THE EFFECTS OF STRIDE LENGTH AND FREQUENCY ON THE SPEEDS OF ELITE SPRINTERS IN 100 METER DASH

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By adopting relative and factor analysis, this study elaborated on the relations and the main factors of the speed growth, the stride length and the stride frequency at each phase in the whole course of 100m dash. Using data from the study it demonstrated that stride length contributes much more to the course of 100m dash than the stride frequency. Furthermore, this study found that excessive accelerating in the fast striding after starting, which is related to the excessively high stride frequency, also affected the speed in a certain degree in the whole course of 100m dash. According to the relative and factor analysis, the study indicated that it is necessary to control the stride frequency and to increase the stride length while accelerating at the first 10m section in fast striding. This occurs in order to reduce or eliminate the negative influence caused by excessive accelerating in the fast striding after leaving the starting line.

KEY WORDS: sprinting, stride length, stride frequency, speeds structure, relative and factor analysis

INTRODUCTION: It is well documented that stride length and frequency are important factors affecting the performance of the athletes in 100m dash. However, it is still not clear how the stride lengths and frequencies in different phases of the 100m dash affect the performance of the elite athletes. The purpose of this paper was to determine the relationships between stride length and average speed and between stride frequencies and average speeds of elite athletes in different phases of the 100m dash.

METHODS: The data include the speed, the stride length (SL) and the stride frequency (SF) of elite sprinters in 100 m final. All the data is obtained from Sports Science (Shen, 1999; Guo 1997) and Journal of Physical Education. (Shen, 1999). All the data are processed with computer with SPSS 8.0.

RESULTS AND ANALYSIS: The descriptive statistic results of the data. Table 1 shows the descriptive statistic results of the data. Results indicated that the 100m dash of elite sprinters' could be divided into six phases: (1) the first accelerating phase; (2) the second acceleration phase; (3) the first peak speed phase; (4) the speed regulating phase; (5) the maximum speed phase; and (6) the final dash phase.

The first accelerating phase started from to 20m. During this phase, the speed (S1), the stride length (SL1) and the stride frequency (SF1) developed rapidly and simultaneously. However, the SF1 reaches 97.1% of its peak value (most sprinters reach the highest frequency here) while the SL1 is only 72.9% of its peak value. This may resulted from a leaning forward of body posture while fast striding after starting. In addition, after this phase, the increased rate of SF changed rapidly, at the section between 20 m and 30 m, after which it decreased sharply to -1.8% from 24.6%.

The second accelerating phase is from 20 m to 40 m. During the next phase, the speed (S2) continues increasing but at a decreased acceleration. The stride length (SL2) also continued increasing while the stride frequency (SF2) decreased, which created a relatively harmonious balanced state (SL2 and SF2 were 94.6 and 92.1% of their peak values, respectively) which provided a foundation for a further development of the speed.

The first peak speed phase was at 50 m section. During this phase, the speed reached its first peak value (S3). The stride length (SL3) had a slight decrease to 94.3 of its maximum while the stride frequency (SF3) reflects a slight increase to 95.1% of its maximum. This showed a more reasonable combination pattern between SL3 and SF3.

Table 1 Descriptive Statistics

Parameter	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m
A	5.39 ±.10	9.38 ±.06	10.87 ±.09	11.25 ±.08	11.55 ±.21	11.48 ±.21	11.53 ±.21	11.70 ±.21	11.21 ±.16	11.24 ±.02
B	3.85 ±.28	4.77 ±.27	4.60 ±.12	4.52 ±.17	4.67 ±.22	4.80 ±.18	4.75 ±.45	4.57 ±.18	4.44 ±.17	4.40 ±.21
C	1.37 ±.08	1.92 ±.03	2.37 ±.05	2.49 ±.10	2.48 ±.12	2.40 ±.10	2.43 ±.07	2.56 ±.11	2.52 ±.09	2.55 ±.12
D	5.39 ±.10	3.98 ±.12	1.50 ±.11	.40 ±.12	.33 ±.23	.04 ±.12	.04 ±.13	.13 ±.15	.47 ±.15	.06 ±.14
E	3.85 ±.28	.92 ±.50	.17 ±.26	.11 ±.14	.11 ±.12	.13 ±.09	.01 ±.16	.15 ±.10	16 ±.14	.05 ±.19
F	1.37 ±.08	.55 ±.09	.45 ±.04	.17 ±.16	.00 ±.07	.06 ±.06	.01 ±.11	.12 ±.05	.02 ±.08	04 ±.10
G	78.4 ±5.8	24.6 ±14.7	1.8 ±6.3	1.7 ±2.3	3.3 ±2.5	2.2 ±2.4	.5 ±3.0	3.7 ±2.4	3.4 ±2.5	1.5 ±4.3
H	52.0 ±2.7	40.6 ±8.7	23.5 ±2.0	5.1 ±2.9	.4 ±2.3	3.3 ±2.1	1.8 ±4.1	4.8 ±2.5	1.6 ±2.8	1.2 ±4.1
I	78.4 ±5.8	97.1 ±5.2	93.7 ±2.0	92.1 ±2.8	95.1 ±3.9	97.4 ±2.7	95.9 ±.2.1	93.1 ±2.6	90.9 ±2.6	89.1 ±.39
J	52.0 ±2.7	72.9 ±2.3	90.0 ±2.5	94.6 ±2.6	94.3 ±3.0	91.2 ±2.6	92.4 ±2.6	97.5 ±3.4	95.9 ±1.6	97.0 ±.29

A is the speed; B is the SF; C is the SL; D is the increased or decreased value of the speed; E is the increased or decreased value of SF; F is the increased or decreased value of SL; G is the increased or decreased percentage of SF; H is the increased or decreased percentage of SL; I is the intensity of SF (%); J is the intensity of SL (%)

The speed-regulating phase was at 60m section. During this phase, the speed (S4) drops marginally. The stride frequency (SF4) continued increasing to 4.8 stride/ second that was 97.4% of its maximum, while the stride length (SL4) decreased to 91.2% from 94.3%.
The maximum speed phase was from 70 m to 80 m. During this phase, the speed (S5) reached its maximum (S6). The stride length (SL5) decreased from 95.9% to 93.1% of its maximum .The stride length (SL5) increased from 92.4% to 97.5% of its maximum.
The final dash phase was from 80 m to finish line. During this phase, the speed (S7) decreased significantly with a large variation between athletes. The stride frequency (SF7) decreased from 93.1% to 89.1% of its maximum, but the stride length (SL7) remained at 97.0% of its maximum to the finish line. This indicated that body straining and tiredness affect the stride frequency more than they do the stride length.
The results of correlation and factor analysis showed significant negative correlation between S1 and S2, S3, S5 and S7(r = -.66, -.69, -.73, -.73 respectively; p<.05). On the contrary, there was significant positive correlation for S2 to S3, S5, S6 and S7 (r = .83, .73 and .79 respectively; p < .05 ~ .01), that S3 to S5, S6 and S7 (r = .77, .93 and .89 respectively; p < . 05 ~ .01), that S5 to S6 (r = .86; p <. 01). In addition, S1 has significant negative effects on stride frequency and the stride length shown as SF2, SF7 (r= -. 68, - 86 respectively; p<. 05

~.01) and as SL2, SL3 and SL4(r=-. 66, -. 74 and -. 71 respectively; p<. 05), However, S2, S3, S4, S5 and S6 have more positive effects on the stride length and the stride frequency than that of negative ones. The factor analysis results of the speed indicate that S2, S3 and S6 were the most important speed factors (% of variance is 35.66. Conversely, S5, S7 and s4 are the second important second factors (% of variance is 25.80), and S1 was the third important speed factor (% of variance is 19.9) of the speed structure in the whole course of 100 m dash.

In addition, SL1 to S5 (r= .87; p< .01), SL2 to S3 (r=. 67,p< .05), SL3 to S3 and S6(r= .86 and .74 respectively; p< .05 ~. 01) have a positive effect except that SL5 and SL6 affect S6 and S7 (r=-.72, -.66 and -.71 respectively; p<. 05) are negative while the parameters of stride frequency have no significant effects, with the exception of SF1 and SF3 that have a significant one on S7 and S4 (r= .69 and .82 respectively; p< .05 ~ .01).

To summarize the correlation and factor analysis of parameters of SL and SF, it was generally believed that both SL and SF reached a high degree. This made it become difficult to develop the speed by increasing themselves simultaneously, presenting an irreconcilable contradiction. However, in the study, it was determined that both factors could help to develop the speed by means of a coordinated increase, to a certain extent and in a certain way. This could be reflected in the relations between SL2 and SF5, SL4 and SF2 (r= .79 and .74 respectively; p< .05). Though the contradiction between the SL and SF still existed in the same sections (such as SL2 and SF2, SL6 and SF6; r=-.76 and -.82 respectively; p< .05 ~ .01), no significant relations exist in some of the same sections (e.g. SL1 and SF1, SL3 and SF3, SL4 and SF4, SL5 and SF5, SL7 and SF7; r =-54, -.36, -.34, .04, -.21 respectively, p>.05), which proved that the combination of elite sprinters' SL and SF is reasonable. It is feasible to believe that this reflects elite sprinter's ability in regulating SL and SF. However, on the other hand, it may have something to do with the speed rhythm in the whole course. Furthermore, it has been determined that there are no significant relationship between elite sprinters' SL and SF in some comparatively important phases. This is particularly obvious where the speed is much higher such as S3, S4, S5 and S7, and while there are significant mutually restricted relations between them at the phases where the speed is affected. It proves from the indirect sources that the reasonable combination and coordinated development of the SL and SF in the whole course are the most important factors to improve the result of 100m dash.

The results of factor analysis on SL and SF indicated that SL3, SF3, SL2, SF2 and SF4 were the most important factors of SL and SF in the whole course (% of variance is 27.73). Second factors are SL6, SF6 and SL5 (% of variance is 21.34). SL7. SF4 and SF5 are the third important factors (% of variance is 20.96), SF1 and SF1 are the fourth important factors (% of variance is 13.39). Finally, SF7 was the last important factor (% of variance is 10.77). The results of the factor analysis were identical to the above analysis. The SF4 appears in the most important factor showed that it is necessary to regulate the SL which increased after a long time and a long distance (0 m ~ 50 m) through the SF.

One-way ANOVA of S, SL and SF. The results showed that, during the course of 100m dash, the effects on the speed caused by SL and SF can be generally divided into several categories. In the first 10m after the leaving the starting line, SL and SF together help to break away from the stationary position. Subsequently, at the 20m ~ 30m section, the rapid increasing SF is reduced slowly, thus SL becomes the main factor which causes the speed increase. At the 40 m ~ 50 m section, there appears to be a very reasonable combination between SL and SF. Both of them cause speed to develop very well. At the 60m section, SL begins to decrease and SF begins to increase which make SF become the main factor of developing speed. At the 70 m section, SL inclines to increase from the stable state, and its leading function of the increasing speed appears again and keeps through to the finish.

DISCUSSION: The analysis of this study showed that the elite sprinters have a relatively reasonable combination and regulating ability on SL and SF. However, the excessively high SF in the first accelerating phase exerts a certain degree of negative effects on the reasonable combination of the SL and SF. This made the speed rhythm in the later part of the whole course variable, and also makes the function of SF weaken, so that the further development of the speed is affected. For example the negative effects of S1 on SF2, SF3 (r= -.76 and -.68 respectively; p< .05) causes a series of negative effects of SF2, SF3 on SF4, SF6, SF7, SL2 and SL3 (r= -.67, -.69, -.71 and -.66 respectively; p< .05). The combination of SL and SF results in a loss of balance, and prevents the important speed factors (S3, S6, S2, S7, etc) from fully developing. The correlation analysis shows that the negative effects of S1 on the speed rhythm. The excessively high SF in fast striding after starting mainly causes the combination of the stride states. As the result, that the movements and the speed in fast striding after starting are affected. If the SF at the phase can be controlled and SL at the first 10-m section of fast striding after starting can be increased a little in a proper way, it can help to improve or even solve the problem raised by the excessive accelerating in fast striding. Someone pointed out, if the reasonable combination of SL and SF is kept through to the finish, the result of 100 m dash will be improved to a certain degree (Guo, 1993). Therefore, as this study has been concerned, we believe that the excessively high SF causes the excessive accelerating at the beginning phase in fast striding after starting. In view of physiology and psychology, the excessive high SF in fast striding after starting, and produces some disadvantages. Firstly, it makes the central nervous system fatigued very rapidly and decreases the flexibility of the alternating change of the nerve muscles which makes the technical movement stiff and uncoordinated. Secondly, it caused a greater consumption of energy and too soon. The study showed that the energy consumed by the muscles is in cubic proportion to the muscle's contracting speed. When the muscle's contracting speed increased by one, its consumption of energy and oxygen demand will increase 7fold. Thirdly, it created a state of over reaction in the psychological state, or in other words, "out of control ". The excessively high SF in fast striding after starting affects the "integration perfection" of the stride state and the speeds rhythm in the whole course which will harm the continuous accelerating process. This prevents the greater speed from becoming even greater, thus fast striding in the latter part of the whole course is affected.

Among the factors of the stride states, which develop the speed in the whole course of 100m dash, SL is the main one. At the second accelerating phase, SL and SF was reasonable and developed a more coordinated combination of the stride states when the speed reached the second highest level. However, this combination can't be sustained or developed, thus the % of variance of SL3, SF3 and SL2, SF2 is greater than when the speed reaches the highest level (27.73 and 21.34 respectively). This shows it is more important to coordinate the combination of the stride states than to emphasize SL or SF individually.

REFERENCES:

Shen, W. (1999). The pattern features and effects of the speed rhythm of elite sprinters in 100 m dash. *Sports Science*. **1**, 62.

Shen, W. (1998). The accelerating pattern and factor analysis of elite sprinters in 100 m dash. *Journal of Physical Education*. **1**, 11.

Guo L, et al. (1997). The correlation between a rational combination of length and frequency of stride and 100m sprint performance. *Sports Science*, **1**, 38.