CONDITIONING AND SPRINTING TECHNIQUE

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The purpose of this paper was to show relationship between muscle strength and sprinting technique. Stride length and frequency correspond to different kinetic chains and by changing their characteristics the stride pattern will change as well. Ground reaction force parameters of squat jump may be used for functional assessment of kinetic chain due to its proximal-distal pattern of muscle activation. The first part of squat jump is dominated by hip extensors (proximal part) while final take-off velocity is related to knee extensors (distal part). Since grabbing is performed by hip extensors, stride frequency is expected to be related to the first part of the squat jump. Pushing is mainly performed by knee extensors and thus provides rationale for relation between stride length and take-off velocity.

KEY WORDS: sprint, stride length, stride frequency, squat jump, resistance training

INTRODUCTION:

Sprinting technique at very basic level is characterized by stride frequency (SF) and stride length (SL). By variation of these two parameters sprinters try to achieve maximal running speed. A lot of training time is spent changing and/or looking for the optimal relationship between SL and SF. Further more, there is opinion that changing sprinting technique is rather demanding task often leading to worse results. If technique depends on conditioning, it should be constitutive part of technique change.

There is some support that muscle force ratio is related to sprinting technique. Two kinetic chains have been identified related to sprint (Wiemann, 1986). The first one responsible for stride length and the second for stride frequency. Ratio between the kinetic chains should determine stride SL and SF. The crucial difference between these two kinetic chains is involvement of hamstring and quadriceps femoris muscles. There are more ways to assess this ratio. Lot of studies measured knee flexion/extension ratio and related to sprinting time (Dowson et al., 1998). However, squat jump (SJ) is possible alternative as well. Bobbert & van Ingen Schenau (1988) showed strong proximal-to-distal sequence of muscle activation. Hip extensors dominated the start of SJ, followed by knee and hip extensors. From ground reaction force-time curve a contribution of distal and proximal muscles can be assessed and related to the SL and SF during maximal sprinting.

Further evidence to support the concept of specific role of kinetic chain regarding SL and SF can be gained with training effect of dominant muscle groups belonging to each kinetic chain. It can be assumed that training of hip extensors will presumably affect SF and training of knee extensors SL.

The aim of the paper is to select SJ parameters obtained from ground reaction force measurement reflecting proximal-to-distal sequence of muscle activation and relate them to the SL and SF during maximal sprint. Further, to show that power training of hip extensors or knee extensors will induce specific change in SF or SL, respectively.

METHOD:

Data collection: Three separated studies were performed. In the first study, 42 male students of PE volunteered the study. The subjects were asked to execute three concentric squat jumps. Force plate (Kistler, 9287, Winterthur, Switzerland) was used for ground reaction force measurement. Starting position at 90° knee angle and trunk was demanded. Each individual performed three jumps. Afterwards isometric torque during maximal voluntary isometric hip extension, isometric knee flexion and extension was measured three times. Subjects were placed into isometric measurement device and fastened to secure isolated moves. During hip extension they were in supine position with hip angle at 90° and during the knee torque measurement they were seated with the knee angle at 60°. The best attempt from the three was used for further calculations. The following parameters were analyzed: height of SJ from the flight time (Height), starting acceleration of body mass during push-off for the first 100ms (Start), ratio between the impulse of the second and the first half of push-off phase (I21), peak isometric torque of hip extension (Hip_ext), knee extension (Knee_ext), and knee flexion (Knee_flex).

In the second study, 36 Slovenian sprinters (12 females and 24 males) participated. Squat jump was analyzed in the same was as in the first study. They run maximally for 30 meters with flying start. Time was measured with photocells. Additionally, stride length and stride frequency were measured with Optojump (Matsport, Saint Ismier, France). The fastest run was used for further analysis.

In the third study, students of PE were divided into knee extension (n=9) and knee flexion training group (N=10). They performed power training for 6 weeks twice per week. Knee extension group performed knee extensions and leg-press (trunk flat) with single leg. Hip extension group performed standing hip extension with cable and standing knee flexion (all Technogym, Gambettola, Italy). Before and after the training period they were tested for change in stride length and frequency during maximal velocity sprinting. The procedure was the same as in the second study.

All subjects were instructed according to Helsinki-Tokyo declaration and gave informed consent. The studies were approved by Slovenian medical-ethics committee.

Data analysis: Descriptive statistics was calculated for each parameter. In the first two studies, multiple linear regression (method enter) was performed with SL and SF as criteria and SJ parameters as predictors.

RESULTS:

Descriptive statistics for the first two studies are presented in Tables 1 and 2.

Table 1 Basic statistics of study 1.

	Mean	SD
Height	35,7	4,6
Start	1,58	0,65
I21	1,35	0,29
Hip_ext	356,8	74,1
Knee_ext	236,5	56,8
Knee_flex	137,5	35,4

Table 2 Basic statistics of study 2

	Mean	SD
Height	42,5	7,1
Start	3,02	1,2
I21	1,21	0,16
Velocity	9,5	0,64
Freq	5,03	0,4
Length	2,34	0,11

Subjects from study 1 differed from those from study 2 in their performance. Main difference was in jumping height (35,7 $\pm$ 4,6 for study 1 and 42,5 $\pm$ 7,1 for study 2, respectively), but also in a way how they distributed ground reaction force: sprinters were able to start faster (1,58 $\pm$,65 and 3,02 $\pm$ 1,2, respectively) and delivered more impulse in the first half of the push-off phase (1,35 $\pm$,29 and 1,21 $\pm$,16, respectively).

Multiple regression analyses in study 1 (Table 3) showed each of SJ parameters was related statistically significantly only to single joint torque. Knee extension contributed mostly to SJ height ($P < .01$, other torques $P > .05$) and that starting force and I21 were dominated by hip extension ($P < .01$ and $P < .001$, respectively, other torques $P > .05$).

In study 2, the multiple regression analyses (Table 4) showed that SF was statistically significantly related to starting force ($P < .01$) and not to height or I21 (both $P < .05$). The only statistically significant predictor for SL was SJ height ($P < .01$), while the contribution of the other two was negligible ($P > .05$).

Table 3 Study 1: Regression analysis

	Height	Start	I21
Hip_ext	0,578	0,001	0,000
Knee_ext	0,002	0,225	0,882
Knee_flex	0,101	0,290	0,900

Cells contain P values (statistical significance) of predictors contribution to criteria.

Table 4 Study 2: Regression analysis

	Height	Start	I21
Freq	0,206	0,001	0,068
Length	0,007	0,995	0,458

Cells contain P values (statistical significance) of predictors contribution to criteria.

In study 3, knee extension/flexion ratio after training was statistically significantly differently changed between groups (P < .01). In the knee extension group the ratio increased (P < 0.1) and in knee flexion group it decreased (P < 0.05). Relative changes of sprinting parameters are shown in Figure 1. Knee flexion group was faster after the training (P < .01) with higher SF (P < .05) but not significantly changed SL (P > .05). Changes in knee extension group were minor and non-significant (all P > .05).

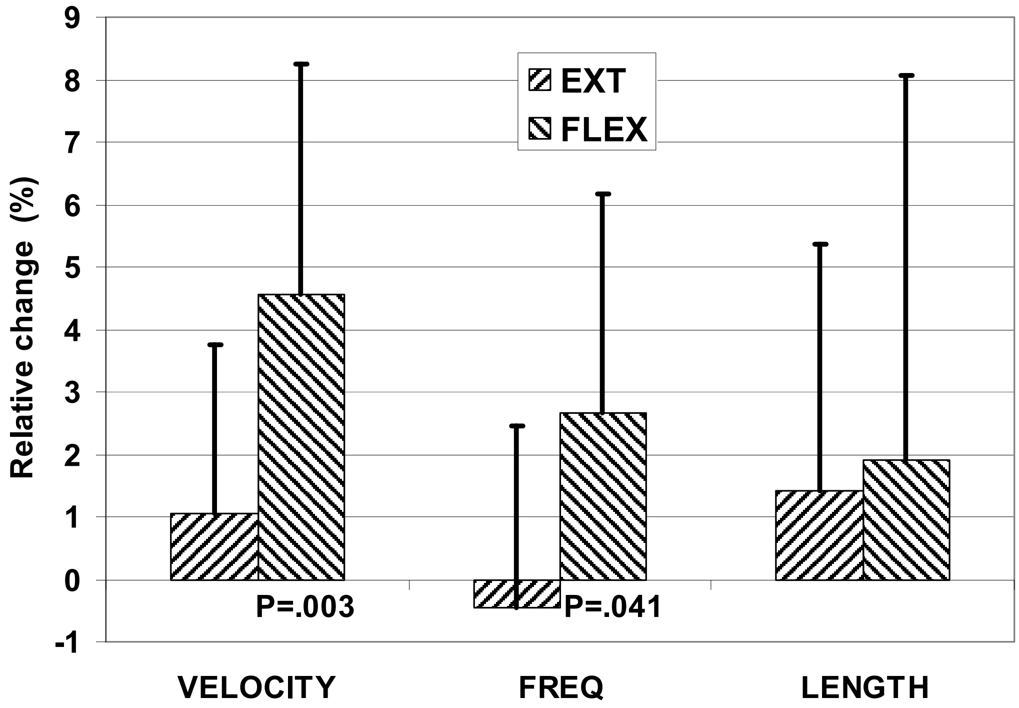

Figure 1 Relative changes in sprinting parameters after 6 weeks of power training in knee extension (EXT) and knee flexion (FLEX) group.

DISCUSSION:

The main results of presented studies can be summarized as follows: SJ height was related to knee extension and SJ starting force to hip extension, SF during maximal sprint velocity was related to SJ starting force while SL was related to SJ height. After training, only knee flexion group experienced faster sprinting and increased SF, while in knee extension group changes were non-significant.

SJ jumps are easy to perform and are routinely used in biomechanical laboratories. It has been shown with EMG (Bobbert & van Ingen Schenau, 1988) that SJ is stereotyped movement with proximal-to-distal sequence of muscle activation. Gluteus and hamstring muscles as hip extensors started the movement and were then followed by quadriceps femoris muscle and later with gastrocnemius and soleus muscles. This corresponds well to

results of the first study based on ground reaction force parameters. The subjects with more powerful hip extensors were capable to attain greater starting force. Thus starting force (actually starting acceleration) of SJ may be valid parameter for hip extensor function assessment. SJ height as the final result of push-off depends on distal part of kinetic chain as was demonstrated in the study 1. According to proposal by Wiemann (1988), these SJ parameters may determine the dominant kinetic chain of the subject. For this reason, I21 was introduced to stress prevalence of proximal or distal part of kinetic chain. From measurement in our laboratory, I21 differs substantially among sports groups. E.g., distance runners normally have I21 above 1.5 and their sprinting technique is practically exclusively based on pushing (pronounced leg extension during sprinting). Significant contribution of proximal and distal part of kinetic chain to I21 was expected. Regression analysis showed strong prevalence of hip extensors although hip and knee extensors had significant ($P < .05$) Pearson correlation coefficients with I21. However, the relationship was much stronger for hip extensors. Study 1 showed that SJ height, starting acceleration and I21 can describe function of proximal and distal muscle groups in concentric vertical jump.
The aim of the second study was to discriminate between grabbing and pushing during maximal sprinting. The SJ provide solid base to identify dominant kinetic chain that can be related to sprinting technique. Therefore it was no surprise that starting acceleration during SJ was the strongest predictor for SF and the SJ height the strongest predictor for the stride length. Most studies that related muscle strength and sprinting time found positive correlation between both (e.g. Alexander, 1990; Dowson et al., 1998), however none specifically stressed influence of influence of muscle strength ratios on sprinting technique although the idea of this relationship has already been put forward (Wiemann, 1988).
If the muscle strength ratio affects the sprinting technique it should be seen after training that changes this ratio. Power training for hip or knee extensors was able only partially to support this idea. Greater effect on sprinting was observed after hip extension/hamstring training where changes were very much in line with the model. One explanation may be weaker hamstring muscles in less active population making training effect larger. The other explanation could be greater importance of hamstrings for sprinting.

CONCLUSION:

There is strong relationship between muscle strength ratio and sprinting technique. Therefore, changing sprinting technique should be supported by proper conditioning of corresponding muscle groups.

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Acknowledgement

This study was supported by Slovenian research agency grant no. L5-6570. Special thanks to Ales Dolenec, Ph.D., Katja Tomazin, Ph.D., and. Nejc Sarabon, Ph.D. for their contributions.