KINEMATIC AND KINETIC ANALYSIS OF THE SPRINT START AND START
ACCELERATION

Milan Coh, Katja Tomazin, Ales Dolenec Faculty of
Sport, University of Ljubljana, Slovenia

INTRODUCTION

The start and the start acceleration are two most important phases, directly
influencing the final result in sprint. It is therefore not surprising that numerous
biomechanical studies have been carried out in the last few years and some very
important information obtained, both for theoretical and practical use in the training
process of sprinters (Mero, 1988; Coppenolle, Delecluse, Goris, Bohets & Eynde, 1989;
Guissard, Duchatenau & Hainaut, 1992; Delecluse, Coppenolle, Diels & Goris, 1992).
With the advancement of modern measurement technology new possibilities appear of
finding relevant and more objective information on the execution of the sprint start and
start acceleration in actual training or competitive conditions. The purpose of our study
was to analyse the kinematic and kinetic parameters of the set position and starting
action and their connection with the start acceleration in top sprinters. The quality of the
data and in consequence the objectivity of the biomechanical analysis are without doubt
dependent on the measurement instruments, therefore special starting blocks were
constructed for this study in order to register the kinetic parameters of the starting action.
The kinematic aspects of the start were assessed on the basis of a two-dimensional video
analysis.

METHOD

The subject sample consisted of thirteen male sprinters and eleven female
sprinters of the Slovene national selection. Each subject performed three sprints from the
starting blocks on a distance of 30 m. The measurement system consisted of three units:
starting blocks (MMIP) with computer support, the kinematic system APAS (Ariel
Performance Analysis System) and an electronic measurement system with four pairs of
photo cells (AMES) for measuring the time parameters of the start acceleration. The
SPSS statistical package was used for statistical data analysis. Basic statistics of the
variables was computed, T-test was used to assess the significance (on the 5 % alpha
error level) of the differences between the male and female sprinters in the parameters of
the start and start acceleration. The correlation between the parameters was assessed
with Pearson correlation coefficients.

RESULTS

Both kinematic as well as kinetic parameters exert influence on the execution of
the starting action. The horizontal start velocity which defines the efficiency of the first
phase of the start acceleration was 3.20 ± .19 m/s for male sprinters and 2.99 ± .23 m/s
for female sprinters. The starting time tells us how much time the athlete needs for the
push-off phase from the starting blocks. This was 0.30 ± .03 s for males and 0.34 ± .02 s
for females. However, the efficiency of the start execution is not dependent just on the
starting time but also on the push-off force from the blocks. A criterion of this action is
the impulse, measuring 201 ± 49 Ns on the front block and 97 ± 32 Ns on the rear block
for males. Male sprinters manage to achieve a maximal force of 936 ± 205 N on the
front block (female sprinters 688 ± 175 N) and 1002 ± 287 N (female sprinters 719 ±
137 N) on the rear block. The efficiency of the transition from the start to the start
acceleration is shown mostly by the parameters of the velocity of C.G. in the first two
strides. The horizontal velocity of C.G. at the end of the first stride (rear support phase) is 4.47 ± .29 m/s and 5.38 ± .24 m/s at the end of the second stride. The horizontal velocity of male sprinters has therefore increased by 2.18 m/s from the moment of leaving the front block to the rear support phase of the second stride. This figure is 2.00 m/s for female sprinters.

The criterion of start acceleration is the velocity developed by the athletes in the start to 30 m segment. Male sprinters achieved a velocity of 3.87 m/s in the first 5 m, 5.05 m/s at 10 m, 6.38 m/s at 20 m and 7.16 m/s at 30 m. The female sprinters' velocity development was as follows: 3.59 m/s at 5 m, 4.69 m/s at 10 m, 5.91 m/s at 20 m and 6.62 m/s at 30 m.

DISCUSSION

The level of correlation between the kinetic and kinematic variables of the set position and starting action can be assessed through their inter-correlation coefficients. The criterion of the efficient start is the horizontal start velocity (Coppenolle, 1989; Delecluse, 1996). This parameter has significant correlation coefficients with the force impulse from the front block (r = .54), reaction time of front foot (r = -.57) and the ankle angle of the front (r = -.62) and rear leg (r = -.53). The significant negative correlation coefficients of the ankle angle of the front and rear leg show that efficiency of the horizontal start velocity is connected with dorsal flexion (a sharp angle between the foot and the Shank) of the leg in the starting blocks. The average value of the ankle angle of the front leg is 97.5° and 97.4° of the rear leg. The effect of a greater obliquity of the front block on start velocity was studied by Guissard (1992) through EMG activity of the gastrocnemius, soleus and vastus medialis. She found that greater obliquity of the front block (30° - 50°) statistically significantly effects greater start velocity, without prolonging the push-off phase from the block. The increase in start velocity is the consequence of a eccentric-concentric muscular contraction of the back Shank muscles and the use of the elastic energy in the concentric phase. Besides the muscles themselves, the muscle spindles also extend in the eccentric phase, causing a reflex activity that raises EMG in the muscle. The obliquity of the block causes both neural as well as mechanical changes in the functioning of the ankle extensors. In the position of dorsal flexion the Achilles tendon also stretches to some extent, storing some elastic energy in the tendon (Bosco, Komi & Ito, 1981; Bosco, 1985) which is freed in flexion. The greater the extension the greater the work the tendon will perform. The efficiency of the push-off from the blocks is therefore the consequence of the action of two energy systems - chemical energy of the extensors of the ankle and the elastic energy of the connective and elastic elements.

REFERENCES: