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STANDARD MOTION OF SPRINT RUNNING FOR MALE ELITE AND STUDENT SPRINTERS

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The purpose of this study was to show standard motion models of male elite and student sprinters and investigate the characteristics of the elite sprinters' motion. Fourteen male international level sprinters and twenty-one male student sprinters were videotaped at the maximum running velocity phase, standard motion models were prepared and kinematic variables were then calculated. Running velocity, stride length, release distance and flight distance of the elite sprinters were significantly greater than in the student sprinters. The elite sprinters did not fully extend the knee and ankle joints of the support leg at the toe-off while the student sprinters tended to show the converse motion. Student sprinters should use hip joint extension rather than flexion-extension of the knee and ankle joints, and should keep the shank leaning forward during the support phase.

KEY WORDS: sprint running, standard motion, motion analysis

INTRODUCTION: The 100 m sprint in athletics is considered an event of human ability to compete at maximum running velocity without any artificial assistance. There are a lot of studies on the 100m sprinting from which insights into effective running techniques can be obtained. In coaching and teaching, it is well known that the first step in learning and improving sprint techniques is to imitate skilled performers as a template of model technique. Coaches and teachers frequently adopt a model technique or a template in which sequential pictures and figures of a skilled performer are used as a motion model. This approach has some limitations, though. For instance, even in a model technique there may be individual differences that can be attributed to the characteristics of the model athlete, and there is no firm, valid base for determining model technique or ideal form. However, these limitations can be overcome if average or standard motion is used as an appropriate motion model for sprint techniques. Thus, the purpose of this study was to show standard motion models of male elite and student sprinters, using the method proposed by Ae et al. (2007), and investigate the characteristics of the elite sprinters' motion.

METHODS: The subjects were fourteen male elite sprinters who competed at the international level (height, 1.80±0.05 m; body mass, 75.6±7.2 kg; 100 m personal best record, 10.01±0.19 s) and twenty-one male student sprinters (height, 1.74±0.04 m; body mass, 70.0±4.0 kg; 100 m personal best record, 11.02±0.26 s). The elite sprinters were videotaped at the 60m mark of 100m races in several international competitions with two video cameras. The cameras were operated at 200 Hz for most competitions, but at 60 Hz for the 3rd World Championships in Athletics, 1991. The student sprinters performing a 60m sprint dash in the experimental condition were videotaped at 45 m with a high-speed video camera operating at 250 Hz. Two dimensional coordinates data of the twenty-three body landmarks were obtained by digitizing VTR images of one sprint cycle and smoothed by a Butterworth digital filter cutting off at 3.75 to 20.00 Hz.
Using the method of Ae et al. (2007), the standard motion model was established as follows:
1) Normalizing coordinates data relative to a reference point, such as the whole body centre of gravity, by body height and the time elapsed during movement phases.

2) Averaging the normalized relative coordinates data. The standard motion model in this study was the averaged motion pattern of sprinters.

Stride length, stride frequency, joint angles and segment angles were calculated from kinematic data. To test differences between the two groups, the Mann-Whitney's U test was used with a significance level of 0.05.

RESULTS: Table 1 presents the selected kinematic parameters of the elite and student sprinters. There were significant differences in running velocity, stride length and support time, but not in stride frequency and flight time. There were also significant differences in release distance (the horizontal distance from the toe at the instant of the toe-off to the body's centre of mass), but not in touchdown distance (the horizontal distance from the toe at the instant of touchdown to the body's centre of mass).

Table 1
Selected kinematic parameters of the elite and student sprinters

	Elite sprinters (n=14)	Student sprinters (n=21)	Sig. diff.
Running velocity (m/s)	10.99±0.47	9.86±0.25	p<0.001
Stride length (m)	2.37±0.16	2.13±0.07	p<0.001
(ratio to height(%))	(1.31±0.07)	(1.21±0.04)	p<0.001
Support distance (m)	1.00±0.05	0.92±0.05	p<0.001
(ratio to height(%))	(0.55±0.03)	(0.53±0.03)	p<0.05
Touchdown distance (m)	0.31±0.05	0.29±0.03	n.s.
(ratio to height(%))	(0.17±0.03)	(0.17±0.02)	n.s.
Release distance(m)	0.69±0.06	0.63±0.03	p<0.001
(ratio to height(%))	(0.38±0.03)	(0.36±0.02)	p<0.05
Flight distance (m)	1.37±0.15	1.21±0.07	p<0.001
Stride frequency (Hz)	4.65±0.18	4.64±0.18	n.s.
Support time(s)	0.100±0.007	0.106±0.005	p<0.05
Flight time(s)	0.111±0.008	0.114±0.009	n.s.

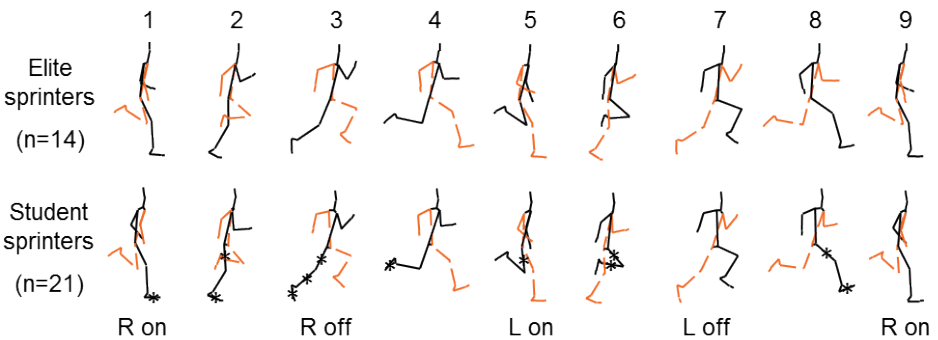

Figure 1: The standard motion models of one sprint cycle for the elite and student sprinters.

Figure 1 shows the standard motion models of one sprint cycle for the elite and student sprinters. The asterisks indicate significant differences between the elite and student sprinters in the right lower segment angles. Significant differences were found in the foot at touchdown (Point 1), the foot and thigh at the mid-support phase (Point 2), the foot, shank and thigh at the toe-off (Point 3), the foot at the mid-flight phase (Point 4), the thigh at touchdown (Point 5), the shank and thigh at the mid-support phase (Point 6), and the foot and thigh at the mid-flight phase (Point 8). In addition, the knee joint of the support leg of the elite sprinters was less flexed at the mid-support phase (Points 2 and 6) and less extended at the toe-off (Points 3 and 7) when compared with the student sprinters. The thigh of the support leg also had less backward swing and the shank leaned further forward than in the student sprinters at the toe-off (Points 3 and 7). Lastly, the elite sprinters swung the recovery leg further forward at touchdown (Points 1, 5 and 9).

DISCUSSION: The standard motion model of the elite sprinters showed similar characteristics to those pointed out by Ito et al. (1994); namely, that excellent sprinters did not fully extend the knee and ankle joints at the toe-off. In addition, Miyashita et al. (1986) reported that elite sprinters leaned the shank of the support leg swiftly just after touchdown. Accordingly, the standard motion model shown in Figure 1 can be used as a motion pattern template for improvement in ordinary sprinters. Comparing the motion of the student sprinters with that of the elite sprinters identified technical faults of the student sprinters that need to be corrected. To illustrate, the student sprinters' knee and ankle joints of the support leg were excessively flexed in the first half of the support phase and extended in the second half of the support phase. In addition, a scissors-like motion of both thighs at touchdown was seen in the elite sprinters, while this motion was smaller in the student sprinters. Since the student sprinters showed excessive extension of the knee and ankle joints in the final stage of the support phase, the forward angular velocity of the shank showed a temporary sluggishness before the toe-off. The insufficient lean of the shank at the toe-off may have caused a shorter release distance in the student sprinters.

CONCLUSION: The running velocity, stride length, release distance and flight distance of the elite sprinters were significantly greater than those of the student sprinters. The elite sprinters did not fully extend the knee and ankle joints of the support leg at the toe-off while the student sprinters tended to show the converse motion. We can therefore suggest that student sprinters should use hip joint extension rather than flexion-extension of the knee and ankle joints, and should keep the shank leaning forward during the support phase.

REFERENCES:

Ae, M., Muraki, Y., Koyama, H., & Fujii, N. (2007). A biomechanical method to establish a standard motion and identify critical motion by motion variability: With examples of high jump and sprint running. *Bulletin of Institute of Health and Sport Sciences, University of Tsukuba*, *30*, 5-12.

Ito, A., Saito, M., Sagawa, K., Kato, K., Morita, M., & Ogiso, K. (1994). Biomechanical analysis of world top sprinters (in Japanese). In Japan Association of Athletics Federations (Eds.), *The techniques of the world top athletes: Research report of the 3rd World Championships, Tokyo* (pp 31-49). Tokyo: Baseball Magazine Co.

Miyashita, K., Ae, M., Yokoi, T., Hashihara, T., & Ooki, S. (1986). Biomechanical analysis of world top sprinters' motion (in Japanese). *Japanese Journal of Sports Sciences, 5,* 892-898.

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