THE EFFECTS OF VISUAL IMPAIRMENT ON COMPETITION SWIM PERFORMANCE

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Several factors contribute to successful swim performance, but how are they affected by impaired vision? The purpose of this study was to examine the relationship between degree of visual impairment and performance variables during the 100m freestyle and backstroke events in Paralympic swimmers and to compare the performances with those of Olympic swimmers. A competition video analysis conducted at the 1996 Paralympic Games showed that performance tends to decrease in all aspects of the race with increasing visual impairment. Continued competition race analyses and delivery of results to the coaches will help in strengthening the competition of Paralympic swimming.

KEY WORDS: swimming, blind, Paralympics, race analysis.

INTRODUCTION: The highest level of competition for athletes with a disability occurs at the Paralympic Games. The Paralympics, not to be confused with the Special Olympics where the focus is on participation, is a competition of elite, world class, well-trained athletes. The Paralympic Games, like the corresponding Olympic Games, take place every two years, alternating between summer and winter sport competition. The events are Olympic events (or equivalents), with modifications of the rules where needed to account for the functional differences of the athletes. The first games for individuals with a disability held in the same venue as the Olympic Games occurred in Rome in 1960 where 400 athletes with spinal cord injury from 21 countries competed (Steadward & Peterson, 1997). Over the years, tremendous growth has occurred as witnessed at the 1996 Atlanta Paralympic Games, where 3195 athletes from 103 countries competed in 19 sports. Various disability groups including spinal cord injured, cerebral palsy, amputee, les autures, mental handicap and visual impairment were involved, oftentimes achieving results comparable to those of Olympic athletes.

Classification. Swimming is one of the most popular forms of physical activity for persons with a disability. At the Paralympic Games in Atlanta, the swimming competition included 374 athletes (243 males, 131 females) from 50 countries competing in 115 individual events. In an attempt to ensure fair and equitable competition, the International Paralympic Committee (IPC) Sports Assembly Executive Committee for Swimming uses a classification system to place athletes into different groups for competition. A unique classification procedure is used for swimmers with physical disabilities, cognitive disabilities, and visual impairment.

For those swimmers who are blind/visually impaired, competition for all events is divided into three classes based on visual acuity, visual field and light perception. Classification criteria are based on the requirements of the International Blind Sports Association (IBSA), the international governing body for athletes with visual impairment. Profiles of each class are outlined below (www.paralympic.org).

Class **B1**: swimmers who are totally blind; may possess light perception, but are unable to recognize hand shapes at any distance (recently changed to Class S11).

Class **B2**: swimmers with visual acuity up to and including 2/60 and/or a field of vision limited to less than 5 degrees (recently changed to Class S12).

Class **B3**: swimmers with visual acuity greater than 2/60 but less than 6/60, or a field of vision ranging from 5 to 20 degrees (recently changed to Class S13).

Coaching. All swim participants deserve the best coaching possible, including those with a disability. At the most basic level of swimming, proper technique is a major factor in developing good habits and preventing the occurrence of injury. As the level of performance increases, so does the need for a thorough understanding of the underlying mechanisms for skilled performance. Sport science in the area of biomechanics has attempted to address these issues with regard to able-bodied swimmers, however, swimming for persons with a disability has not been afforded the same attention, and only recently has it become the focus of scientific research.

Today, as disabled swimmers are being integrated into able-bodied clubs, and as competition at the Paralympic level is increasing, the need for coaches to understand the requirements for successful performance by these athletes is more important than ever. In the case of disabled swimming, not only must the general requirements for each swim stroke be understood, the functional aspects of different impairment profiles (e.g. no arms; paralyzed legs; blindness) must be examined. The various combinations of swim stroke, classification, gender, and individual impairment profile leads to an enormous task for the coach together with sport scientists in developing the proper competition model for a particular individual.

Competition swimming analysis. Competition swimming analysis has been conducted during the Olympic Games since 1988. Such research involves the video recording of athlete performances during competition and the subsequent identification of key performance variables. Data obtained provides comparative information for the coach and athlete such as the effectiveness of starts, turns, and finishes, stroke rate changes throughout an event, stroke length calculations, and measures of clean swimming speed at different points throughout the race. As pointed out by Mason (1999), the results of a competition video analysis can be used to identify where a swimmer's weaknesses exist, to compare performance between swimmers, and to identify general competition models for each event.

Previous research related to swimmers with disabilities had been limited to the examination of performances of those with physical impairment using only end race result (Daly & Vanlandewijck, 1999; Wu & Williams, 1999) or analysis of stroking parameters in one event (Pelayo, et al., 1999). One group of swimmers that had not been the subject of a competition analysis was those with visual impairment. This group of swimmers poses an interesting question as to the affect of impaired vision on performance of a motor skill. Several factors contribute to successful swim performance (i.e., clean swim speed, stroking parameters, effectiveness of starts and turns), but are they all affected the same by impaired vision? It can be hypothesized that visual impairment would have a greater affect on turning ability than stroke rate for example. Hesitancy to hit the wall could decrease turning speed, whereas stroke rate should not be limited by loss of sight alone, but by a combination of other factors (i.e., physiological measures, training background).

The purpose of this investigation, therefore, was to examine the relationship between degree of visual impairment and swimming performance variables during the 100m freestyle and backstroke events in male and female Paralympic swimmers and to compare the performances with those of Olympic swimmers.

METHOD: To examine the performance of visually impaired swimmers and to collect information for additional investigation, a competition swimming analysis was conducted with the approval of the International Paralympic Committee, Sports Assembly Executive Committee for Swimming at the 1996 Atlanta Paralympic Games. Data was collected on all swimmers with visual impairment, as well as those with physical disabilities, during all events (Malone, Steadward, & Smith, 1997).

During competition, eight cameras directly linked to two control panels recorded all swimmers in each heat. The video cameras were positioned in front of the first row of spectator stands running the length of the pool, with six cameras operating into one recorder and two cameras (for stroke rate analysis) operating into another recorder. Cameras were placed perpendicular to the swimming direction at 7.5m, 10m, 15m, 25m, 40m and 42.5m from the start. The distances used for measurement of the various race components and stroking variables agree with those used by Arellano et al. (1994) and suggested by Haljand (1997). Each recorder was operated from a central control panel and videotaping was switched from camera to camera as the race progressed. Video timers were triggered by the starting gun and the official timing system was used to determine time of wall touch at each end of the pool.

Before filming each day, the cameras were calibrated using pre-measured marks on the pool deck. Using a special effects generator, a researcher viewing a color monitor matched a thin white line, which had been added to the lens of each camera, with the markings on the deck. Each camera line represented a given distance from the start and delineated a segment of the race for subsequent analysis. Following an event, frame by frame viewing of the recorded race allowed the viewer to determine the time at which the swimmer's head first crossed the reference line in each camera view.

Data reduction and analysis. Following each event, the data obtained from the video recordings was downloaded into a computer. For the purposes of this portion of the study the 100m freestyle and 100m backstroke events were examined. End race result (ERR) for each swimmer was acquired from the official timing system. All events were analyzed in 25 meter segments and the following swim performance variables were identified from the video recordings: start time (ST), clean swimming speed (CSS), stroke rate, stroke length, turn time (TT), and finish time (FT). ST was measured as the time from the official start to the 10m mark; TT as the time to swim 7.5m into the wall to 7.5m out from the wall; FT as the time to swim the final 7.5m of the race. CSS was calculated for four sections of the race (10 - 25m, 25 - 42.5m, 57.5 - 75m, and 75 - 92.5m), and then combined to determine an average CSS for each lap. Stroke rate and stroke length were each measured at the 25m and 75m marks. Stroke rate was calculated as the average number of strokes completed in one minute, calculated from the time to complete two full stroke cycles. Stroke length, as a measure of distance covered with one complete stroke cycle, was calculated from the stroke rate and clean swimming speed for that length. Similar data was obtained for the top sixteen Olympic swimmers competing in the 1996 Olympic Games (IOC, 1996).

To compare the competitiveness between groups ERR for each swimmer was converted to a point score (Daly & Vanlandewijck, 1999). The point system is based on a function in which the World Record (WR) for each event - gender, stroke, class and distance - receives 1000 points (Van Tilborgh, Daly, Vervaecke, & Persyn, 1984). A constant (C_{event}) specific to each event was then calculated as follows:

$$C_{event} = WR^{(3)}_{event} * 1000.$$

When all the constants were determined, each individual time was assigned a point score specific to the event:

For statistical analysis, ANOVA tests and Spearman correlations were calculated ($p < 0.05$) using SPSS software, while group means were compared using Scheffe post-hoc tests.

RESULTS:

100m Freestyle

MEN: The Olympic swimmers had significantly faster ERR times than the three B classes (B1>B2=B3>Olym). The B1 swimmers were the slowest, with no significant difference between B2 and B3. Conversion of ERRs to point scores, as an indicator of competitiveness within a class, showed that the B1 class was least competitive and the Olympic group the most competitive.

The Olympic group had a significantly faster CSS than all three B classes during both laps (B1<B2=B3<Olym). For all groups, CSS was slower in the second lap. Class B1 had the slowest stroke rate, significantly different from B3 in the first lap and from all groups in the second lap. No significant differences in stroke rate were seen between B2 and B3 during either lap. The Olympic group had a significantly longer stroke length than the B classes during both laps. No significant differences in stroke length were seen between the B classes (B1=B2=B3<Oly). The Olympic swimmers had significantly faster start, turn and finish speeds than the B classes, B1 swimmers being the slowest. There was no significant

difference in turn or finish speed between B2 and B3.
The correlation results showed that, disregarding CSS, turn speed was most related to ERR for classes B1 and B3 (-.81, -.92, respectively), whereas, for class B2 swimmers it was both finish and turn speed (-.86, -.85), and for Olympic swimmers, start speed (-.75). Start speed was also strongly related to ERR for the B1 and B3 classes (>-.72).

Table 1 Means and SD for Race Segment Speeds and Stroking Variables in the Olympic and Visually Impaired Paralympic 100m Freestyle

	B1	B2	B3	Olympic
MEN (n)	12	9	11	16
End Race Result (s)	68.44 (5.6)	61.20 (2.0)[a]	61.08 (1.8)[a]	49.73 (.56)[abc]
World Record (s)	56.67	56.22	55.69	48.21
Point Score*	586 (118)	779 (75)[a]	762 (65)[a]	912 (31)[abc]
Start Speed (m/s)	2.12 (.13)	2.22 (.08)	2.27 (.14)[a]	2.81 (.10)[abc]
CSS(m/s) - Lap 1	1.50 (.11)	1.65 (.04)[a]	1.67 (.05)[a]	2.02 (.03)[abc]
Turn Speed (m/s)	1.48 (.12)	1.70 (.07)[a]	1.68 (.08)[a]	2.09 (.03)[abc]
CSS(m/s) - Lap 2	1.36 (.11)	1.51 (.06)[a]	1.50 (.05)[a]	1.87 (.02)[abc]
Finish Speed (m/s)	1.36 (.15)	1.54 (.11)[a]	1.54 (.07)[a]	1.82 (.01)[abc]
Stroke Rate (str/min)				
Lap 1	47.26 (7.2)	51.84 (3.2)	53.88 (5.8)[a]	50.23 (4.7)
Lap 2	44.33 (5.3)	50.57 (3.2)[a]	49.96 (4.7)[a]	50.16 (4.3)[a]
Stroke Length				
Lap 1	1.88 (.30)	1.87 (.13)	1.83 (.23)	2.39 (.24)[abc]
Lap 2	1.83 (.27)	1.77 (.11)	1.80 (.20)	2.21 (.19)[abc]
WOMEN (n)	11	10	6	16
End Race Result (s)	82.73 (4.4)	72.78 (3.1)[a]	64.56 (4.6)[ab]	55.76 (.60)[abc]
World Record (s)	71.52	60.01	59.88	54.01
Point Score*	656 (95)	566 (69)	817 (161)[ab]	910 (30)[ab]
Start Speed (m/s)	1.71 (.12)	1.80 (.09)	2.09 (.17)[ab]	2.19 (.06)[ab]
CSS (m/s) - Lap 1	1.27 (.05)	1.41 (.08)[a]	1.59 (.10)[ab]	1.80 (.04)[abc]
Turn Speed (m/s)	1.23 (.06)	1.40 (.09)[a]	1.60 (.12)[ab]	1.86 (.03)[abc]
CSS (m/s) - Lap 2	1.10 (.06)	1.28 (.04)[a]	1.43 (.09)[ab]	1.67 (.02)[abc]
Finish Speed (m/s)	1.12 (.08)	1.30 (.06)[a]	1.44 (.12)[ab]	1.66 (.06)[abc]
Stroke Rate				
Lap 1	45.82 (5.4)	51.19 (4.4)	52.70 (6.1)	52.33 (4.9)[a]
Lap 2	43.71 (4.1)	48.37 (6.1)	48.28 (4.7)	50.31 (4.0)[a]
Stroke Length				
Lap 1	1.61 (.23)	1.61 (.13)	1.80 (.26)	2.03 (.17)[ab]
Lap 2	1.49 (.15)	1.59 (.18)	1.76 (.24)[a]	1.98 (.17)[ab]

* a score of 1000 points = world record time

[a] significantly different from Class B1 (p<.05); [b] significantly different from Class B2 (p<.05); [c] significantly different from Class B3 (p<.05)

WOMEN: There was a significant difference in ERR between all groups, with Olympic swimmers having the best times (B1>B2>B3>Oly). Conversion of ERRs to point scores, as an indicator of competitiveness within a class, showed that the B1 and B2 classes were less competitive than the B3 and Olympic groups.
Clean swim speed increased with an increase in class (B>B2>B3>Oly) during both laps. All groups had a slower CSS during the second lap. The B1 class had a significantly slower stroke rate than Olympic swimmers for both laps. There was no significant difference in

stroke rate between the B classes. B1 and B2 had a significantly shorter stroke length than Olympic swimmers in the first and second lap. B1 and B2 had a significantly slower start speed than the B3 and Olympic groups. For turn and finish speeds, there was an increase in speed with an increase in class (B1<B2<B3<Oly).
The correlation results showed that, disregarding CSS, turn speed was most highly correlated to ERR for all three B classes (>-.85), and also the most related for the Olympic swimmers (-.57). Finish speed was also significantly correlated to ERR for classes B1 and B3 (>-.85), whereas start speed was for B2 and Olympic swimmers (-.75 and -.51, respectively).

Table 2 Means and SD for Race Segment Speeds and Stroking Variables in the Olympic and Visually Impaired Paralympic 100m Backstroke

	B1	B2	B3	Olympic
MEN (n)	6	5	6	16
End Race Result (s)	77.93 (5.8)	72.72 (4.1)	72.48 (5.5)	55.79 (.77)[abc]
World Record (s)	69.23	67.27	64.80	53.60
Point Score*	721 (162)	804 (137)	737 (175)	888 (37)[a]
Start Speed (m/s)	1.69 (.18)	1.71 (.08)	1.77 (.15)	2.18 (.08)[abc]
CSS (m/s) - Lap 1	1.30 (.09)	1.38 (.07)	1.41 (.10)	1.77 (.05)[abc]
Turn Speed (m/s)	1.31 (.13)	1.45 (.07)	1.45 (.16)	1.86 (.04)[abc]
CSS (m/s) - Lap 2	1.22 (.09)	1.30 (.09)	1.30 (.10)	1.66 (.04)[abc]
Finish Speed (m/s)	1.21 (.08)	1.33 (.09)	1.29 (.11)	1.69 (.04)[abc]
Stroke Rate (str/min)				
Lap 1	39.23 (4.1)	38.68 (3.2)	40.88 (3.9)	48.30 (3.3)[abc]
Lap 2	37.83 (1.7)	38.26 (3.0)	38.37 (4.0)	47.18 (3.3)[abc]
Stroke Length				
Lap 1	1.94 (.26)	2.11 (.27)	2.02 (.11)	2.18 (.13)[a]
Lap 2	1.91 (.15)	2.04 (.22)	2.00 (.15)	2.08 (.15)
WOMEN (n)	9	8	4	16
End Race Result (s)	90.22 (3.3)	87.56 (7.2)	73.7 (3.3)[ab]	62.82 (.86)[abc]
World Record (s)	82.39	69.76	69.28	60.16
Point Score*	767 (82)	525 (138)[a]	838 (117)[b]	880 (36)[ab]
Start Speed (m/s)	1.41 (.06)	1.44 (.04)	1.84 (.19)[ab]	1.87 (.07)[ab]
CSS (m/s) - Lap 1	1.15 (.04)	1.18 (.12)	1.24 (.16)	1.58 (.03)[abc]
Turn Speed (m/s)	1.07 (.08)	1.21 (.10)[a]	1.30 (.19)[a]	1.65 (.04)[abc]
CSS (m/s) - Lap 2	1.05 (.04)	1.08 (.09)	1.32 (.06)[ab]	1.50 (.02)[abc]
Finish Speed (m/s)	1.06 (.06)	1.05 (.07)	1.52 (.24)[ab]	1.49 (.04)[ab]
Stroke Rate (str/min)				
Lap 1	46.71 (8.2)	42.45 (3.4)	45.25 (4.0)	46.54 (2.8)
Lap 2	44.08 (7.8)	39.79 (2.6)	43.40 (6.1)	44.63 (2.4)
Stroke Length				
Lap 1	1.50 (.33)	1.60 (.15)	1.64 (.36)	2.01 (.11)[abc]
Lap 2	1.44 (.23)	1.67 (.21)	2.21 (.16)[ab]	2.00 (.10)[ab]

* a score of 1000 points = world record time

[a] significantly different from Class B1 (p<.05); [b] significantly different from Class B2 (p<.05); [c] significantly different from Class B3 (p<.05)

100m Backstroke

MEN: The Olympic group had significantly better ERR times than all three B classes (B1=B2=B3>Oly). Point scores indicated that the Olympic group was the most competitive followed by B2, B3 and B1.

The B classes had significantly slower CSSs and stroke rates than the Olympic group during both laps (B1=B2=B3<Oly). The only significant difference in stroke length was seen between B1 and Olympic during the first lap, B1 being shorter. For start, turn, and finish speed, the Olympic group was significantly faster than the B classes (B1=B2=B3<Oly).

The correlation results showed that start, turn, and finish speeds were all highly correlated to ERR for the B classes (>-.82), as was turn speed for the Olympic group (-.87).

WOMEN: All three B classes had significantly slower ERR times than the Olympic group. (B1=B2>B3>0ly). Point scores indicated that the B2 class was the least competitive and the Olympic group most competitive.

During both laps, the Olympic swimmers had a significantly faster CSS than the B classes. In the second lap, B3 was also significantly faster than B1 and B2. There were no significant differences in stroke rate between the groups during either lap. The B classes had a significantly shorter stroke rate than the Olympic group in lap 1, whereas B1 and B2 were significantly slower than B3 and Olympic in the second lap (B1=B2<B3=Oly). Similarly, B1 and B2 had significantly slower start and finish speeds than B3 and Olympic. In turning, B1 was significantly slower than all other groups, the Olympic group significantly faster than the B classes, and no difference between B2 and B3.

The correlation results showed that turn speed was most related to ERR for the B2 and B3 classes (>-.97) and the Olympic group (-.73). Equally important for B3 were stroke rate and length during the first lap (.99). Stroke rate during the first lap was also related to ERR for B2 (-.82). Finish speed was strongly related for B2 swimmers (-.91), and was most important for B1 swimmers (.-78).

DISCUSSION: Unequal *n* and variances between the groups and a low number of participants in some classes made it difficult to detect statistical differences. What is consistently evident is that performance decreases in all aspects of the race with increasing visual impairment. This at least gives some credibility to the classification system used.

In men, nevertheless there was almost no difference in performance between classes B2 and B3 in either backstroke or freestyle. In fact the 100m freestyle WRs hardly differ between class B3 and B2 resulting in no difference in competitiveness. When all male 100m freestyle swimmers were ranked without considering class, B2 swimmers held the 2nd and 3rd places. There was only 0.35s difference between the first two swimmers. The best B1 swimmer was also faster than three B3 and three B2 participants. Of all 32 B class swimmers, only three swam more than 10s slower than the absolute fastest swimmers. In women the fastest B2 swimmer was 10s slower than the fastest B3 swimmers and the B1 first place was 7s further behind. The very best woman, however, would have placed 4th among all men. It could therefore be concluded that the depth of ability of men is much greater than that of women in all classes of 100m freestyle, but that the very best women are relatively better than the very best men, certainly in class B3. It is interesting to note that as many women as men took part in the 100m freestyle, which was not the case for any of the classes in the events for physically disabled.

Backstroke had only half as many male participants as freestyle, while for the women about the same number competed in each event. Actually, in both men and women, only 2 backstroke competitors did not swim the100m freestyle. In men's backstroke the distinction between classes is much more vague than in freestyle. Again, when all swimmers were ranked regardless of class, B3, B2, B3 and B1 held the first four positions, respectively. In women one exceptional B3 swimmer was far ahead of all others, while the B1 swimmers were furthest behind.

Because of the overall small group of swimmers it is difficult to give a definitive answer as to which race part might be more determinant for the ERR. In men's 100m freestyle, the most visually impaired class B1 lost more time in turning than the other groups and did not finish well. In women this group also lost time turning but finished better.

In general, for men and women in both events, the stroking parameters tended not to be as highly related to ERR as was the speed of starts, turns and finishes. With the exception of 100m freestyle for men, the groups showed a similar relationship between SL and CSS as has been seen in functional class swimmers (those with physical disabilities). It should be remembered, however that there is a relatively small range of ERR in the men's 100m free.

In backstroke all visually impaired classes turned slower than the Olympic swimmers, with the B1 swimmers tending to finish the race most slowly. The correlations showed that turn speed was strongly related to ERR for the men and women B classes in both events, and more important in the backstroke, as compared to the freestyle, for Olympic swimmers. Although the visually impaired swimmers receive a signal indicating that they are nearing the wall, and in the backstroke the flags are lowered to 3.5 feet above the surface of the water, hesitancy in order to avoid hitting the wall is difficult to overcome. Coaches should work with swimmers to take advantage of the signal and then use their full capacity to turn and push off without worry. Coming off the turns, the visually impaired swimmers may also tend to swim relatively slowly because of the need to count their strokes, to determine their position in the lane, and the difficulty in maintaining a straight swimming line. These problems may be especially apparent in the backstroke because, unlike the freestyle where athletes are able to use other information for guidance (e.g. the wide black lane line), the swimmers have little reference regarding their position.

Several other factors must be considered in reviewing the performances of these Paralympic swimmers. From a purely theoretical viewpoint, lack of vision alone should not affect the mechanics of the basic swim stroke. Stroking parameters and clean swimming technique should be similar between Olympic and Paralympic swimmers, with the largest differences expected in performance of the turns. As the results of this investigation did not clearly support this hypothesis, and degree of vision did always affect these performances in a predictable manner, the question becomes, what other factors might be involved? A few possibilities include skill level, access to proper training programs and coaches, and physiological characteristics.

First the question must be asked as to whether access to effective training programs and top-level coaches are equally available to Paralympic and Olympic swimmers? If not, are some of the differences in performance due to a lack of proper training regimes and skill development, rather than an effect of visual impairment alone? As noted by Makris et al. (1993), in a study of visual function and athletic performance, hours training and years of participation were significantly associated with swimming performance. Unfortunately, many swim clubs are still unwilling to incorporate individuals with a visual impairment into their programs. Swimmers with visual impairment are often subject to less competitive clubs and inexperienced coaches, and therefore may not be achieving their highest potential. Of course, the total number from which to select visually impaired swimmers for elite competition is also smaller. These factors may be contributing to the discrepancy between Olympic and Paralympic performances and reduced competitiveness within the visual impaired classes. Perhaps if more swimmers with visual impairment are given equal opportunity as those without visual impairment the differences in performance will decrease or at least competitiveness within the groups will increase.

Finally, another factor to consider is looking at the performances of Paralympic swimmers is whether visual impairment of an individual is congenital or acquired. The question must be asked as to whether swimming performance is affected by when and/or how vision was lost or impaired? Although this information was not available for this investigation, future studies will look at performances within and between classes taking into account the conditions surrounding loss of sight.

CONCLUSION: This investigation has provided a preliminary look at the performances of Paralympic swimmers with visual impairment in the 100m freestyle and backstroke events. Further study on all the strokes and a larger number of swimmers is needed to fully understand the affect of visual impairment on swimming performance. Continued competition analysis and delivery of results to the coaches will help in narrowing the field and strengthening the competition of Paralympic swimming.

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Table 3 Correlation of Performance Variables with ERR

	Men 100m Freestyle				Women 100m Freestyle			
	B1	B2	B3	Olympic	B1	B2	B3	Olympic
Start speed	-.74*	-.69*	-.72*	-.75*	-.38	-.75*	-.83*	-.51*
Turn speed	-.81*	-.85*	-.92*	-.67*	-.87*	-.87*	-1.0*	-.57*
Finish speed	-.47	-.86*	-.37	-.60*	-.78*	-.49	-.94*	.06
Stroke length lap 1	-.15	-.23	-.51	-.51*	-.58	-.31	-.43	.22
Stroke length lap 2	-.10	-.37	-.50	-.29	-.43	-.37	-.77	-.15
Stroke rate lap 1	-.32	.12	.40	.30	.17	-.40	.14	-.36
Stroke rate lap 2	-.30	-.48	.42	.20	-.31	.09	.29	.02
	Men 100m Backstroke				Women 100m Backstroke			
Start speed	-.89*	-.82	-.94*	-.25	-.46	-.80*	-.80	-.61*
Turn speed	-.90*	-.90*	-.83*	-.87*	-.68*	-.97*	-1.0*	-.73*
Finish speed	-.88*	-.87*	-1.0*	-.48	-.78*	-.91*	.80	-.56*
Stroke length lap 1	-.37	-.70	-.20	.35	.02	-.82*	-1.0*	.57*
Stroke length lap 2	-.71	-.60	-.43	.46	.12	-.64	-.40	.33
Stroke rate lap 1	-.32	.20	-.77	-.44	-.27	.02	1.0*	-.65*
Stroke rate lap 2	-.03	-.20	-.32	-.62*	-.27	.28	.80	-.45

* p<.05