of this study is in its importance to swimmers and coaches. This is the first study to examine the effects of drafting in swimming at various distances behind a leading swimmer and at different positions in a pace line. There exists a very real potential in a pool situation for athletes to be swimming at a lower relative power output thus would be predicted by their lap time. In many cases, swimmers must swim in line within their lanes during training with numerous swimmers in each lane. Such a practice is necessary because of limits in pool time and space, and because of the number of athletes needing to practice at once. In such cases the athletes may swim close (only a few meters) behind a leading swimmer. Coaches, athletes, and scientists have suspected for years that swimming in the wake of another swimmer made the task easier. The present study is the first to show that swimming even six to 12 meters behind a leading swimmer decreases heart rate by 4-9 beats per minute, representing an energy savings in the range of approximately 3-8%.

When this type of training is done, the swimmer, and possibly the coach, would record times per lap and assume a certain difficulty of the task being performed. When the swimmer is in a lane alone, however, to accomplish the same pace requires about 3-8% more energy expenditure. This increased energy expenditure requires the swimmer to either decrease their pace from that which was done during swimming in line or decrease the distance at which they could maintain the set pace. Either option is viewed negatively by the athlete and coach. Future research should be directed to understanding the magnitude of the drafting effect and the effect of drafting distance on the energy requirements.

To avoid some of these complications, it would be suggested that swimmers in lanes maintain as long a distance as possible behind the preceding athlete. This will allow the athlete to keep the intensity of their workout as close to the expected as possible. An alternative to this practice would be to monitor heart rate, either at the end of a set of laps by counting pulse or with a heart rate monitor. Such monitoring of heart rate would document to the athlete and to the coach that the swimmer was working at the desired intensity. While the measuring of lactate, as we did in this study, may be useful, minor changes in energy expenditure will often not show up in blood lactate changes simply because of the variables inherent in blood lactate concentration. These variables include such things as diets composed mainly of carbohydrates or low in carbohydrates, and day to day variability in a person’s response to a work load, and would render blood lactate measurements less useful when determining differences in power output that were likely to be less than 10%.

References


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Bloomington, Indiana

Note

In order to narrow the focus of the In-Print bibliography, we have eliminated some articles that do not contain a significant scientific or research emphasis. This includes the entire Administration, Biography, Facilities, and Sports Law sections plus several articles from the Coaching, General, and Teaching sections. Readers who have a special interest in these areas may obtain a complete listing from the editor of the JSR.

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Safety first teamwork

NEW GRIFF'S GUARD STATION™
by KDI Paragon teams up with the
FIVE MINUTE SCANNING STRATEGY
for increased lifeguard
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The Five Minute Scanning Strategy, available on videotape, was developed by Tom Griffiths, Ed.D., Director of Aquatics and Safety Officer for Intercollegiate Athletics at Penn State University. It was created to help lifeguards stay alert while on the job by using a series of exercises that increase visual awareness.

Griff's Guard Station, developed to complement the Five Minute Scanning Strategy, has a front entry, elevated viewing station, easy access and non-skid surface. The wide front step provides an additional viewing station and brings the lifeguard closer to the pool's edge. The heavy-duty wheels allow convenient and easy portability. Stainless steel and fiberglass construction help assure long lasting and trouble-free service. Available in two unique styles.

Griff's Guard Station is just the latest product of our winning teamwork. Teamwork that's always win-win — with everyone working together: our Paragon people with architects, distributors, contractors, aquatics and facilities managers, coaches, and swimmers.

We’re Paragon Aquatics.
"Swimming Fun Sources"
1. Goal Orientation Theory describes two basic perspectives: 1) _________ where a performer focuses on judging success based on direct comparison and 2) _________ where a performer focuses judging success based on personal, self-referenced comparison with themselves.

2. The two most important fun items reported by age group swimmers are _________ and _________.

3. The results indicated age related trends in swimming fun sources. Receiving medals and awards was an important fun source for the youngest swimmers ages 7-10 years. As swimmers got older, the importance of receiving medals _________ with the age of the swimmers.

"Wetsuits and Swim Performance"
1. Maximum swimming velocity (m/sec) is achieved when the swimmer is able to _________ and _________.

2. Swimming efficiency index, identified as _________ is calculated with higher values being interpreted as having a more optimal swimming efficiency.

3. As reported in the study, wearing a sleeveless wetsuit was shown to give the greatest improvements in swimming velocity. Over an 800m race, this translates into a practical distance advantage of _________ meters.

"Block Time"
1. Mean block time for Olympic 50 and 100 meter freestyle swimmers is about _________ second, to the nearest tenth of a second.

2. Block time accounts for no more than _________ percent of the variability in 50 and 100 meter times for Olympic swimmers.

3. True or false: Men perform significantly faster times in the 50 and 100 meter freestyle events than women because men are faster off the starting blocks than women. _________

"Drafting in Swimming"
1. In this study, drafting behind a preceding swimmer resulted in an average _________ percent decrease in heart rate compared to the lead swimmer.

2. Blood lactate by itself is not likely to be a good predictor of the change in energetics of swimming in cases like this because: _________.

3. Results were _________ between the 5-sec and 10-sec draft conditions. This indicates that by swimming 10 seconds behind a preceding swimmer _________ the drafting ability.
THE JOURNAL OF SWIMMING RESEARCH

MISSION STATEMENT. The Journal is an official publication of ASCA (American Swimming Coaches Association). Manuscripts dealing with original investigations, comprehensive reviews, or brief reviews on the science of swimming and closely related topics, will be considered. This journal is a researcher-to-coach publication. Information presented must be receiver-oriented. Authors must verify in writing that contents represent original unpublished material not under consideration for publication elsewhere.

BRIEF REVIEWS. Authors are encouraged to submit manuscripts suitable for brief review papers that can be used for educating the non-expert on a particular issue or problem. The editor or editorial board will also select brief reviews; however, solicitation is not guaranteed for acceptance.

EXCHANGE FORUM. Readers and/or authors may submit a topic for discussion by experts in a particular aspect of swimming science. The question must be clearly developed and narrowly defined. It must be typewritten, double-spaced and no more than 500 words. The editor or editorial board will solicit a response or responses. The questions will be published pending approval by the editorial board.

LETTERS TO THE EDITOR concerning a recently published article must be typewritten, double-spaced and include an informative title. Three copies are to be submitted. Letters must be no more than 100 words long. The appropriate associate editor reviews the letters. If the letter is acceptable, a copy will be sent to the author of the original article. If applicable; and the author will have the opportunity to provide a rebuttal or additional information that will be considered for publication with the letter.

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