

# BIOMECHANICS OF ELITE JUNIOR RACE WALKERS

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The elite junior race walker is less studied than the infrequently studied senior race walker. Data collection and analysis of the younger walker might be of some value to coaches and biomechanists in studying the development of young athletes aside from the obvious benefits to a particular competitor. What parameters of style might be exhibited by the younger walker? How do these parameters differ among the elite junior walkers? How might the studied parameters change with fatigue during competition. This exploratory study, the initial phase of ongoing research into the dynamics of the sport, focuses on stride lengths, stride frequencies, arm angles and foot strike angles.

## Method

The investigation was performed by filming during competition using a 16mm Canon Scoopic camera. The film speed (48 fps) was checked by filming a falling ball and calculating segmental accelerations. Reference measurements were a marked meter stick and track markings where appropriate. Analysis of the film was done by standard hand tracing techniques using a Recordak viewer.

## Subjects

Eight elite junior male race walkers were studied in competition in this investigation, six in competition during an international 10,000 meter track race held in July, 1983 at New Britain, Connecticut and two during the National Championship 3 Kilometer race for junior men also held in July at Ledyard, Connecticut. Of the six, two each were representing Italy, Canada, and the United States. The remaining walkers were two of the top non-qualifiers for the United States Junior Team. Films were taken of the eight during the competition without their knowledge, thus ensuring realistic competition conditions. All measurements, including heights of individuals, were taken from film analysis.

## Procedure

During the 10,000 meter race, film was taken of the 2nd, 9th and 17th lap, these being most representative of the beginning, middle and latter part of the race of those portions filmed. The camera was set up to view an opening in the border on the turn, just past the midpoint of the first turn. Any film of the race taken after the 17th lap was not used since not all of the competitors were included. The 3 kilometer race was conducted on a level 1,000 meter loop which included a track as part of the loop. The filming was done at the completion of the track part of the loop during the entrance to the last lap, starting the final thousand meters. The analysis, in all cases, was done on a five meter segment, either side of camera center. In the film analysis, the crotch height was estimated from the inseam leg length while extended. Normal joint marker positions were estimated and care taken that the measurements were consistent. The foot strike angle for the right foot was taken, as the toe was more easily measured than that for the left.

## Results

The final order of finish in the 10,000 meter race was, in order, subjects 1, 2, 4, 5, 3, and 6. The walkers in the 3 kilometer race finished in a virtual dead heat, although subject 7 was leading at the end of two kilometers.

The stride lengths listed in Table 1 are somewhat unimportant by themselves since stride length will vary with leg length and velocity. Table 1 is included here for reference purposes.

The results shown in Table 2, the ratio of stride length to apparent crotch height, appear significant in two respects. First, a mean of .97 among this group of walkers seems to indicate that stride length is approximately equal to crotch height. Also, the mean stride length to apparent crotch height of each individual ranks each in order of finish, the exception to the order being subject number three or six.

Stride frequency, Table 4, varies little throughout the competition. If this is the case, then the determinant of success would be stride length and the ability to maintain optimal stride length at a constant velocity.

Unfortunately, the range of motion of the arm shows little consistency, as shown by the first part of Table 5. Besides providing balance to the act of walking, arm rotation should also complement stride length and stride frequency. The fact that subject 1, the winner of the 10,000 meter race, had the greatest range of motion may be of some significance, but it is unsupported by measurements of the other subjects. Arm rotation measurements were clearly affected by the amount of crossover toward the midline of the body by each subject. Inspection of the film shows a wide variety of styles in this area.

Table 1 Stride Length (meters)

Subject	lap 2			lap 9			lap 17		
	left	right	total	left	right	total	left	right	total
1	.76	.82	1.58	.75	.80	1.55	.73	.84	1.56
2	.84	.84	1.67	.84	.87	1.71	.82	.84	1.65
3	.78	.75	1.53	.73	.78	1.51	.75	.76	1.51
4	.78	.76	1.55	.76	.80	1.56	.76	.78	1.55
5	.73	.78	1.51	.82	.87	1.69	.76	.80	1.56
6	.82	.82	1.64	.73	.76	1.49	.73	.75	1.47
7 (2k)				.91	.87	1.78			
8 (2k)				.93	.91	1.85			

Table 2 Ratio Stride Length/Apparent Crotch Height

Subject	lap 2		lap 9		lap 17		mean
	left	right	left	right	left	right	
1	1.05	1.13	1.03	1.10	1.00	1.15	1.08
2	1.00	1.00	1.00	1.04	.98	1.00	1.00
3	.91	.87	.85	.91	.87	.89	.88
4	1.00	.98	.98	1.02	.98	1.02	1.00
5	.85	.91	.96	1.02	.89	.94	.93
6	.98	.98	.87	.91	.87	.89	.92
7 (2k)			1.00	.95			.98
8 (2k)			1.00	.95			.98

Table 3 Velocity (meters/second)

Subject	lap 2	lap 9	lap 17
1	3.6	3.7	3.6
2	3.6	3.9	3.8
3	3.5	3.5	3.3
4	3.7	3.6	3.5
5	3.5	3.9	3.6
6	3.7	3.3	3.1
7 (2k)		3.9	
8 (2k)		4.2	

Table 4 Stride frequency  
(strides/second)

subject	lap 2	lap 9	lap 17
1	2.3	2.4	2.3
2	2.2	2.3	2.4
3	2.3	2.3	2.2
4	2.4	2.3	2.3
5	2.3	2.3	2.3
6	2.3	2.2	2.1
7(2k)		2.2	
8(2k)		2.3	

Table 5 Arm rotation and Elbow angles (left arm)

lap subject	arm rotation			mid stride arm angle			back arm angle		
	2	9	17	2	9	17	2	9	17
1	108	116	112	99	86	79	81	86	80
2	80	81	76	105	94	88	98	87	89
3	62	46	82	79	102	81	68	97	69
4	69	73	75	79	72	76	79	77	70
5	83	94	96	80	85	100	83	77	83
6	64	81	65	73	76	75	69	60	66
7(2k)		108			96			67	
8(2k)		91			92			68	

The elbow angle has generally been considered as optimal at 90 degrees by most coaches. Here measurements were taken at mid-stance, when the leg was directly under the body, and at the point when the arm was farthest back. The point when the arm was most forward was impossible to measure with any accuracy due to the amount of crossover by some of the subjects. Means of 86 and 73 degrees, respectively, seem to indicate that, for this group at least, junior men operate at less than what is considered best for efficiency. The results, however, do indicate a variety of styles. In the case of the 10,000 meter walkers, the effect of walking on the turn on the left arm angle is not known. Turn walking could have a pronounced effect on elbow angle, since the right or outside arm would be the driving force holding the body in the turn, whereas, the left or inside arm would be the reaction or balance arm.

Table 6 Foot strike angle (right foot)

subject	lap 2	lap 9	lap 17
1	34	39	41
2	40	43	43
3	39	35	37
4	39	32	39
5	--	40	38
6	43	46	35
7(2k)		40	
8(2k)		40	

An excessive foot strike angle or an insufficient foot strike angle would prevent efficient rolling across the foot, and thus act as a braking effect. Among this group of subjects the mean angle of foot strike was 39 degrees, Table 6. There appears to be no correlation between velocity or stride ratio with foot strike among these subjects, however, the constancy of the value may be indicative of the elite junior male. Perhaps, the fact that frequency and foot strike angle are both somewhat constant might indicate a relationship between the two.

## Discussion

Three problems immediately became apparent on analysis of these competitions: (1) In dealing with unmarked subjects, measurements such as crotch height had to be estimated from the film as well as consistent points chosen for angle measurements. (2) The segment of the competition, both of the total distance and the location within a lap, might possibly not be representative of each subject's form. Any measurement taken at only one point of a competition, or few points, is dependent on whatever that subject happens to be doing at that moment. (3) Measurements from film, whether taken by hand or electronically, are limited without a large degree of image enlargement.

Naturally, for any study of the elite junior male race walker to be conclusive, many more subjects need to be measured. The fact that this study was undertaken "in competition" eliminates the artificiality of special sessions and may be considered representative of elite junior males. However, lacking a greater number of measurements at other points in the race it is hard to judge the consistency of the results for any particular subject. In spite of the draw-backs of the situation, it is somewhat significant that the ratio of stride length to crotch height is consistent among the subjects, and that this appears to be a predictor of success - particularly, in light of the fact that the stride frequency varied little during the course of the race. The range of motion of the arm throughout a stride varies greatly among these competitors. Perhaps some of this variability is due to measurement site, being on the turn. However, it would seem that this is a function of form and balance, best described as style. The variability in elbow angles might be best attributed to walking the turn as the left, measured arm would become the reaction arm while the right would be the driving force holding the walker into the turn. Finally, the mean foot strike angle of 39 degrees with its small variability (3 degrees) seems to indicate that among this group of elite males, at least, foot strike angle is consistent throughout the performance. In all cases, the measurements taken of subjects 7 and 8 compared favorably with the others.

Exclusive studies of elite senior race walkers might identify the end product by optimum parameters of style and technique, but would give no insight into the development process. Studies of the elite junior walkers may provide a key to the development of the elite seniors and the development of young men into outstanding race walkers.

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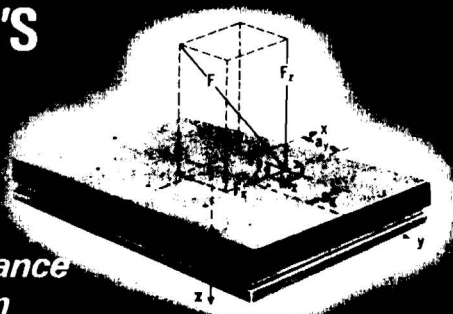
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