A COMPARISON OF EMG AND KINEMATIC ANALYSIS BETWEEN GROUND AND TREADMILL RUNING FOR CHINESE ELITE SPRINTER-PU FAN FANG

Weiping Li[1], Jia Gang[1], Nianjun Zheng[1], Zhenyu Liu[1], Shouzheng Zhang[1], Kang Kai[1], Kangwei Ai[2]
[1]Shandong Sports Science Center, Jinan, China
[2]China Institute of Sport Science, Beijing, China

Ms. Pu Fan-fang, a Chinese National championship, has been training on simulated treadmill for 4 years to improve her ability of velocity endurance. The purpose of the present study was to compare the changes of her movement structures in ground and treadmill running. EMG and kinematical analysis were used in the test. The kinematical data results show that significant differences were noted between the two conditions for the take off angle, minimum knee angle of swing leg, the minimum angle between thigh and horizontal line, soar high and soar time. The EMG result revealed that the obvious differences of EMG distribution of eight muscles existed in the two conditions. According to the testing results, it should be considered that more using treadmill training could influence her movement structure although it is a good method to improve velocity endurance.

KEY WORDS: EMG, treadmill running, kinematical analysis, elite sprinter

INTRODUCTION: Ms. Pu Fan-fang is a Chinese elite sprinter who won two golden medals of female 400m and 4X400m events in the 9th National Game. She has been training in simulated treadmill for 4 years to improve hers ability of velocity endurance. The simulated treadmill is 10 meters long and 1 meter wide, manufactured by Shandong Research Center of Sports Science, China. Its velocity can be automatically controlled by a computer. To compare the differences of her technical structure between ground and treadmill, we have finished this testing research.

METHODS:

1. The controlled running speed was 7 m/s for the simulated treadmill test and 7.8 m/s for the ground test respectively.
2. A high-speed video camera, JVC-DVL9800 was used for filming at the frequency of 100f/s and the shuttle speed of 1/250 s^{-1}. The camera was placed on the side of the runway, vertical to the movement plane. The view of the camera was one meter from the ground and three meters width of the treadmill during the simulated runway test. It was one meter from the ground and seven meters width of the runway during the ground test. Both were all used with the fixed lens and focus. The object on the runway was filmed as the calibration scale. The lower extremities were chosen as the body segment model due to the limits of the shooting distance in the laboratory as shown in Figure 1. With the SIMI°Motion Analysis System, the kinematical parameters such as time, angles, displacements, angular velocities etc. were obtained and the movement curves were drawn. Under the each condition, treadmill and ground, the subject carried out the test twice respectively. The definitions of various angles were shown in Figure 1.
3. MEGA EMG analytical instrument was used for the test. The EMG of 8 muscles on the right leg, Gluteus maximus, Semitendinosus, Biceps femoris, Gastrocnemius muscle-medial part, Gastrocnemius muscle-lateral part, Gastrocnemius muscle-lateral part, Quadriceps femoris muscle-vastus lateralis and Tibialis anterior muscle, were measured at the same time. The electrodes were strictly pasted on the parts of the muscles according to the prompt of the software. The data was collected into the computer through the specific interface and an analysis was made with MEGA analytical software.

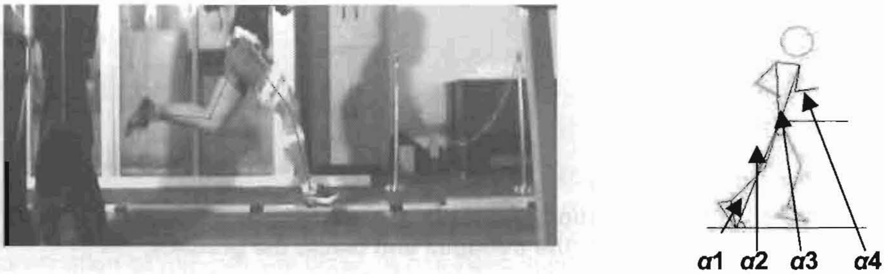

Figure 1 Treadmill running by Pu Fanfang and definition of joint angles.

α1: Takeoff Angle, the inclination of the line between the takeoff point and the hip joint and the ground level when taking off.

α2: Takeoff Knee Angle, the inclination of thigh and crus when taking off.

α3: Maximum Hip Angle, the maximum angle between the two thighs.

α4: Maximum Straight Angle of the Thigh, the inclination between the highest point of the swing leg and the horizontal level.

RUSELTS AND ANALYSIS:

Table 1 Comparison of Kinematical Index of Running Technique on the Simulated Treadmill and on the Ground by Pu Fanfang.

	T1 (s)	T2 (s)	T2-1 (s)	T2-2 (s)	α1 (g)	α2 (g)	α2' (g)	α3 (g)	α4 (g)	H (m)
Treadmill	0.185	0.12	0.05	0.07	77.80	166.75	24.4	52.46	54.0	0.26
Ground	0.15	0.11	0.03	0.08	76.40	173.90	27.6	60.51	50.90	0.12
Difference	0.035	0.01	0.02	-0.01	1.40	-7.15	-3.2	-8.05	3.10	0.14

T1: Fight Time: the time from the takeoff of one foot to the landing of another.

T2: Support Time: the time of the foot on the ground

T2-1: Front Support Time: the time needed from the landing of the swing leg to the perpendicularity between body center and the ground.

T2-2: Rear Support Time: the time needed from the perpendicularity between the body center and the ground to the takeoff of the leg.

α2': Minimum Folding Knee Angle, the minimum angle of the knee joint when quick folding after taking off.

H: Difference of Perpendicular Displacement of the Hip Joint:

As shown in Table 1, there are slight differences for the total support time in comparison with the track and the treadmill running. However, the front support time in treadmill running is obviously longer than that in the ground running and the rear support time in treadmill running is slight shorter than that in the ground running. By analyzing the joint angle of every time phase, the takeoff angleα1 in treadmill running is larger than that on the ground running and the takeoff knee angleα2 is smaller than that on the ground running. From the mentioned above, it has been shown that her swing leg pushes down actively when landing. The contact time of foot and track is longer for the counteraction of the forward motion speed and backward motion speed of the body center. In the phase of rear support, the backward motion of the track makes her takeoff time short during the treadmill running to cause the smaller of takeoff knee angleα2 and the larger of the takeoff angleα1. This has increased her vertical motion component and caused a large undulation of her center of gravity (Figure 2), and the flight time is obviously longer than that on the ground running.

In addition, her maximum hip angle α3 is obviously larger on the ground running. It has been shown that she has a good extension of both legs but she has an insufficient detach of both legs on the treadmill running. The maximum thigh straight angleα4 of her thigh swing is larger to show that the leg raised height is less than that on the ground running. The minimum knee angle on the treadmill running is smaller than that on the ground running and the folding is more sufficient. This is because the backward motion of the treadmill brings along the crus of takeoff leg.

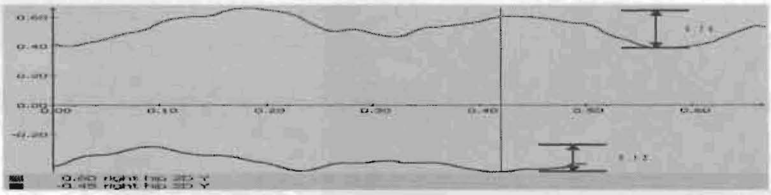

Figure 2 Y Displacement of Hip Joint on the Treadmill and Ground Running by Pu Fanfang (Red :the treadmill and black: the ground).

In a word, there are quite differences of technical motion structure on the treadmill running and on the ground running with analysis from the viewpoint of kinematics.

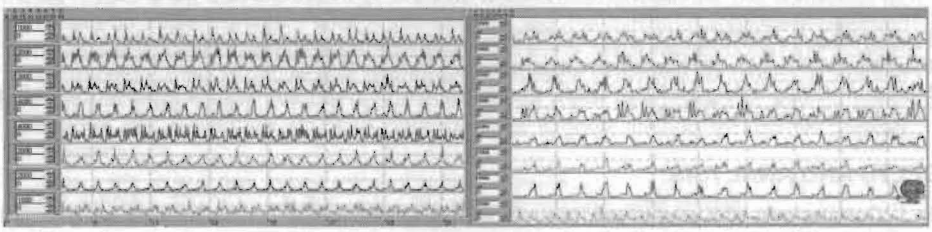

Figure 3 and Figure 4 8-Channel EMG Signals on Both Treadmill and Ground Running by Pu Fanfang.

Table 2 Comparison of the EMG Distribution Rate of 8 Muscles on Both treadmill and Ground Running by Pu Fanfang (Unit: Percentage).

	M1	M2	M3	M4	M5	M6	M7	M8
Treadmill	4	18	10	18	27	10	6	7
Ground	10	24	14	12	9	7	14	10
Difference	-6	-6	-4	6	18	3	-8	-3

M1: Gluteus maximus muscle; M2: Semitendinosus muscle;
M3: Biceps femoris muscle; M4: Gastrocnemius muscle-medial part;
M5: Gastrocnemius muscle-lateral part; M6: Gastrocnemius muscle-lateral part;
M7: Quadriceps femoris muscle-vastus lateralis; M8: Tibialis anterior muscle.

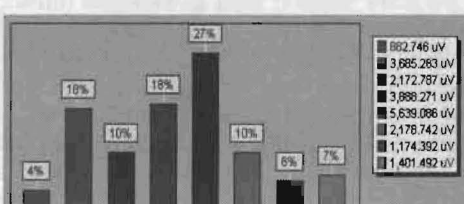

Figure 5 EMG distribution rate of each Muscle on ground running.

Figure 6 EMG distribution rate of each Muscle on treadmill running.

The analysis from the EMG distribution rate of 8 muscles are shown in Table 2, Figure 5 and Figure 6, there is a significant difference between the treadmill running and the ground running. The major difference relies on the rear group muscle of the thigh and that of the crus. It has been shown in Table 2 that the total distribution rate of two muscles in the rear group muscle of the thigh, semitendinosus muscle and bi8ceps femoris muscle on the treadmill running is 10% less than that on the ground running. The total distribution rate of the rear group muscle of crus, gastrocnemius muscle on the treadmill running is 24% more than that on the ground running. The total distribution rate of other 4 muscles also exists 3%-8% differences.

CONCLUSION AND SUGGESTION: As an innovative training method, the simulated runway training has a prominent effect to improving the speed endurance level for 400m sprinters and it has been proved by Pu Fanfang, an elite sprinter in China. From the viewpoint of the motion technical structure, it has been proved that there existed a significant difference of both by analyzing with biomechanics of motion technique and EMG. If long-term simulated runway training is taken, the change of technical motion of the sprinters and the in-coordination of muscles will occur. It has been suggested that the proportion of simulated runway training for sprinters should not be too large and it is better to adopt it in the phase of intensity training. Even so, the simulated runway training should not exceed once a week at most.

REFERENCES:

Thomas J. (2000). Methodological limitations of EMG-based biomechanical motion analysis. *Proceedings of XVIII International Symposium on Biomechanics in Sports*, Volume II, 769-772.

Alton F, B.L., C.S., M.MC. A kinematic comparison of overground and treadmill walking. London E15 4LZ, UK: University of East London.