FACTOR ANALYSIS OF SPRINT PHASES ON THE SPEED CURVE OF THE 100M DASH

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Previous studies have indicated that the speed curve of the 100m dash consists of some distinct phases which can be used to analyze an athlete's performance. The purpose of this study was to introduce a method using a portable computer as a device for the measurement of sprint time and the illustration of the speed curve, and to clarify a simple model of sprint phases on the factor structure. Based on the data of 133 participants, principal factor solution was given to the correlation matrix, and varimax rotation was applied to simplify the factorial structure of sprint phases. Finally, two factors were extracted and interpreted. It is suggested that this method is useful for measurement and evaluation in the 100m dash, and that a simple model of sprint phases may be explained by these two factors. These findings are important in predicting the ability of 100m sprinters and in considering coaching methods in terms of technique, training, strategy, etc.

KEY WORDS: portable computer, speed curve, factor analysis, sprint phases

INTRODUCTION: The speed curve of the 100m dash illustrates the change of velocity in each section from start to finish, and is used to analyze sprint phases such as start, acceleration, transition, maximum speed, speed endurance, finish, etc. (Sugiyama et al.; 1993). The measurement of the speed curve is advantageous for the understanding of technique, training, and strategy for the sprint race, and for accurate evaluation of the ability of the sprinter. However, complicated and expensive systems of measurement are not suitable for coaching usage. Therefore, in this study, a personal computer application to measurement and evaluation of the 100m dash was made. A standard portable computer is lighter and more transferable to outdoor use such as at the track. It may also provide visual information and an initial assessment as feedback after measurement. Furthermore, the quantitative sprint evaluation by factor analysis arranges various sprinters into the same scale and makes the comparison easier. These factors may predict and/or estimate the ability of the sprinter. The purpose of this study was to discuss the effectiveness of using a portable computer as a device for the measurement of sprint time and the illustration of the speed curve, and to clarify the factor analytical structure of the speed curve.

METHODS: Participants, aged 18 to 23, were comprised of 88 male and 45 female students from secondary schools and universities. All the measurement had been conducted in physical education classes or in school club activities under conditions of fine weather and absence of wind. A straight lane of 100m was divided into 10 equal sections using passage marks (See Figure 1). To obtain basic data for the speed curve, each passage time from the start to each mark was measured. As an apparatus for the measurement of sprinting time, an attempt was made to use a portable computer with a system printer. The original computer program was developed to measure the time at each mark, to calculate velocity, and to illustrate speed curve. Passage time was measured when a functional key on the keyboard was pushed. With the support of mathematical and computer analysis, the data could be formed into continuous curves which show the speed of each section. To clarify the factor structure on print phases, principal factor solution was given to the correlation matrix with 10 variables, and varimax rotation was applied to a simple structure.

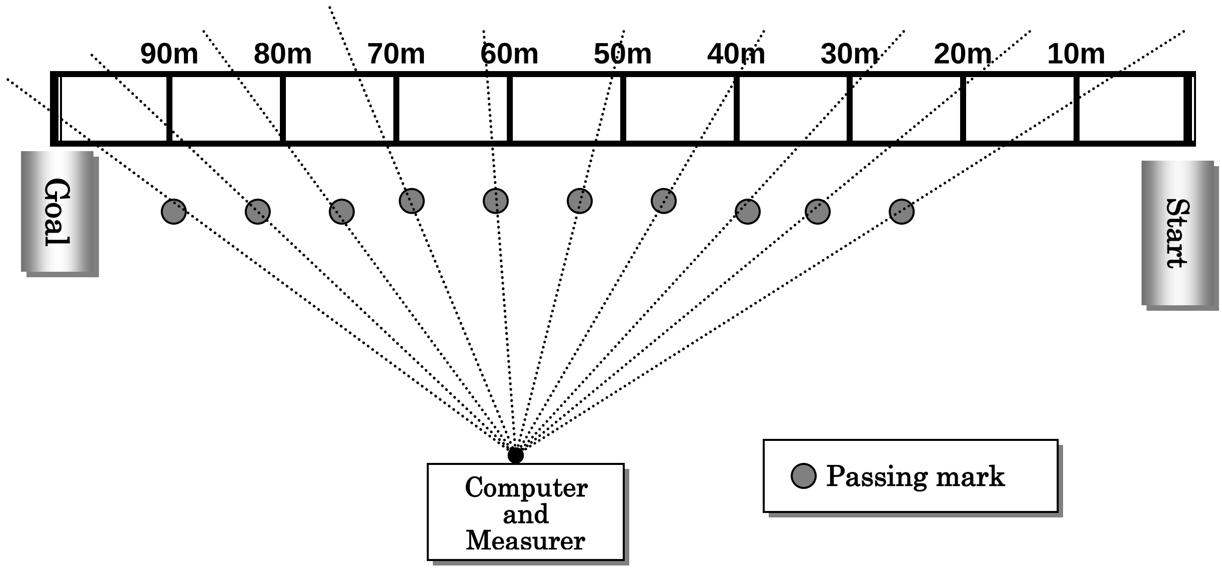
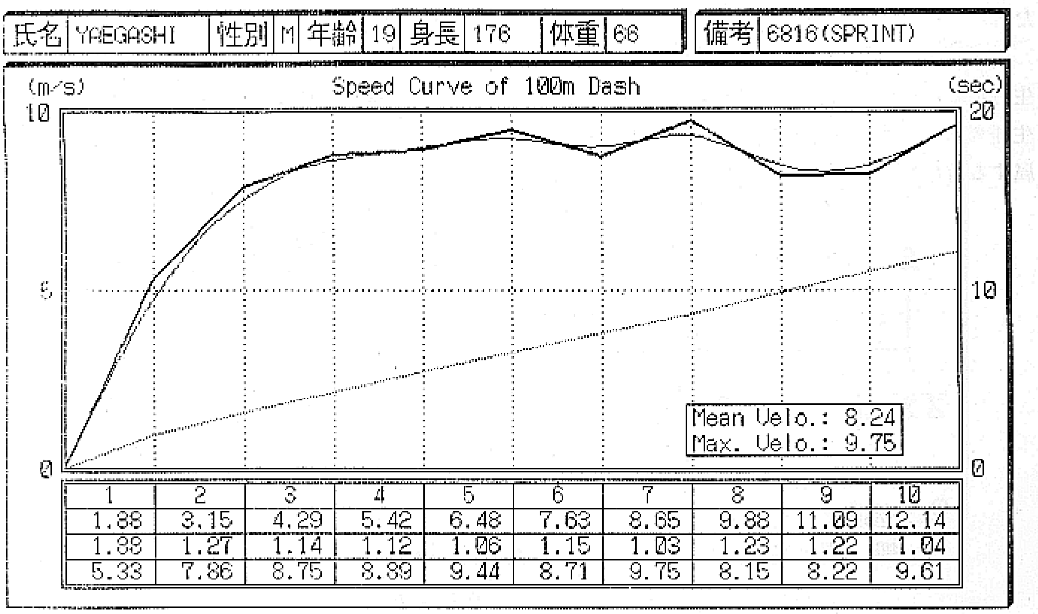


Figure 1 - The experimental straight lane for the measurement of the 100m dash is shown. The lane was divided equally into 10 sections. Each passing mark was placed on an extension line from the measurer to a passage point of each section.

RESULTS AND DISCUSSION: Figure 2 shows an illustration of the speed curve printed out as a hard copy. These curves were interpolated with a spline function. In addition to personal data, the results such as the passage time at each mark, the time required for each section, and mean and maximum velocities are shown in the illustration. This information on the speed curve was given to each participant as quick feedback after they reached the goal. All data of the 133 participants were recorded on a floppy disk and later utilized in statistical treatment.



1	2	3	4	5	6	7	8	9	10
1.88	3.15	4.29	5.42	6.48	7.63	8.65	9.88	11.09	12.14
1.88	1.27	1.14	1.12	1.06	1.15	1.03	1.23	1.22	1.04
5.33	7.86	8.75	8.89	9.44	8.71	9.75	8.15	8.22	9.61

Figure 2 - An output example (hard copy) of the system printer after the measurement of the 100m dash.

There are some devices used to measure sprint time, such as electric timing systems, a video tape measure with video timer, a hand-measure, etc. However, it is noted that the major advantages of using a portable computer in the case of this measurement are cost, quantitative assessment and quick feedback, illustration of graphics, data file maintenance and processing, and printing. For the application of factor analysis to the interpretation of the simple structure (Yamamoto et al., 1983), eigenvalues and factor loadings were calculated from a matrix of the Peason correlation coefficient of input variables. Table 1 contains a list of the sections, the eigenvalues, percentages of the total variance, and factor loadings (more than 0.6). The results of factor analysis reveal two underlying scales of sprint phase in male, female, and total groups.

Table 1 Factor Loadings after Rotation to Simple Structure

	TOTAL		MALE		FEMALE	
Section	F1	F2	F1	F2	F1	F2
0-10m		0.8466		0.8368		0.8919
10-20m	0.6567	0.7429	0.6179	0.7614		0.8048
20-30m	0.7226	0.6758	0.6788	0.6961	0.6940	0.7056
30-40m	0.7770	0.6255	0.7506	0.6517	0.7747	0.6259
40-50m	0.7891	0.6093	0.7639	0.6349	0.7943	
50-60m	0.8126		0.7936	0.6003	0.8315	
60-70m	0.8372		0.8353		0.8631	
70-80m	0.8458		0.8419		0.8824	
80-90m	0.8594		0.8654		0.8959	
90-100m	0.8632		0.8672		0.9040	
Eigenvalue	5.95	3.91	5.71	4.01	6.02	3.84
% Var.	59.5	39.1	57.1	40.1	60.2	38.4
Cum. of % Var.		98.6		97.2		98.6

The first principal factor (F1), which has the largest eigenvalue, shows a large positive loading for nine variables out of ten. This factor after rotation makes up 59.5 % of the total race, thus, the F1 phase is highly significant, and may affect the sprint performance. These sections (20m to the finish in the 100m dash) in F1 involve a wide variety of phases, such as acceleration, transition, maximum speed, speed endurance and finish. Acceleration in this phase should be explained in terms of speed change from higher to maximum level, which is called "pick-up." This F1 may be interpreted as "the phase of ultimate speed and endurance." The loading factors of the second principal factor (F2), which is interpreted as "the phase of start-acceleration," show highly positive for five variables. These sections (start to 50m in the 100m dash) in F2 are closely related to the initial phase of the 100m dash. The start-acceleration phase is a sub-factor, which makes up 39.1 % of the total race. This acceleration in F2 represents the rapid acceleration from low speed in the start phase, which is called "intensive." This phase is one of the most important ones, which sets up all other phases of the race (Hopkinson, 1993). Focusing upon the sprint phases of 20-50m in the total group, the factor loadings in both F1 and F2 were duplicated. This phase may be interpreted as a "transition" phase observed in the process from acceleration to maximum speed. Comparing male and female groups, there seems to be no difference in this factor analytical structure. However, the transition phase of the male group is longer than that of the female group. In this study, these two factors accounted for 98.6 % of the whole variance. Considering the contribution of these two factors, it has been demonstrated that the ability in the 100m dash may be estimated by this simple model. Figure 3 shows an illustration of the speed curves of three male runners, who ran 100m with 12, 13, and 14 second ranges, respectively. Among these runners, the fastest sprinter, who ran in the 12 second range, was relatively superior in both the F1 and F2 phases to the other two runners. Conversely, it is evident that the runner who ran 100m in the 14 second range had a poor technique for achieving maximum speed and its endurance in F1. These discussions will provide not only an outline of the sprint phases in order to improve sprinting speed, but also a guideline for coaches to establish training for the athletes.

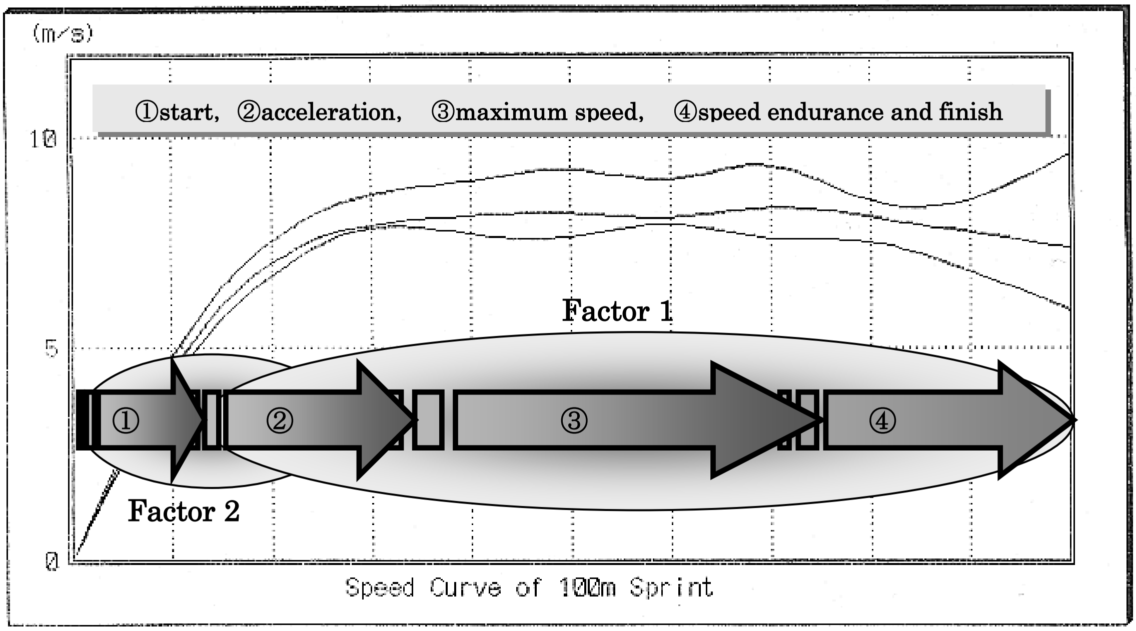


Figure 3 - Comparison of the speed curves of three athletes who ran the 100m dash in the 12, 13, and 14 second ranges.

CONCLUSION: In this study, the method of using a portable computer as a device for the measurement of sprinting time and the illustration of speed curve was introduced. Applying this method to sprint running, it is clear that our measuring system is advantageous for cheap and simple availability, quick and illustrative feedback, quantitative evaluation, and data processing and management. These data were useful for simplifying the structure of the sprint phase. Using factor analysis, a simple model consisting of two factors was developed. This model may be useful for the evaluation and estimation of the ability of participants in the 100m dash. The evaluation illustrates how our system for measurement can extract useful information for giving directions on coaching and insights into the basic technical phases of sprint running.

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