AN INVESTIGATION OF SCHEMA THEORY APPLIED TO THE BIOMECHANICS OF THE SPRINT START IN ATHLETICS

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Schmidt's schema theory (1975) predicts that variable practice (VP) will outperform constant practice (CP). The implications of this for the teaching of skills such as the sprint start are that VP should allow equal or better learning to CP. The aim of this study was to examine the effect on novice subjects of practicing with varying block settings on the learning of the sprint start. A deterministic model of the spint start was derived using the guidelines of Hay and Reid (1982) to identify factor likely to affect performance. Measures of the factors were obtained using video and laser analysis. The affect of VP and CP on these factors was evaluated using a pre, post retention expermental design. Performance of the sprint start was compared between VP (n=6), CP (n=5), and Control (n=5) groups. Results showed no significant difference (p<0.05) between the VP and CP groups, as both groups improved to the same extent.

KEY WORDS: variable practicee, constant practice, motor learning, reaction time.

INTRODUCTION: Schmidt's schema theory (1975) predicts that variability in practice will facilitate motor learning. In post intervention transfer tests, schema theory predicts that variable practice (VP) will outperform constant practice (CP). This is known as the VP hypothesis (Landin, Herbert & Fairweather, 1993). Many studies have supported the VP hypothesis (Newell & Shapiro, 1976; Moxley, 1979; Shea & Kohl, 1990). Most research has investigated the VP hypothesis in laboratory settings, (Bird & Rakli, 1983; Piggott & Shapiro, 1984; Doddy & Zelaznik, 1988; Shea & Kohl, 1990). The generalizabilty of the theory requires support by evidence from field based studies. The sprint start in athletics presents a useful skill which can be varied by changing block settings.

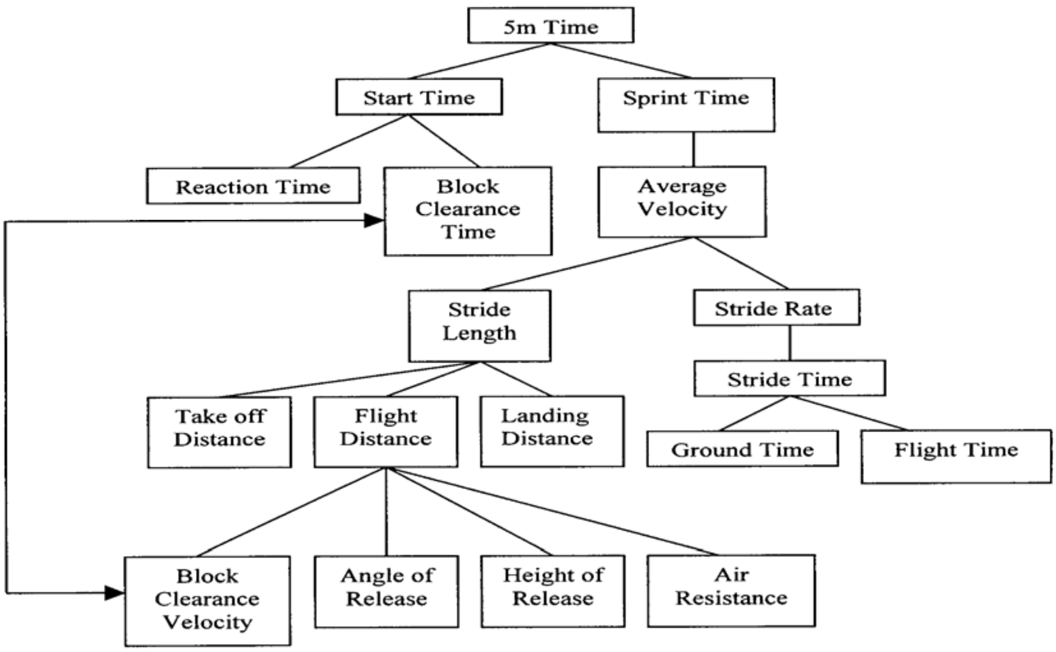

Figure 1: Deterministic model for the sprint start

Most investigators have treated the sprint start as a totally discrete activity that is independent of the total race (Barlow & Cooper, 1972). However, coaches and athletes are cognisant that a good start will affect acceleration patterns up to 30 m into the event.

Therefore, in examining the biomechanics of the activity it is important to consider effects beyond the instant when the athlete loses contact with the blocks. To identify the biomechanical factors that affect starting performance a deterministic model was constricted for the activity using the guidelines of Hay and Reid (1983), see figure 1. This deterministic model considers performance of the start to be based on the time it takes to move 5 m, however, this distance could be extended to any length and in doing so the 'sprint time' component of the performance model would increase.
The purpose of this study was to examine the affects of varying block spacings on the biomechanics of the sprint start in the learning of the skill. It is hypothesised that VP will be equally or more effective in improving technical efficiency in the event and transferability onto a similar task using different block settings.

METHOD:
Participants: Sixteen volunteers (2 male and 14 female) who considered themselves as beginners never having performed a sprint start were selected as participants in this study. All participants completed a familiarisation session where they completed several sprints from blocks and decided upon their preferred block settings. Participants were randomly assigned to three groups: Control, CP, and VP.
Intervention: The VP and CP groups underwent a 9-session intervention period over 5 weeks, with 2 sessions per week. In each session CP and VP groups performed 10 maximal effort 20 m sprints from blocks. For the CP group, all 10 trials were at fixed block settings established in the familiarisation session. The VP group varied their block positions over the 10 trials. The variable positions were designed to allow the athlete to practice at a range of bullet, medium and long positions as defined by Warden (1986). The control group did nothing except their normal physical activity. Each group practiced separately without knowledge of what other groups were doing.
Testing: The study incorporated a pre, post and retention test design. The pre test was completed immediately after the familiarisation session, the post test was completed immediately after the intervention period and the retention test was completed two weeks after the end of the intervention period. Reflective tape markers were placed the toes of the particpants shoes and also on side of their body just above the hip joint. In all tests the participants performed 5 maximal effort, 20m sprints. The participants set position and first 3 strides were recorded using a Canon Pal-MV600i digital camcorder placed at right angles to the start position. A Jenoptik Laveg model LDM 300laser, (Optik system GmbH) was placed behind the participants and obtained measures of distance during the sprint at sample rate of 100 Hz.
Data Analysis: All video data was analysed with the Peak Motus™ video analysis system, (Peak Performance Technologies Inc., Colorado). The following variables were obtained using the video data: Reaction time (RT), movement time (MT), block clearance time (BCT), block clearance velocity BCV, and the stride length for the first three strides of the sprint, ST1, ST2, and ST3 respectively. The following variables were obtained in Microsoft Excel by analysis of the laser distance data: Time to 5 m (T5), velocity at 5 m (V5m), Peak Velocity (PV), Time to Peak velocity (Tpv), Distance to Peak Velocity (Dpv), Average Velocity (Ave.Vel.), Time to 20m (T20).
These parameters were statistically analysed in SPSS 11.0, using General Linear Model, ANOVA with repeated measures. The GLM ANOVA had one between-subjects factor, namely group with 3 levels (control, VP and CP), and two within-subjects factors, namely phase with 3 levels (pre, P and Ret. tests) and trials with 5 levels. Alpha was set at the $p \leq 0.05$ significance level.

RESULTS: The results showed no significant difference ($p<0.05$) between the VP and CP groups in test performances, as both groups improved to the same extent. The difference between PV pre and P test scores for the CP group were found to be significant ($p<0.05$). Table 1 shows the group means for all tests. The CP group mean PV improved from 6.12 ms^{-1} to 6.33 ms^{-1} ($p=0.002$). The VP group did improved the group mean PV of 6.17 ms^{-1} to

6.33 ms^{-1} but this was not significant (p=0.06). Control group means for PV were better than the VP and CP. This superiority was evident in the pre-test, indicating a difference in participants' ability within the allocated groups.

Table 1: Variables of Significance (*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001).

Measure	Practice type	PRE	POST	RETENTION
Peak Velocity (ms^{-1})	V.P	6.17	6.33	6.21
	C.P**	6.12	6.33	6.25
	C	7.23	7.28	7.06
Time to Peak Velocity (s)	V.P*	3.31	3.59	3.40
	C.P	3.49	3.71	3.46
	C	3.27	3.41	3.32
Distance to Peak velocity (m)	V.P***	14.04	16.69	15.45
	C.P	15.17	17.65	15.88
	C	16.40	17.80	16.88
Time to 20m (s)	V.P**	4.34	4.13	4.19
	C.P***	4.30	4.11	4.18
	C	3.79	3.73	3.77
Average Velocity (ms^{-1})	V.P**	4.62	4.76	4.79
	C.P	4.67	4.81	4.82
	C	5.24	5.32	5.32

The VP group significantly changed between pre and P tests in Tpv and Dpv (see table 1). T20 saw both VP and CP groups significantly improve from pre to P tests. Group improvements were VP= 4.34 s - 4.13 s, and CP= 4.30 s - 4.11 s (see table 1). Ave. Vel. for the CP group improved significantly from pre to P (pre: 4.67 $m.s^{-1}$, P: 4.81 $m.s^{-1}$). There were two trends among all variables that seemed to be evident. Trend 1: the group deteriorated from pre to post test, then improved from Post test to Ret., resulting in an improvement from pre-Ret. Trend 2 (more common): the group improved from pre-P, then deteriorated from P-Ret, resulting in an improvement from pre-Ret. (see table 2).

Table 2: Variable Trends. I: Improved, D: Deteriorated, (*p < 0.05, **p < 0.01, ***p < 0.001).
A specific Trend: D, I, I A specific Trend: I, D , I

	VP			CP		
VARIABLE	Pre-P	P-Ret	Pre- R	Pre-P	P-R	Pre- R
Reaction Time	D	I	I	D	D	D
Time to block clearance	D	I	I	D	I	I
Block clearance velocity	I	D	I	I	D	I
Stride length 1	I	D	D	D	I	I
Stride length 2	I	I	I	I	D	I
Stride length 3	I	D	**I**	I	D	I
Time to 5m	D	I	I	D	D	D
Velocity at 5m	I	I	I	I	I	I
Peak velocity	I	D	I	**I****	D	I
Time to peak velocity	**I***	D	I	I	D	D
Distance to peak velocity	**I*****	D	**I***	I	D	I
Average velocity	I	I	I*	I*	D	**I***
Time to 20m	**I***	D	I**	I**	D	I*

DISCUSSION: All significant changes occurred later in the sprint after the participants had cleared the blocks. The magnitude of the scores on these variables was greater, allowing for a greater training effect. Alternatively, the accumulation of small improvements in earlier variables may have resulted in significant differences in later variables. Variables that changed significantly from pre to post tests were: PV, Tpv, Dpv, Ave.Vel, and T20. All changes in the above variables were improvements. PV, Tpv and Dpv are all directly related. PV occurred between 14-20m. Tpv is the accumulation of time from start to PV. Changes in Dpv from 14-20m resulted in changes in Tpv. Schmidt (1975) recognised the transfer test as the ideal test of VP learning. The transfer test should vary from the criterion task but be of the same class. It is possible that transfer test used in this investigation (different block spacing) did not provide sufficient novelty to test the stability and transfer of learning. Furthermore the physical limitations in variability of the block settings in the VP sessions may not have been sufficient to cause an evident change in performance. It is however noteworthy that VP did not cause any decrement in learning when compared to the more commonly used constant practice procedures.

CONCLUSION: The present study provides limited support to the schema theory since the VP condition proved as effective as CP in the learning of the sprint start, among novice sprinters. The study supports growing links between biomechanics and motor learning psychology. Future studies exploring motor control and learning should use biomechanical techniques as a method of evaluating changes from pre to post and retention tests.

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