EFFECTS OF BATON EXCHANGE PAIR STRATEGIES ON THE RELAY PERFORMANCE OF COLLEGE STUDENTS IN PHYSICAL EDUCATION CLASS

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We examined the effects of baton exchange pair strategies on the college students‘ relay performance in physical education (PE) class. The subject included 72 students in relay PE class. A multiple regression analysis was conducted by setting 2 x 50 m relay time as an dependent variable and the sum of each personal 50-m run time (50RT) for a baton exchange pair (Σ50RT), delta of each 50RT (Δ50RT), and distance between from the start line of baton exchange zone and the receiver’s position to start running (d_{SL}) as independent variables. All independent variables were significant; the coefficient of determination of the multiple regression model was 0.601 ($P < 0.05$). The Σ50RT as physical resource accounted for 31.6%, Δ50RT for 16.9%, and d_{SL} for 11.6% of the variance of 2 x 50 m run time. Thus, Δ50RT and d_{SL} were considered important in strategy.

KEYWORDS: relay, baton exchange, PE class.

INTRODUCTION: Relay is a unique team item in the track and field. The teamwork in relay includes techniques and strategies that can be considered important in relay practices. Efficient baton exchange requires baton to be passed when the carrier (or the incoming runner) accelerates enough in the exchange zone (Boyadjian et al., 1999) and for the maintenance of the baton speed throughout the race (Maisetti, 1996). On this account, the baton is exchanged at the later stage of the exchange zone (Aki and Salo, 2001).

On the other hand, the 10-m interval between the blue line and the start line of the baton exchange zone was added to the 20-m baton exchange zone as per the revised regulations (IAAF, 2017), such that the baton exchange zone was extended to total 30 m after 2018. If the baton exchange is conducted at the later stage after the receiver’s accelerated run (Aki and Salo, 2001), revised regulation will not bring disadvantage, especially for excellent relay teams. However, in the PE class, there may be strategy, whereby a runner with a high sprint ability runs using the 30-m baton exchange zone effectively, because the relay team consists of runners with apparently different sprint abilities or running readiness. Consequently, it is possible to use different strategies because of the revised regulation in the PE class.

To investigate the strategies of the relay or the baton exchange program from the perspective of the difference in the sprint abilities of the carrier and receiver (i.e., order of the runners) and the use of the baton exchange zone (the receiver’s position to start running), 2 x 50-m relay of a pair of baton exchange was examined. That provides useful information for the PE learner in setting a concrete learning objective such as learning practices that are necessary for shortening the relay time.

The purpose of this study was to identify the effect of the strategy of baton exchange pair on the relay performance in PE class.

METHODS: The subjects included 72 freshmen aged 15–16 year (56 boys, average height: 168.2 ± 6.4 cm, average body weight: 57.5 ± 10.3 kg; 16 girls, average height: 156.3 ± 4.7 cm, average body weight: 49.7 ± 5.5 kg) from the National Institute of Technology college who participated in the relay PE class. The Research Ethics Committees of National Institute of Technology, Fukui College approved this study (#30-6).

The relay unit included 5 classes, with each class lasting 90 min. The guidance of the relay item and the practice of the sprint running were performed on day 1. A 50-m run time was also measured after the sprint running practice. On day 2, based on measuring a 100-m run time, the teacher arranged 18 teams of 4 x 100-m relay such that the sum of personal 100-m run time of 4 runners approximately equaled among the teams. The order of the runners was decided by the runners themselves. On day 3, a 2 x 50 m run time for 54 pairs (3 pairs/team x

18 team) and 4 x 100 m run time (18 teams) were measured as the data for pre-training. Then, the practice of baton exchange was performed on day 4, and the data for post-training same measurements as on day 3 were obtained on day 5. The measurements of 2 x 50 m run time were performed using a straight 100-m lane, including 30-m baton exchange zone to evaluate baton exchange for each pair. In this lane, the baton exchange zone was placed between 30 m and 60 m from the start line.

After obtaining the data for pre-training, the techniques (a, b, and c) and a strategy (except for the order of runners, d) were instructed as follows; a) receiver sets the go-mark (d_{GM}; Figure 1, m) and he or she starts running with maximal effort when the carrier reaches the go-mark; b) the receiver accelerates as quickly as possible and stretches his or her hand high and backward with the palm facing upward when the carrier gives a signal ("hand"); c) the carrier tries to pass the baton by reaching its arm to the receiver (whole distance of the race gets shorter in effect for both length of each arm); d) the receiver decides the position to start running (d_{SL}; Figure 1, m).

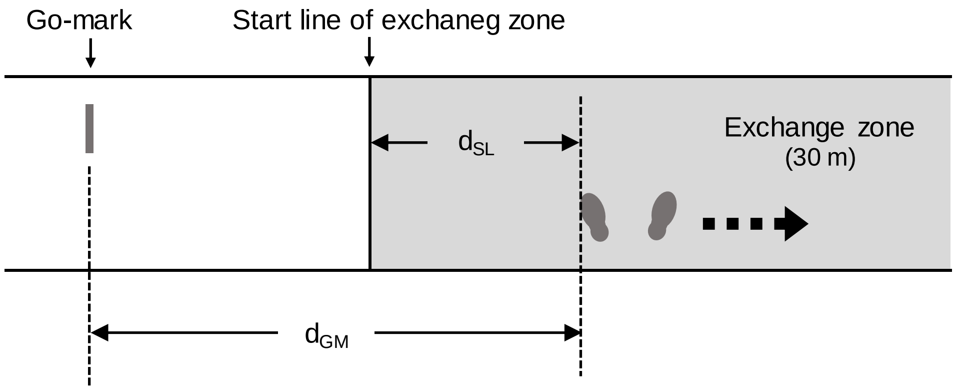

Figure 1: Schematic diagram of the distance from baton receiver to go-mark (d_{GM}) and to start line of exchange zone (d_{SL}).

On day 4, based on the instructions mentioned above, the students were involved in the baton exchange practice (training). The difference of the 50-m run times (50RT) for the carrier and receiver was calculated as follows: Δ50RT (s) = carrier's 50RT − receiver's 50RT. The 1/100 second digital stopwatches were used for all measurements of time in this study.

In this study, the contributions of the strategies to 2 x 50 m run time (relay performance in a pair) were examined by multiple regression analysis (stepwise method). Δ50RT indicates not only the difference in the sprint abilities but also the order of the 2 runners due to its sign. In addition, d_{SL} indicates ≥0 and it brings variations in the running distance of the carrier and the receiver. In these reasons, Δ50RT and d_{SL} were regarded as the strategy factors for 2 x 50 m relay in this study. Furthermore, the sum of 50RT for the carrier and the receiver was added as a physical resource to independent variables with the purpose of comparison among the strategies.

In the multiple regression analysis, data for post-training were used because the techniques (a, b, and c) and the strategy (d) were leaned and fixed in their performances. The independent variables; Σ50RT (x_1), Δ50RT (x_2), and d_{SL} (x_3) were assumed to possess additive relation to the dependent variable (2 x 50 m run time, y), and 54 pairs were investigated. Variance inflation factor (VIF = $1 / (1–r^2)$) did not exceed 0.57 (between Δ50RT and d_{SL}) at the maximum either. The difference in the average value of 4 x 100 m run time (18 teams) and 2 x 50 m run time (54 pairs) were examined using a paired t-test and its effect size (ES) were also calculated. The relationship between Δ50RT and d_{GM} was calculated using Pearson product-moment correlation coefficient. Statistical significances were set at $P < 0.05$.

RESULTS: Significant differences between pre- and post-training in 4 x 100 m run time and 2 x 50 m run time (both $P < 0.05$) were noted, and the relay times were improved after training (pre- and post-training in 4 × 100 m relay time: 59.9 ± 1.3 s and 58.8 ± 0.8 s, ES = 0.83; 2 x

50 m relay time: 15.7 ± 1.2 s and 14.9 ± 1.0 s, ES = 0.68). In the multiple regression analysis, all independent variables were significant (P < 0.05, respectively), and the regression equation was $y = 0.673x_1 - 0.278x_2 - 0.062x_3 + 3.900$. The coefficient of determination of the regression equation was 0.601 (Table 1; P < 0.05); this equation accounted for 60.1% of the variance of 2 x 50 m run time. In addition, calculating from the coefficients of determination and the standardized regression coefficients, Σ50RT accounted for 31.6% (0.601 × 0.696 × 100/(0.696 + 0. 372 + 0.256)), Δ50RT accounted for 16.9% (0.601 × 0.372 × 100/(0.696 + 0.372 + 0.256)), and d_{SL} accounted for 11.6% (0.601 × 0.256 × 100/(0.696 + 0. 372 + 0.256)) of the variance of 2 x 50 m run time. On the other hand, a significant negative correlation was observed between Δ50RT and d_{GM} (Figure 2; r = −0.748, P < 0.05).

Table 1. Multiple regression analysis for determining the 2 x 50-m relay time in Σ50RT, Δ50RT, and d_{SL}.

Independent variable	Regression coefficient	Standardized regression coefficient	Partial F-value	r^2	F-value
Σ50RT (s)	0.673	0.696	63.28*		
Δ50RT (s)	−0. 278	−0. 372	12.33*		
d_{SL} (m)	−0.062	−0. 256	5.79*		
Constant	3.900	1.056	7.59*	0.601*	27.60*

* P < 0.05
r^2 is the coefficient of determination of the regression model.

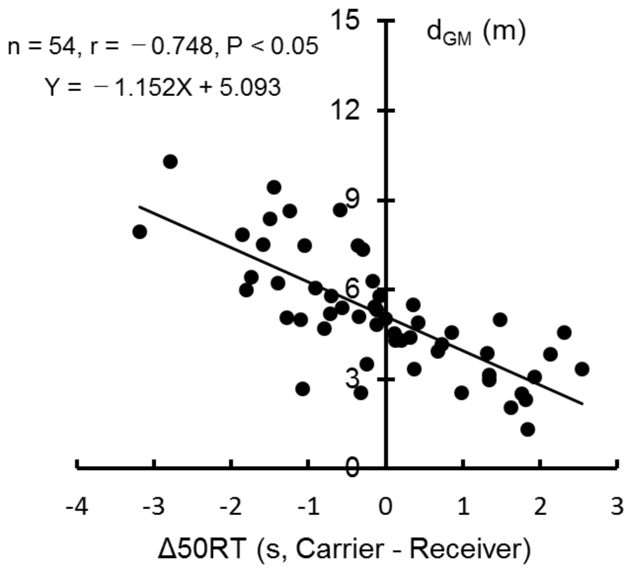

Figure 2: The relationship between Δ50RT (X) and d_{GM} (Y).

DISCUSSION: Baton exchange practice (training) brought improvements in the relay performance on an average of 2% in 4 x 100 m relay time and 4% in 2 x 50 m relay time. It was postulated that the techniques and the strategies of baton exchange would be reflected in the post-training performance. In fact, the receiver set the go-mark in consideration of Δ50RT as shown in Figure 2. Moreover, the difference of 50RT among 4 runners in a team was not small, and there were large variations in Δ50RT. Δ50RT was an independent variable that largely contributed to 2 x 50 m run time (16.9%) after Σ50RT. It was empirically understandable that Σ50RT would be the independent variable that was most accountable for the dependent variable (2 x 50 m run time). Hence, because the sign of regression coefficient of Σ50RT was plus, larger Σ50RT (slow runners) indicates greater (slower) relay time. However, because the sign of regression coefficient of Δ50RT was minus, the relay time becomes smaller (faster) so that the carrier is slower than the receiver (Δ50RT is greater). Furthermore, because the sign of regression coefficient of d_{SL} was minus, the greater distance from the beginning of the baton exchange zone to the receiver's position to start running makes the relay time smaller (faster).

On day 4, students were instructed that the d_{SL} must be set when Δ50RT was minus because a fast carrier could catch up to the receiver. Therefore, the baton exchange pair whose Δ50RT was minus and greater attempted to set greater d_{SL}. In other words, large/small relation of

Δ50RT and d_{SL} was reverse. The baton exchange pair was given an option to not set d_{SL} (d_{SL} = zero) when the receiver is faster than the carrier or set the d_{SL} in proportion to Δ50RT when the carrier is faster than the receiver. However, because the contribution of Δ50RT was greater than that of d_{SL}, the former option was considered valid.
On the other hand, the start position of the receiver (d_{SL}) is also an effective strategy, accounting for 11.6% of 2 x 50 m relay time variance. d_{SL} is a strategy whereby a carrier who has high sprint ability can run long by setting it over zero. Namely, the baton exchange pair is required to set d_{SL} in proportion to the difference in the sprint ability and the order of the runners between the carrier and receiver. In an efficient 4 x 100 m relay race, the baton speed is maintained (Maisetti, 1996) because the baton exchange is done after the 2nd, 3rd, and 4th runners accelerating sufficiently. However, the first runner loses time during the accelerating phase from the starting point. Therefore, it is expected that the fastest runner in a team will cancel out this time loss as much as possible. Our results are applicable only to the order of a pair (carrier and receiver) and do not refer to the order of runners in a 4 x 100-m relay.
In a 4 x 100-m relay race, curve running (Chang and Kram, 2007; Greene, 1985) and the starting response (Collet, 1999) may also affect the relay time. Therefore, it is considered that making selections of the curve runners (the 1st and the 3rd runners) and/or the 1st runner who can overcome the time loss at acceleration during the starting are also important strategies.

CONCLUSION: We investigated the effects of strategies of a baton exchange pair on the relay performance. Consequently, considering the difference in the sprint ability (order of runners) and distance between from the start line of baton exchange zone and the receiver's position to start running (d_{SL}) was regarded as valid strategies to a 2 x 50-m relay performance. Moreover, we propose that d_{SL} not be set when the receiver is faster than the carrier or d_{SL} be set in proportion to the difference in the sprint abilities when the carrier is faster than the receiver. Our findings clarify the purpose of baton exchange practice and suggested the possibility that the learners' training plans and confirmation of its effect would be promoted by group learning in PE class.

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