EFFECT OF DIFFERENT RUNNING SPEED ON VERTICAL OSCILLATION AND STRIDE

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The main purpose of this study was to investigate the effect of different running speed (3.5±0.3 and 4.9±0.2 m/s) on vertical oscillation of the center of gravity and stride. Ten male elite running players served as subjects. A camera (60Hz) was to collect the parameters during running. From this research, the t-Test is used to analyze the parameters of the kinematics in different running speed. Results indicated that different running speed would not affect the vertical oscillation of human body center of gravity. In addition, a significant difference ($p< .05$) was found in the same speed of different step, but no significance was found in different running speed of the same step. The duration of the stance phase in lower speed for about 38.34% of the stride and the swing phase for 61.66%, in higher speed for about 32.11% and 67.89%.

KEY WORDS: vertical oscillation, stride, step, stance phase, swing phase.

INTRDUCTION: Human gait involves alternating sequences in which the body is supported first by one limb, which contacts the ground, and then by the other limb. Human gait has two modes, walking and running. One distinction between these two modes lies in the percentage of each cycle during which the body is supported by foot contact with the ground. When we walk, there is always at least one foot on the ground; in contrast, running involves alternating sequences of support and nonsupport, with the proportion of the cycle spent in support varying with speed. For both walking and running, however, each limb experiences a sequence of support and nonsupport during a single cycle. The period of support is referred to as the stance phase, and nonsupport is known as the swing phase. The stance phase begins when the foot contacts the ground (footstrike), and ends when the foot leaves the ground (toe-off). Conversely, the swing phase extends from toe- off to footstrike. Gait cycles are usually defined relative to these events. For example, one complete cycle, such as from left foot toe-off to left foot toe-off, is defined as a stride (Enoka, 2002). The scholars point out when to fix a speed, each runner has his own optimal stride length. Whether increase or decrease the stride length, will add the body vertical oscillation of C.G. and then let runner consume more the energy. Therefore, scholars make a definition for stride when running -- the minimum stride of vertical oscillation of C.G is called optimum stride (Lin & Wang, 1995). Energy cost is one of the scopes that the sport physiology and sport biomechanics have studied continuously. As to sport biomechanics researches, the popular topic to explore what index to measure the energe cost in recent year. Therefore, how to use as more scientific mathod to control energy cost in contest is the important key factor for the athlete's performance. Running economy is developed from energy cost perspective. There are lots of science literatures confirmed the value of vertical oscillation of C.G in running and made it became an important index to estimate the running economy. To explore the characteristic of running further, it's usually subdivided running movement into stance phase and swing phase. This would be beneficial to evidence slight variety of the action(Enova, 2002). Base on the reason, the research attempts to explore the effect of different running speed on vertical oscillation and stride.

METHODS: Ten elite male running players participated voluntarily in the study. Their mean age, height and weight were 26.8±2.4 years, 1.72±0.03 and 74.5±7.0kg, respectively. Data was gathered using a JVC Cybercam 9800 digital vedio camera, recording at 60 Hz with a shutter speed of 1/250. The camera was set up to record the movement of the sagittal plane whole body. Nine landmarks were placed on head, shoulder, elbow, wrist, hip, knee, ankle, heel, tiptoe. The participators individually run for about one minute in two different running speed (3.5±0.3 m/s and 4.9±0.2 m/s), and then select three steadily running stride data to do the analyzsis. The standardize process was to divide vertical oscillation of C.G. and stride length in participate's height.

RESULTS: Table 1 shows the average vertical oscillation of C.G.in the different speed. No significant difference in it. Through the standardize process, relative to height are 4.20% and 4.72%. The data shows that the vertical oscillation accompanies with to running speed to increase.

Table 1 Average vertical oscillation of C.G.

Running speed	3.5±0.3 (m/s)	4.9±0.2 (m/s)	t - values
vertical oscillation (cm)	7.21±1.00	7.80 ±1.04	-1.68(n.s)

p>.05

Table 2 shows the average vertical oscillation of C.G in the different speed of the same side stpe. No significant difference in it. The data shows that the vertical oscillations accompany with to running speed to increase.

Table 2 Average vertical oscillation of C.G for single step. (The same side steps in different running speed).

Running speed	3.5±0.3 (m/s)	4.9±0.2 (m/s)	t - values
vertical oscillation (cm)			
left step	6.03±1.51	6.77 ±0.95	-1.83(n.s)
right step	8.40±1.35	9.50 ±1.36	-2.43(n.s)

p>.05

A stride contains two steps. Table 3 shows the average vertical oscillation of C.G in the same running speed of the different side step. A significant difference was found in it. On average, left and right step in the same speed were clear different. This is show while running the vertical oscillation will diversity. As a result of all the participators common usage side are at right, it may cause the muscle of right side more strong, and to make the take-off force is higher than left.

Table 3 Average vertical oscillation of C.G for single step. (The different side step in the same running speed).

	Single step	left step	right step	t - values
vertical oscillation (cm)				
	3.5±0.3 (m/s)	6.03 ±1.51	8.40 ±1.35	4.105*
	4.9±0.2 (m/s)	6.77 ±0.95	9.50 ±1.36	6.175*

*p<.05

Figure 1 shows a stride for different running speed. The cycle in Figure 1 begins with initiation of the right footstrike, right toe-off, left footstrike, and left toe-off. The range of vertical oscillation in 4.9m/s is large than 3.5m/s. It also shows that the first wave trough is the lower point of vertical oscillation, and the phase is right stance phase. Among 3.5 m/s speed, the lower point at 50.05% stance phase, and 56.69% in 4.9 m/s.

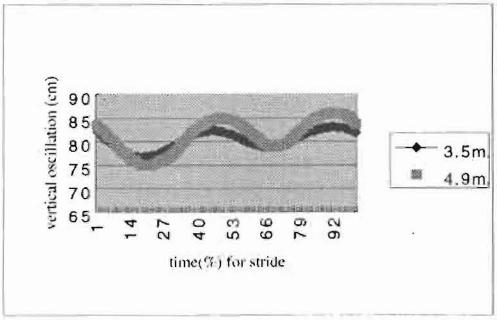

Figure 1: The vertical oscillation was compare with 3.5 m/s and 4.9 m/s for time%.

Figure 2 shows the relative duration (%stride) of that stance or swing phase. During 3.5m/s, each foot is on the ground (stance phase) for 38.34% of the stride and off the ground (swing phase) for 61.66%. The durance of the stance phase decrease to 32.11% and swing phase increase to 67.89% for 4.9m/s. This is likely a result of what Vaughan (1984) has researched. He found the durance of the stance phase about 50% for race walk (3.0m/s), 30% for run (5.0m/s).

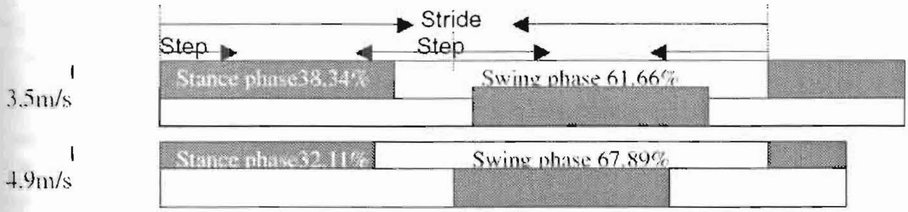

Figure 2: The numbers in various rectangles indicate relative duration (%stride) of that stance or swing phase (R=right foot:L=left foot).

DISCUSSION AND CONCLUSION: Each runner has his own optimal stride length. Whether increase or decrease the stride length, will add the body vertical oscillation of C.G. and then let runner consume more the energies. The result indicated that different running speed did not affect to the vertical oscillation of human body center of gravity. But a significant difference was found in the same speed of different step. The result may all the participators common usage side are at right. And the lowest point of center gravity was at right foot stance phase during running. The duration of the stance phase in 3.5±0.3m/s for about 38.34% of the stride and the swing phase for 61.66%,in 4.9±0.2 m/s for about 32.11% and 67.89%.

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