STRIDE CHARACTERISTICS RELATED TO RUNNING VELOCITY IN MAXIMAL SPRINT RUNNING

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INTRODUCTION: In sprint-related events, athletes and coaches strive to increase running speed by means of general and specific training methods. As running velocity is always the product of stride length and stride frequency, in the end, all methods aim to improve one or both of these factors. The relation between stride length, stride rate and running velocity has been discussed in the literature from different points of view. Alexander and Goldspink (1977) analyzed the movement speed and stride characteristics of mammals. As they wanted to compare mammals of different sizes, they transferred stride characteristics and speed into dimensionless parameters, taking into account gravity and the length of the leg. Their conclusions should also be valid for humans. But it is not clear if these formulas can predict stride characteristics in maximal sprint running.
The most specific way to affect stride characteristics is by means of 'facilitated' or 'hindered' running. In facilitated sprinting, the athlete runs at supramaximal velocity through an external aid. In hindered sprinting, the running velocity of an athlete is kept lower than normal through external resistance (Frishberg, 1983; Sinning & Forsyth, 1970). In some studies the momentary effects of facilitated and hindered running are analyzed. The experimental group in the study of Viitasalo et al. (1982) reached significantly higher stride frequencies and higher running velocities following facilitated sprint training. Hindered sprinting is supposed to result in greater stride length.
It was the purpose of this study to analyze whether there exists a clear relationship between stride characteristics and running velocity in maximal sprint running. A better understanding of this relationship could probably help coaches in developing training strategies. It is also the objective to analyze how this relationship is changed in conditions of facilitated or hindered sprint running.

METHODOLOGY: In this study twenty male physical education students (body height: 1.77 ±0.07m/ length of lower limbs: 0.83 ±0.04m) performed a maximal sprint over 100 meters, and seventeen female students (body height: 1.69 ±0.05m/ length of lower limbs: 0.79 ±0.04m) ran three 40 meter sprints: a maximal, a facilitated and a hindered sprint run.
Running speed was continuously recorded by means of a velocimeter (Witters, Heremans, Bohets, Stijnen, & Van Coppenolle, 1985). The principle of this velocimeter consists of a nylon wire connected to the dorsum of the trunk of the subject. This wire unwinds over a precisely machined wheel as the runner moves forward, and an optical sensor mounted over the wheel sends a pulse to the processor for every 0.1 m of path length. Based on these data running speed and running times were calculated.
A computer-guided horizontal towing system was developed to enable standardized facilitated or hindered sprint run over a 40 meter distance. The device was developed such that the subject was running within a closed circuit of nylon

wire. This wire is connected to the front and back of the subject by means of a belt. In facilitated sprinting a towing ratio of 9 kg on the front side and 3kg on the back side was applied. In hindered sprinting this ratio was the other way round.
Surface electrodes were used to record the muscle activity of four thigh muscles: m. rectus femoris, m. gluteus maximus, m. vastus lateralis and m. biceps femoris. During the sprint runs the EMG-recordings were stored in a small computer in a backpack. The subject had to carry an extra weight of 1.8 kg. The EMG-data were used to determine the duration of each stride cycle and to calculate mean stride rate per 5 meter-interval.
A regression analysis was performed between stride characteristics and running velocity.

RESULTS AND DISCUSSION: The average maximal velocity of the male sprinters was 9.37 ±0.52 m/s (100 m), while the female sprinters attained 7.38± 0.52 m/s (40 m).
The relation between stride length (SL) and running velocity (V) in male 100 meter performance was determined by means of linear regression analysis:

$$\mathbf{V=0.79+(3.89*SL)}$$

Almost 85 % of the variance in running speed can be explained by the variance in stride length. On the other hand, the variance in stride rate explains less than 20% of the variance in running speed. These findings are confirmed by means of the 40 meter sprint data of the female group:

$$\mathbf{V= 0.53 +(3.71*SL)}$$

whereby 80% of variance in running velocity is explained by variance in stride length, while only 20% of the variance is explained by stride rate.
In contrast to the findings reported in the literature, a clear linear relationship was found between SL and V. There existed no significant correlation between SR and V. This finding was confirmed in two separate analyses: one with females and another with males. These results are contrary to some data in the literature stating that the increase in stride length drops with higher running velocities (Williams, 1985; Bosco, Vittori, 1986), while stride rate becomes the performance determining factor.
The discrepancy between the results in the literature and this study can probably be explained by the fact that in this investigation pure sprint performances were analyzed, in contrast to most studies analyzing running speeds ranging from jogging to sprinting.
In this study it was also noticed that in all-out sprinting the stride rate reached it’s maximum already in the second 5 meter interval. From that interval on differences in running speed were mainly due to changes in stride length.
The resulting maximum speed for the facilitated test condition was 115% of the normal maximum velocity. The maximum velocity for the hindered test condition equaled 88.1%. Percentage changes in stride length for the facilitated and hindered run are much greater then percentage changes in stride frequency. This implies that mainly stride length is responsible for changes in running velocity between maximal and supramaximal or submaximal sprint running.
Despite the rather high resistance and assistance forces, used in these test conditions, the relation between stride length and running speed did not change significantly (table 1).

Table 1:Regression equations between stride length (SL) and running velocity.(V) for 100 meter sprinting (n=20 males) and for 40 m maximal, facilitated and hindered sprinting (n=17 females).

TEST	Regression equation
100 m - maximal	V=0.79 + 3.89 SL
40 m - maximal	V=0.53 + 3.71 SL
40 m - facilitated	V=0.39 + 3.69 SL
40 m - hindered	V=0.20 + 3.80 SL

Surprisingly, the facilitated sprinting velocity of 115% of maximal velocity did not result in changes of the stride pattern, as the relation with running velocity was not altered. Nevertheless, in training practice it is generally accepted that velocities over 110% of the maximal velocity should disturb the relation between running speed and stride length or stride rate. This finding implies that training intensity in facilitated running can be increased without damaging the balance between stride length and speed.

CONCLUSIONS: Despite the small range of running velocities (6-9m/s) and two rather homogeneous groups of subjects in this study, a clear consistency was found in the different regression equations between stride length and running velocity in different all-out sprint conditions.
In sprint running, stride rate seems to reach its maximum after a few steps, while stride length increases over a longer distance, being a key-factor in developing high running velocities.

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