A KINEMATIC COMPARISON OF THE UP START AND DOWN START TECHNIQUES USED IN IN-LINE SPEED SKATING

SPIROS G. PRASSAS[1] & KURT WATT[2]

[1]Department of Exercise and Sport Science, Colorado State University, Fort Collins, CO 80523 USA

[2]School of Kinesiology and Physical Education, University of Northern Colorado Greeley, CO 80631 USA

Introduction

Despite the sport's ever increasing popularity in recent years, research on in-line speed skating consistsof a single study examining the physiological and biomechanical relationships between in-line skating and speed skating on ice (Boer, de R., Vos, E., Hunter W., Groot., & Ingen Shenau, van G.J., 1987). Although similarities between the two sports exist, the sports differ, especially during the starting phase. In in-line skating the competitors are accelerating forwards not by "digging-in" and pushing backward as in speed skating on ice, but by pushing sidewise. Regardless of this difference, the starting phase in in-line speed skating is equally important as in other ice and track and field speed events. The two predominantly used starting techniques are the up start and the down start. The former resembles the starting technique used in speed skating on ice and the latter resembles the crouch start used in track and field events when athletes' hips are higher than their shoulders. Since in-line races do not distinguish between lanes, and in order to avoid getting caught in the "pack", it is imperative that the racers have the fastest possible start. The purpose of the study was to determine if any of the two starting techniques is superior to the other by comparing their respective kinematics. It was hypothesized that there will be significant kinematic differences between the two techniques and that for an equal time interval, the down start technique will produce larger displacement than the up start.

Methods

Twelve elite subjects were videotaped with two 60 Hz cameras while performing two up starts and two down starts each. The fastest performance of each subject in each style was analyzed utilizing a Peak5 Motion Analysis system. Three dimensional coordinates of 14 body points of each subject were calculated by combining the images of the two cameras, utilizing the direct linear transformation (DLT) technique (Abdel-Aziz and Karara, 1971). The raw position data were digitally filtered with (optimum) cut off frequencies of 4 to 7 Hz before being submitted to further analysis. Dempster's (1955) data as presented by Plagenhoef (1971) was utilized to predict the segmental and total body anthropometric parameters necessary to solve the mechanical equations. Multivariety analysis of variance (MANOVA) was conducted to test for significant differences between the two techniques in center of mass (CM) displacement, velocity and height above ground, hip and knee joint angles and angular velocities, and angles of lean and push off. If the MANOVA revealed significant differences, repeated analysis of variance (ANOVA) was administered to determine the source of the differences.

Results and Discussion

Table 1 presents results for CM displacement during the first 1.52 seconds, maximum velocity of the CM during the same time period and height of the CM above ground at the start and end of the analyzed motion segment. There were no significant differences in CM displacement and maximum velocity and by the end of 1.52 seconds the height of the CG above ground was identical.

Table 1
Center of Mass Kinematics (Means and SDs)

	Up start		Down Start		F	P
Displacement during the first 1.5 sec. (m)	4.78	0.47	4.81	0.40	2.2669	0.1284
Max. Vel. (m/sec)	4.83	0.42	4.75	0.36	0.3255	0.9144
Height at Start (m)	0.75	0.08	0.57	0.05	46.12	0.0001
Height at Finish (m)	0.81	0.09	0.81	0.08	0.000	0.9639

Table 2 presents hip and knee joint angles and angular velocities, and angles of lean and push off at or during the first and fourth toe off. With the exeption of knee joint angular velocity, all variables were found to be significantly different at the initial phase (at the end or during step one). None was different at the fourth step.

Speed skating on ice resembles in-line speed skating, however it only utilizes the up start technique. On the other hand, sprint events in track and field utilize both techniques. Related research offers conflicting results as to which one is superior. For example, Bowerman and Freeman (1974) found elite subjects to improve forty yard performances using the standing start, whereas Turner and Henson (1985) found the crouch start to be faster.

The deeper initial hip and knee joint flexion observed in the down start technique (Table 2) as well as in the crouch start in track and field offer a theoretical framework as to why this technique should be superior to the up start or standing technique. Greater hip and knee ROM allows for greater work which, in theory, should translate to greater velocities and therefore displacements. In this study, however, no significant differences between the two techniques were found in CM velocity and displacement (Table 1).

Table 2
Joint Angles, Joint Angular Velocities and Angles of Lean and Push off
(Means and SDs)

	Up start		Down Start		F	P
KJA1 (deg)	156.12	9.65	144.99	11.08	6.88	0.0156
KJA4 (deg)	161.86	6.47	158.65	7.88	1.19	0.2860
HJA1 (deg)	155.89	11.74	140.58	9.80	12.04	0.0022
HJA4 (deg)	166.98	7.78	162.00	9.57	1.95	0.1764
AOL1 (deg)	75.59	4.60	69.75	4.08	15.09	0.0008
AOL4 (deg)	69.71	3.44	69.89	1.48	0.29	0.5952
AOP1 (deg)	18.27	6.00	32.76	16.01	8.61	0.0077
AOP4 (deg)	22.42	5.44	22.6	3.31	0.02	0.8896
AVH1 (deg/sec)	247.31	101.23	346.28	67.48	7.94	0.0100
AVH4 (deg/sec)	402.58	75.54	381.90	56.07	0.58	0.4546
AVK1 (deg/sec)	177.16	70.52	222.83	56.06	0.753"	0.568"
AVK4 (deg/sec)	391.90	95.94	397.54	73.98		

*: F andp for entire model (main effects of AVK)
K/H/JA: Knee/ hip joint angle.
114: First/fourth push off.
AOP: Angle of push (angle formed between the line connecting the tip of the push off skate and the center of mass and the vertical line through the tip of the skate --frontal plane).
AOL: Angle of lean (angle formed between the line connecting the tip of the push off skate and the center of mass and the ground--sagital plane).
AV: Angular velocity.

Conclusion

The results revealed significant ($p<.05$) differences between the up start and down start techniques at the end of the first push off or during it in: 1) height of CM; 2) knee joint angle; 3) hip joint angle; 4) push off angle; 5) angle of lean; and 6) angular velocity of the hip joint. These differences were not significant at the end of the analyzed time period (at the end of the fourth push off or during it). In addition, there were no significant differences between the two techniques in the horizontal displacement of the CM during the time period studied (1.52 seconds) and maximum linear velocity attained by the subjects. It was concluded that neither of the two in-line skating techniques is superior to the other.

References

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