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Comparison of Four Feedback Methods Used to Help Improve Swimming Relay Exchanges: A Pilot Study

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Relays are a regular part of swimming competitions at all levels and are worth up to twice the points compared with individual events. Relay exchange technique may affect the final time and place of a relay team (Siders, 2010, 2012). The purpose of this pilot study was to compare four methods of feedback provided regarding relay exchanges (time only [TO], time and video [TV], video only [VO], or coach only [CO]) to determine whether any feedback method had a greater effect on improving relay exchange times. Fifteen males (*M* age = 15.357 years., *SD* = 2.7; *M* height = 170.76 cm, *SD* = 12.30; *M* weight = 63.40 kg, *SD* = 7.60), all members of a high school varsity swim team, served as participants in this study. Each swimmer had a minimum of 1 year of competitive swimming experience (*M* competitive = 3.938 years, *SD* = 2.12). We randomly assigned each swimmer to one of the four feedback conditions. Participants performed 12 relay exchanges 1 day a week for 9 weeks. Group exchange order was randomized. Exchanges were videotaped and images temporarily stored on a TiVo DVR playback device. The replay delay time of the TiVo system was set so groups getting video feedback could review their exchange immediately upon exiting the water. The Colorado Timing Relay Judging Pad System (Loveland, CO) was used to determine the exchange time for all groups. A factorial ANOVA determined differences between groups and between week 1 and week 9 performances for each of the conditions. Relay exchange data falling within 0.05–0.20 s were used for analysis. No significant differences ($p < .05$) were found when feedback methods were compared, but the results may have been influenced by small sample size and insufficient statistical power.

Keywords: swimming instruction, swimming strokes, relay exchange, feedback

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Most competitive swimmers at some point in their swimming experience participate as a part of a relay. Swimming relays consist of four swimmers. The first swimmer does a standard forward start from the starting platform for the freestyle relay or a backward start from the water in the case of the medley relay. The remaining swimmers may leave the starting platform, in order, as soon as the swimmer in the water completes that leg of the relay. The swimmer who is on the starting platform may begin the movements of the start before the swimmer in the water completes that leg of the relay. The swimmer on the starting platform must have his or her toes in contact with the starting platform until the swimmer in the water touches the touch pad at the finishing end of the pool. If the outgoing swimmer's feet leave the block before the swimmer in the water touches, the relay is disqualified from scoring in that event.

One of the challenges of a successful relay exchange is to be able to correctly time the movements of the incoming swimmer with the movements of the outgoing swimmer. The outgoing swimmer's start may consist of a weight shift, a weight shift combined with an arm swing, or a weight shift, arm swing, and a step or two to get into the ideal relay exchange position. An ideal relay exchange consists of the incoming swimmer's fingertips touching the finish pad while the outgoing swimmer is simultaneously fully stretched out over the water with only their toes still in contact with the starting platform (Maglischo, 2003). If the outgoing swimmer begins the start too early, they will end up leaving the starting platform before the incoming swimmer touches the end of the pool. Conversely, if the outgoing swimmer waits too long to begin the start, the exchange will be slow, adding valuable time to the relay.

Relays are a regular part of most swimming competitions. Championship swimming competitions can include up to five different relays. College dual meets include at least two relays while a high school meet has three relays which comprise 25% of the total number of events. Whether in dual or championship competition, the relay is worth up to twice the points of individual events making relays strategically important events. Close dual competitions often come down to the final event which is a relay. For this reason, fast relay exchanges can be very important to a team's overall success.

In competitive swimming, event finish times are recorded to 0.01 s. Often, close races are decided by as little as 0.01 s, as was seen in the 2008 Summer Olympics when United States swimmer Michael Phelps won the 100 m butterfly by 0.01 s. In a relay event, the exchange time between the swimmer in the water and the next swimmer can be a determining factor and affect the final relay time and place of the relay team (Siders, 2010, 2012). A faster exchange can lead to a faster finish time. Relay exchange time is measured between the hand touch on the finish pad and the moment the feet have left the starting platform surface. Learning to perform a fast relay exchange may take years of practice on the part of the swimmer. A coach more than likely can play a critical part in the learning of this technique through skill teaching and providing feedback regarding the correctness of the performance.

Feedback plays an important role in the learning of all motor skills. Different feedback methods have been used in an attempt to improve swimmers' relay exchange techniques as well as exchange times. Previous feedback methods have primarily included the coach watching relay exchanges and telling the athletes if the exchange is good, too fast, or too slow. Early use of video feedback was cumbersome for a coach because the coach had to record an exchange, then rewind, and replay

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the performance, sometimes more than once, all of which used valuable practice time. Within the last 10 years, the introduction of the relay judging pad has changed how quickly and accurately immediate feedback can be given to swimmers. The use of a digital video recorder (DVR) allows for immediate playback of the relay exchange without coach involvement. Athletes may use information from each of the feedback methods to make adjustments in the timing of their movements. A lack of current research exists regarding the effectiveness of feedback methods used in the instruction of swimming relay exchanges. The purpose of this pilot study was to determine whether any of four feedback methods had a greater effect than others on improving relay exchange times.

Method

Participants

Participants were 15 boys (age, years. = 15.357 ± 2.7; height, cm. 170.76 ± 12.30; weight, kg. = 63.40 ± 7.60; years of competition = 3.938 ± 2.12) recruited from a local high school swimming team to participate in the study. Proper Institutional Review Board protocol was followed, and each participant and a parent provided consent for participation in the study. Each participant had at least 1 year of competitive swimming experience. Table 1 provides participant demographics by group.

Groups. Participants were divided randomly into four groups and remained with that group for the duration of the study. Group 1, called the time only (TO) group, was able to see their time for each exchange immediately following their entry into the water; Group 2, labeled the time and video (TV) group, was able to see their time immediately *and* see the video record of their exchange; members of Group 3, termed the video only (VO) group, were able to see the video of their exchange but were not given their exchange time; finally, members of Group 4, called the coach only group (CO), received feedback from a swimming coach with 30 years of experience who watched all exchanges and told group members if their exchange was early, on-time, or slow. Exchange times were recorded for all participants of all four groups for all exchanges.

Instructions. Swimmers were told what an ideal relay exchange should look like and were instructed to perform the best relay exchange they could on each trial. The performance order within each group was randomly determined for each data collection day to reflect what might happen in regular competition through a

Table 1 Participant Demographics by Group

	Age (years)	Height (cm)	Weight (kg)	Compete (years)
Time ($N = 3$)	16.67 ± .577	176.10 ± 2.67	64.11 ± 4.59	5.33 ± 1.15
Time and video ($N = 4$)	16.75 ± .50	177.17 ± 6.43	69.51 ± 3.59	4.75 ± 1.70
Video ($N = 4$)	16.50 ± 2.38	166.37 ± 19.28	62.82 ± 6.68	4.25 ± 2.36
Coach ($N = 4$)	14.75 ± 2.22	170.03 ± 9.04	61.01 ± 8.24	1.75 ± 1.50

typical high school swimming season. Swimmers performed 12 relay exchanges during each session with one session per week for 9 weeks. Each swimmer dove off the starting platform, swam 12.5 yards to a bulkhead, and returned to finish for the next person on the starting platform. Testing was continuous until each group member completed 12 exchanges. Group testing order was randomized to reduce the possible effects of training fatigue on exchange performance.

Instrumentation

Participants started from a Paragon Varsity Standard Model starting platform (LaGrangeville, NY). Video data were gathered from the side of the pool using a Sony DCR HC40 mini digital video camcorder connected to a TiVo model TCD540080 Series 2 DVR system where data were recorded to a hard drive and could be viewed by swimmers from appropriate groups on a 27 inch Panasonic monitor while sitting several feet from the starting platform. The video captured the complete relay exchange including the finish of the in-water swimmer and start of the outgoing swimmer. Times for the relay exchanges were collected using the Colorado Timing Classic Relay Judging Pad system which included a Colorado relay judging pad, in-water touch pad, and a digital clock. This relay judging pad system has been accepted for use at NCAA Division I, II, and III national championships. The digital clock displayed the relay exchange time between the finishing and outgoing swimmers. A value of -0.01 s and beyond was shown with a minus sign and was red in color. Any value of 0.00–0.20 s was indicated in green. A value of 0.21 s and greater was indicated in yellow. The digital clock was blocked from view for members of the VO and CO groups.

Data Analyses

Descriptive analyses of the means and standard deviation (*SD*) for participant height, weight, age, and years of competitive experience were conducted. Two-tailed *t* tests were run to determine group homogeneity. T-tests were used to determine differences between feedback groups. All relay exchange data falling within 0.05–0.20 s were used for analysis. Most high school competitions and championship meets do not use relay judging pads but instead use officials who must make a visual judgment as to the legality of the relay exchange. Accounting for the possibility of human error in judgment between 0.00–0.05 s, this study used 0.05–0.20 s as an acceptable time range denoting a good exchange.

Means and standard deviations for relay exchange times were calculated for each group for each day's trials. Two-tailed *t* tests were run to determine the effectiveness of feedback between days 1 and 9. Individual and group time variability between relay exchange trials and days was calculated. Years of experience and percent of trials falling within 0.05–0.20 s were calculated. For analyses described above, an alpha level of 0.05 was used to determine statistical significance.

Results

Two-tailed *t* tests demonstrated the homogeneity of the participants in each group for age, height, and weight across all groups (see Table 2). Significant interactions were found between years of competition for the TO versus CO

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(p = .002) and TV versus CO (p = .046). No significant difference was found between conditions/treatments for relay exchange times for week 1 versus week 9 (see Table 2).

A factorial analysis of variance (4 [group] × 2 [weeks]) was calculated to compare feedback methods using all trials falling within 0.05–0.20 s seconds. No significant main effect or interaction differences were found when feedback methods were compared (see Table 3). Although values were not significantly different among groups, the overall mean relay exchange times across all four groups descriptively appeared to be slightly faster in the week 9 session than in week 1. From a strict statistical testing perspective, however, a lack of significance means that the values should be considered equal.

Groups whose participants had more average years of competitive experience did have a greater percentage of their trials within the acceptable range of 0.05–0.20 s across all trials and days (see Table 4).

Table 2 Comparison of Week 1 and Week 9 Mean Values of Data Points Within Acceptable Range

Group	Week 1	Week 9	T-test *p* Values
Time only	.1386 ± .0496	.155 ± .0576	0.280
Time and video	.1411 ± .0373	.1395 ± .0438	0.910
Video	.14 ± .0418	.1092 ± .0459	0.074
Coach	.1283 ± .047	.1253 ± .0424	0.860

Table 3 Feedback Methods Compared

Groups	Time Only vs. Time and Video Only	Time Only vs. Video Only	Time Only vs. Coach Only	Time and Video vs. Coach Only	Time and Video vs. Video Only	Video Only vs. Coach Only
T-test *p* values	0.751	0.532	0.248	0.205	0.749	0.164

Table 4 Percent of Trials Within Acceptable Range Compared With Participant Years of Experience, Mean Percent

	Time Only	Time and Video	Video Only	Coach Only
Years of experience	5.333 ± 1.155	4.75 ± 1.708	4.25 ± 2.36	1.75 ± 1.50
% time within 0.05–0.20	45.67 ± .0838	44.25 ± .075	35.5 ± .0914	32.5 ± .0719

Discussion

The purpose of this pilot study was to determine whether any of the four feedback methods had a greater effect on improving relay exchange times. The results of this small pilot study showed that none of the four feedback methods was significantly different from others for improving the performance of the relay exchanges. Unfortunately, the small sample size of this pilot study, especially relative to the number of different groups and the short times involved, casts doubt on whether there was sufficient statistical power to actually find significant and meaningful differences if they did exist.

Using data from the 2008 Olympics, Siders (2010, 2012) has demonstrated that the faster relays had faster average exchange times. David Marsh, former Olympic and NCAA Division I coach at Auburn University, sets a goal of 0.15 s for his athletes' target relay exchange time (Stott, 2007). In 2005, Auburn's men's winning relay had a total exchange time of 0.43 s (average of 0.14 s per athlete), while those who finished behind the Auburn team had greater total exchange times (Mills, 2005). Improving relay exchange times may be accomplished with a variety of instructional feedback methods.

Feedback Procedures

Video feedback has been used in a variety of physical education skill instructional settings with mixed results (Jambor & Weekes, 1995; Darden, 1997, 1999; Anderson, Magill, & Sekiya, 2001; Hodges, Chua, & Franks, 2003; Romack & Valantine, 2005). Boyce, Markos, Jenkins, and Loftus (1996) used video feedback with third and fifth graders and found that it was somewhat successful with third graders but more successful with the fifth graders. They concluded that teacher-enhanced video feedback was most successful with their groups. Competitive swimmers and divers are no different. Swimming and diving coaches have recently incorporated a variety of motion capture technologies including video feedback for swimming strokes and diving performances. For this study, both groups using video feedback were able to see their performance almost immediately. There was no additional feedback given by a coach so the participants were left to make decisions on their own or to coach each other while watching the video of their performance. Investigators were surprised to observe random and inconsistent peer coaching in the video feedback groups. More experienced participants were observed to coach less-experienced subjects.

Time only feedback information is commonly provided to competitive swimmers during their training. Coaches have used the timing of relay exchanges as one method of improving the overall time of the relay. A coach may use a point-to-point system in which the incoming swimmer's head crosses a certain point (e.g., crossing under the backstroke flags) and a stopwatch is started. As the head of the outgoing swimmer crosses the same point, the watch is stopped and the time recorded. The faster the time the better the exchange as long as the exchange would not disqualify the relay. The use of the relay judging pad improves the accuracy and precision of the relay exchange information. The investigators assumed that the combination of video and time information would provide the swimmer with a more accurate representation of their relay exchange performance. With this

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precise and multimodal information, participants should have been able to make more precise technique adjustments with fewer additional trials. It is possible that the time and video information required additional guidance about starting strategies to improve their performance. Determination of subject technique adjustment was beyond the scope of this pilot study.

Coach only feedback is frequently the primary method used to teach and improve relay exchanges. In this study, the coach's accuracy in determining the quality of the relay exchange was calculated by comparing the results provided by the judging pad to the coach's statements of too fast, on-time, or too slow. The coach who provided feedback in this study had 30 years of competitive swimming coaching experience at the club, high school, and collegiate levels. Coach accuracy for all trials in the CO group was 64.67 ± 26.64%. No data similar to these exist in the literature.

Limitations

Based on the results of this pilot study, further research is needed to address limitation issues that arose. As with any kinesiology-related research, there were limitations associated with the equipment used in this pilot study. Multiple-step relay starts would tend to cause a system error because the pad could not reset quickly enough to measure the actual exchange time. This underlines the value of using video feedback along with the relay judging pad. The small size of the convenience sample potentially provided a lack of statistical power wherein small effect sizes between groups and between weeks 1 and 9 could not be detected. Swimmers were randomly assigned to groups; however, it may be more important to balance groups based on years of competitive swimming experience. A four-way matched pair design could have provided more equitable groups.

Another limitation that arose involved the amount of information provided to the swimmers who were in the VO and TV groups. All participants were shown a drawing of an example of a successful relay exchange before testing (Maglischo, 2003). No discussion occurred as to which critical features should be observed when reviewing the video feedback. Discussion of critical features before testing may result in improved participant observation skills and notable changes in subsequent relay exchange technique (Jambor & Weekes, 1995; Boyce, Markos, Jenkins, & Loftus, 1996; Darden, 1999; Romack & Valantine, 2005). An unexpected occurrence of intrasubject coaching was detected with the VO group. During testing, participants with more experience tended to informally coach participants with less experience without prompting. In a future study, participants should be instructed as to the amount of peer coaching allowed.

Future Research Questions

System errors were seen in data from the relay judging pad a greater percentage of the time in the TO group compared with other groups. The TO group turned out to have the most competitive swimming experience overall (average years of competition for the TO group = 5.33 years). There may have been more sophisticated starting methods used by these participants compared with less experienced members in the other groups. One example would be the two-step relay start that requires more coordination and practice compared with the other basic relay starts (one-step and no step).

Another question that was raised during data analysis was whether the range of 0.00–0.20 s is appropriate for defining a successful relay exchange. Published conference, national, and Olympic championship data from several hundred Division I and Olympic relay exchanges over the past several years has shown that the average relay exchange time for the 200 free relay is 0.23 s for men and 0.24 s for women. In the 400 free relay, the average exchange times were 0.25 s for men and 0.27 s for women; in the 800 free relay, the exchange times were 0.27 s for men and 0.29 s for women. Does this mean that the precision of the cutoff for a good exchange time as determined by Colorado Timing is realistic given the actual exchange time data?

Obviously, future research should include increased number of participants to determine if one of the feedback methods is better at improving the learning of the relay exchanges. Further research should be done to determine whether specific cues can be used by the swimmer on the starting platform to begin the movements of their start. It is important when using video feedback that participants fully understand the appropriate critical features that lead to the most successful relay exchanges. Further research should be aimed at providing swimmers with methods for evaluating relay exchanges and making technique corrections as necessary. Because feedback was provided immediately following each exchange, it is possible that swimmers became more dependent on the extrinsic feedback and less dependent on their own intrinsic feedback that would help with the adjustments necessary for a better exchange (Darden, 1997).

Conclusions

The purpose of this pilot study was to determine whether any of the four feedback methods had greater effect on improving relay exchange times. Experience seems to play a role in successful relay exchanges which could suggest that regular practice of the relay exchange should lead to improved success of relays in competition. It appears that the guided use of technology might lead to more effective feedback and more consistent practice of successful relay exchanges. This pilot study has raised a number of interesting questions for future research that may be extrapolated to providing feedback in the aquatic and swimming environment broadly.

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