FORCES AT THE FRONT AND REAR BLOCKS DURING THE SPRINT START

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Five male sprinters (mean ± SD: age 21.0 ± 0.5 years; height 1.80 ± 0.07 m; body weight 763 ± 29 N) started a sprint using different combinations of front and rear block angles. The vertical and horizontal forces at the front block were significantly greater with the 300 block than with the 40° or 50° blocks, and sprint speed using the 300 front block was significantly higher over 10m and 5m than with 40° or 50° ($P<0.05$). The greatest overall mean force for both blocks occurred using the 30° front block and the 50° rear block, followed by the 40° front block angle and 50° rear block angle. The 50° rear block gave the greatest vertical and horizontal force with the front at 30°, 40°, and 50°. A correlation of 0.81 was found between front block force and sprint time ($P<0.05$).

KEY WORDS: athletics, blocks, sprinting, start, time.

INTRODUCTION: In sprinting the efficacy of the start is crucial to race performance. One of the factors influencing the start is the ability of the athlete to attain a high force generation at the starting blocks. In 1997 Harland & Steele published a review and discussion of scientific investigations into the sprint start, and identified that one of the most detailed studies was conducted by Mero et al. (1983). This latter study was one of the few that allowed the performance at the front and rear blocks to be considered within a single start.
The aim of this current study was to evaluate the influence of different combinations of front and rear block angles upon horizontal and vertical force generation at each block, and to consider the forces in relation to the sprinting speed in the initial phase of the start.

METHODS: Five sprinters gave their written informed consent to participate in the study following an explanation of the testing procedure and familiarisation with the recording equipment. Their physical characteristics were mean SD: age 21.0 ± 0.5 years; height 1.80 ± 0.07 m; body weight 763 ± 29 N. The participants wore their own personal shoes and clothing, and the spacing between the blocks was constant for each subject.
Two 0.6 m by 0.4 m Kistler type 9851 piezoelectric force platforms (Kistler, Alton, UK) were situated within a section of a specially designed outdoor polyflex surface (International Amateur Athletics Federation Standard). The two platforms were recessed into the track surface and were covered with a 0.017m polyflex layer adhered to an aluminium sheet, which was mounted on to the top plate of each force platform. Competition standard Cantabrian starting blocks for the front and rear foot were mounted seperately onto the polyflex surface above each of the force platforms. These blocks allowed the rear and front foot block angle to the horizontal to be varied independently with 10-degree intervals. The force platforms were connected to Kistler 9865 amplifiers located at the side of the track. The acquired force platform data were converted to digital form and sampled at 500 Hz for a three-second period using Provec 5.0 software (Orthodata, Ludenschneid, Germany) running on an IBM compatible personal computer (Viglen, Alperton, UK) fitted with a 12 bit analogue to digital converter (Amplicon, Brighton, UK). Cla-win infrared timing gates (University College Chichester) were placed immediately parallel to the starting blocks and at 5 metre intervals to determine sprint speed over the first 5 and 10 metres. A Panasonic video camcorder recorded a sagittal view of the initial strides to aid analysis.
During data acquisition the subjects used their own preferred starting position upon the blocks. After a period of familiarisation each subject performed two starts at maximum intensity when one of three front block angles to the horizontal (30 degrees, 40 degrees, and 50 degrees) was set in combination with 50 degrees, 60 degrees and 70 degrees on the rear block. A selected range of block angles was used to avoid fatigue undermining data quality. The order of testing was randomised for each subject. The start was initiated by an audio signal and the fastest trial was selected on the basis of speed at 5 metres. Force data were analysed to determine mean peak horizontal and vertical force levels occurring during the start at both the front and rear foot.

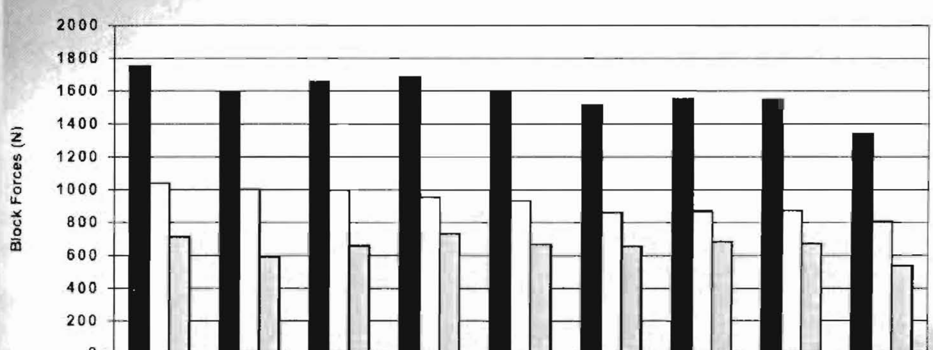
Peak force data were calculated in terms of each individual's body weight. Analysis of Variance with repeated measures was performed with a Bonferoni adjustment to examine significant differences (2-tailed) in force production and sprint speed with the different combinations of front and rear block angles.

RESULTS: The measured force data are summarized in the following table.

Table 1 Mean peak horizontal and vertical ground reaction forces (±SE) at the front and rear block for selected combinations of rear and front block angles.

Block Angle °		Front block Peak Force (N)		Rear block Peak force (N)	
Front	Rear	Horizontal	Vertical	Horizontal	Vertical
30	50	602 ± 62	845 ± 71	526 ± 47	481 ± 33
	60	607 ± 58	795 ± 77	429 ± 36	407 ± 35
	70	593 ± 39	799 ± 71	456 ± 31	475 ± 24
40	50	553 ± 58	776 ± 47	513 ± 20	523 ± 27
	60	554 ± 63	746 ± 68	485 ± 18	456 ± 28
	70	539 ± 41	668 ± 61	467 ± 72	456 ± 33
50	50	540 ± 57	680 ± 92	472 ± 35	496 ± 32
	60	543 ± 33	678 ± 88	468 ± 45	482 ± 22
	70	490 ± 62	635 ± 77	371 ± 50	384 ± 29

These measured horizontal and vertical forces at the front and rear blocks were used to calculate front and rear block resultants, and also overall force for each combination of both front and rear block as shown in Figure 1.



	30F 50R	30F 60R	30F 70R	40F 50R	40F 60R	40F 70R	50F 50R	50F 60R	50F 70R
■ Both	1754	1595	1655	1689	1600	1515	1555	1545	1341
□ Front	1041	1001	996	955	933	860	869	872	804
□ Rear	713	594	659	734	666	655	685	673	537

Figure 1: Mean forces in the horizontal and vertical planes exerted on the front and rear blocks together during a sprint start, with additional detail of the resultant forces occurring at the front and rear blocks individually.

The greatest overall mean force for both blocks occurred for the 30° front block in combination with the 50° rear block as shown in Figure 1, followed by the 40° front block angle and 50° rear block angle. Relatively the 50° rear block angle gave the greatest mean horizontal and vertical force with the front block at 30°, 40°, and 50°. The mean vertical and mean horizontal forces at the front block were significantly greater with the 300 block than with the 400 or 500 blocks, and mean sprint speed at the 300 front block was significantly higher over 10m and 5m than with the 40° or 50° front blocks ($P<0.05$).

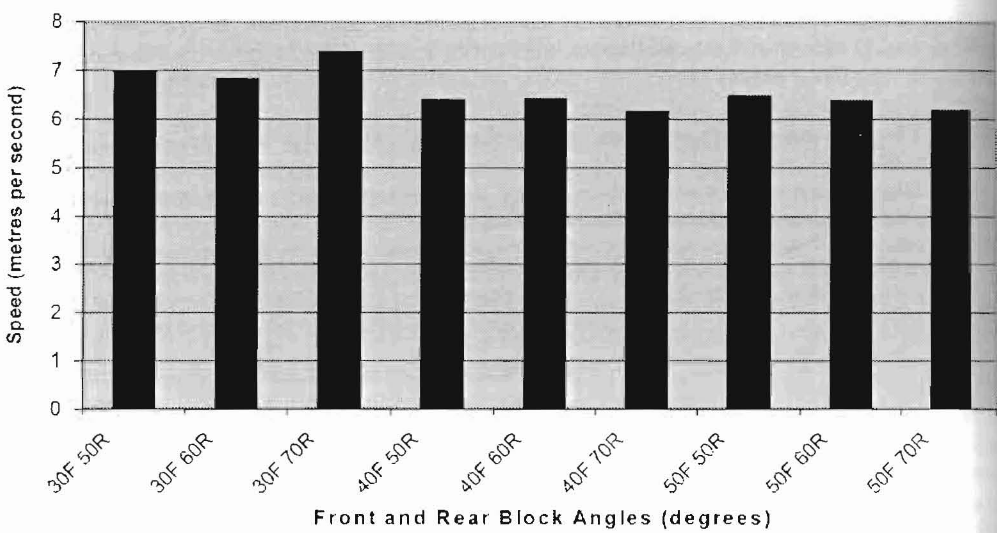


Figure 2: The speeds (ms-1) reached at 10 metres for different block angles.

The fastest mean speed at 10 metres occurred for the 30° front block as shown in Figure 2. A relationship of the mean speeds at 10 metres to recorded overall front block Pythagoras resultant of horizontal and vertical force was evident. After plotting the data shown in Figure 3 a Pearson correlation of $r = 0.81$ was revealed ($P<0.05$).

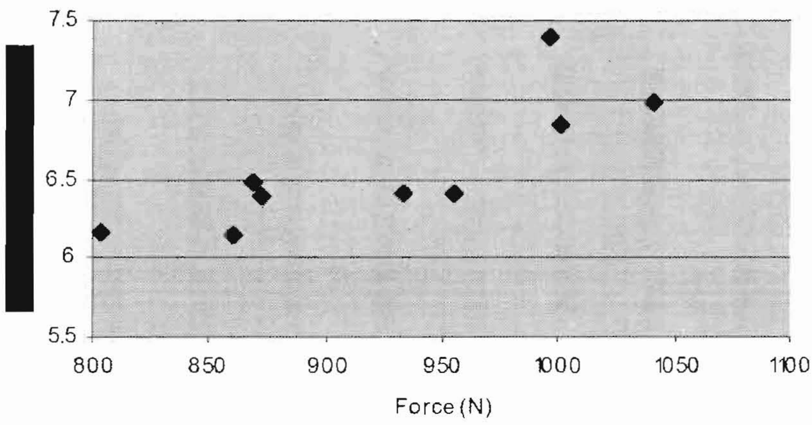


Figure 3: Scatter plot showing the relationship between the mean speed at 10 metres and the front foot resultant of the vertical and horizontal force components.

When the mean speeds at 5 metres were considered, as illustrated in Figure 4, it was evident that performance with the 30o front block was much faster whatever rear block angle was adopted, between 500 and 700 degrees.

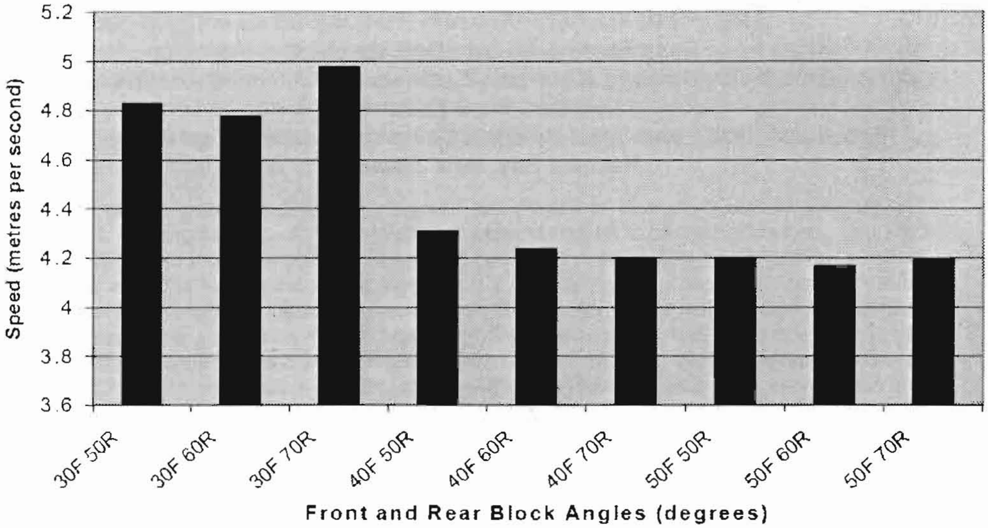


Figure 4: The mean speeds (ms-1) reached at 5m for different block angles.

DISCUSSION: The results support the importance of the relationship between force generation at the front and rear blocks and sprint time. It has highlighted that a 300 front block angle significantly aided force generation and sprinting in the initial phase of the race and also the importance of the choice of a 500 rear block angle when a front block angle of 300 degrees was used. In addition it has supported the relatively greater importance of the front block angle to force generation for propulsion. Interestingly the adoption of the 700 rear block angle with the 300 front block seemed to give an advantage in sprinting time, which might be related to aiding a more upright position of the sprint. The finding that performance in terms of speed was the best with the 30o front block angle (followed by 400 and 500) concurs with the electromyography study performed by Guissard et al. (1992), which reported an improved starting velocity and acceleration as front block angle decreased. The lower block angles were considered to aid the eccentric-concentric action of the medial gastrocnemius during the start movement.

CONCLUSION: The vertical and horizontal forces at the front block were significantly greater with the 300 block than with the 400 or 500 blocks, and sprint speed at the 300 front block was significantly higher over 10m and 5m than with 400 and 500 block obliquities ($P<0.05$). The greatest overall mean force for both blocks occurred with the 30o front block in combination with the 50o rear block, followed by the 40o front block angle with the 50o rear block angle. Setting the rear block at 50o gave the greatest vertical and horizontal force with the front block at 30o, 40o, and 50o.

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