ANALYSIS OF STRIDE PARAMETERS AND RUNNING VELOCITY AT INDOOR 400 M RUNNING

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ABSTRACT

Background. 400 m race is one of most difficult and complex events in athletics. In order to achieve good results in the distance an athlete must have not only good velocity characteristics, but also be able to tactically correctly allocate them, i.e. depending on their total and special endurance level be able to distribute efforts in the entire range, select the optimum running velocity for the start and keep it until the finish. Research aim was to analyse the choice of running tactics and change of stride parameters and running velocity of the best Lithuanian 400 m runners during a running indoor contest.

Methods. The study was conducted during Lithuanian Indoor Championship. The best 15 runners of 400 meters were investigated. The runners were filmed by Digital cameras from the side at a distance of 90, 190, 290 and 390 meters. We analysed stride kinematic parameters (duration of support and flight, stride length, stride frequency) and the running velocity.

Results. The maximum decrease of the stride length and running velocity were observed between 190 and 290 m where the stride length decreased from 2.22 ± 0.03 to 2.08 ± 0.03 m and running velocity from 8.18 ± 013 to 7.36 ± 0.07 m/s. In the first distance range, i.e. 90 m, the stride frequency was 3.83 ± 0.05 Hz. Later it gradually decreased to 3.46 ± 0.05 Hz in 390 meters. Duration of support at 90 m was 0.119 ± 0.001 s and till 290 m it become longer, later it was almost unchanging. Time of flight phase changed insignificantly over the entire distance.

Conclusion. It was found that athletes' choice of running tactics depended not only on their preparation type (sprint or endurance), but also on the conditions in which the athlete starts (indoor or outdoor), as well as on the number of the track in which the athlete starts. The maximum change of running velocity and stride length during the indoor running was observed in the second half of the range, while the stride frequency decreased gradually during the entire range. Change of support time had greater impact for stride frequency than change of flight time.

Keywords: stride frequency, stride length, duration of support, duration of flight, tactics.

INTRODUCTION

400 m race is one of most difficult and complex events in athletics. In order to achieve good results in the distance an athlete must have not only good velocity characteristics, but also be able to tactically correctly distribute them, i.e. depending on their total and special endurance levels be able to distribute efforts in the entire range, select the optimum running velocity for the start and keep it until the finish (Бухарина, 2003; Мирзоев, 2002). Generally, it can be assumed that 400 m runners should maintain an average velocity that corresponds to 94% of the best athlete's 200 m result. At the same time, the athlete must be able to maintain stride length which corresponds to 1.3 of athlete height (Jarver, 2005).

Running velocity during the distance decreases gradually and reaches a maximum change at 50 m till the finish (Gajer, Hanon, & Thepaut-Mathieu, 2007; Letzelter & Eggers, 2003). The difference between the first and second half-range drubbing time is 1.6 to 2.0 seconds (Мирзоев 2002). For 400 m runners energy supply is very important, in particular glycolytic capacity (Duffield & Dawson, 2003; Duffield, Dawson, & Goodman, 2005; Лисовский, 2001). There are a number of works dealing with the change of running velocity and stride parameters on the 400 meters run in the stadium (Bruggemann, Koszewski, & Müller, 1999; Gajer et al., 2007; Hanon & Gajer, 2009; Nummela, Stray-Gundersen, & Rusko, 1996), but we could not find any studies where these parameters were examined in indoor running.

Research aim was to analyse the choice of running tactics and changes of stride parameters (stride length, frequency, duration of support and flight) as well as the running velocity of the best Lithuanian runners during indoor contest running.

METHODS

The study was conducted during Lithuanian Winter Championship. The best 15 runners of 400 meters were investigated. Their mean age, height and body mass were (mean ± standard error) 20.3 ± 0.68 years, 1.81 ±.01 m and 72.6 ± 2.3 kg, respectively. Runners were filmed with digital 25 Hz for Canon XM1 video cameras from the side at the distance of 90, 190, 290 and 390 meters (Figure 1). Video cameras were directed perpendicular to the track. After that the filmed material by the SIMI MOTION program was transferred from the cameras to a computer and analysed by 50 Hz. The analysis of running technique was performed using a specialized motion analysis program SIMI MOTION 2D where we analysed and calculated stride kinematic parameters (duration of support and flight, stride length, stride frequency) and the running velocity.

The time after the first and second half of the distance was registered by fully automated finishing system ("Monochrome EtherLynx 2000 Black & White Camera", standard resolution 1000 lines/ sec @ 500 pixels.), which automatically turned on by the starter's signal (shot) and automatically recorded the finish time. This finish system is certified by the IAAF.

Two-way analysis of variance (two-way ANOVA) for the dependent samples was applied for the evaluation of changes between the measurements. The difference between the measurements (Student's *t* test) was considered to be significant at $p \leq .05$. Before the test of means, equality of dispersion was checked. The data are expressed as means ± standard error. These calculations were performed by using statistical functions of the SPSS statistics 17.0.

RESULTS

Analysing results of 400 m runners' run we can see that the best Lithuanian athletes overcome the first half of the distance on the average 3.02 ± 0.21 seconds faster than the second one (Figure 2).

Also we calculated the relationship between this difference and the running track on which athlete ran. Athletes who ran the first half of the distance on the fourth track were on the average 3.77 ± 0.31 seconds faster than when they were on

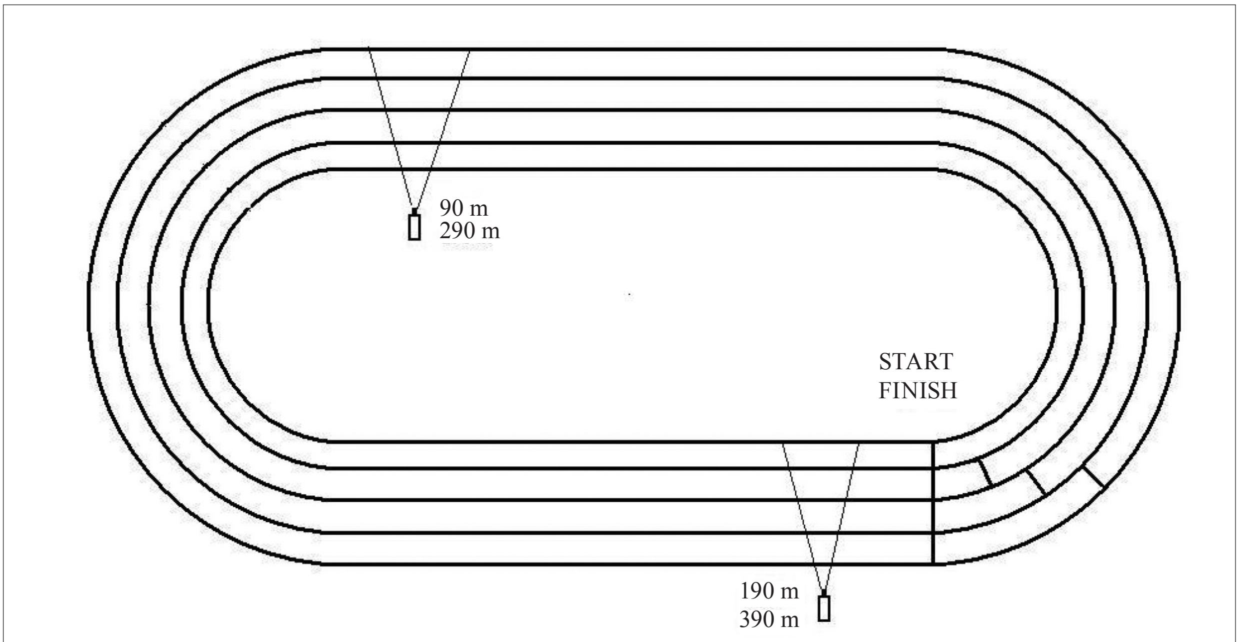


Figure 1. **Layout of cameras**

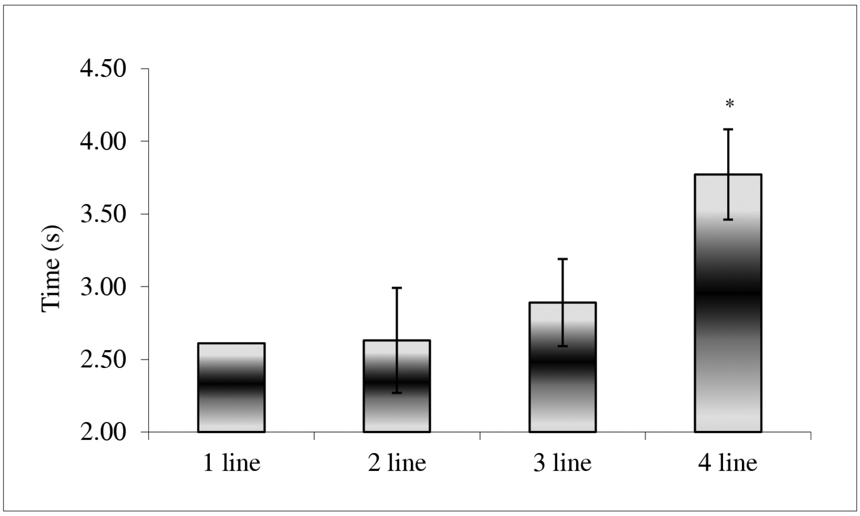


Figure 2. **Difference in time between the first and second halves of the race depending on the running track**

Note. * – significantly different, compareв with values of other lines ($p \leq .05$).

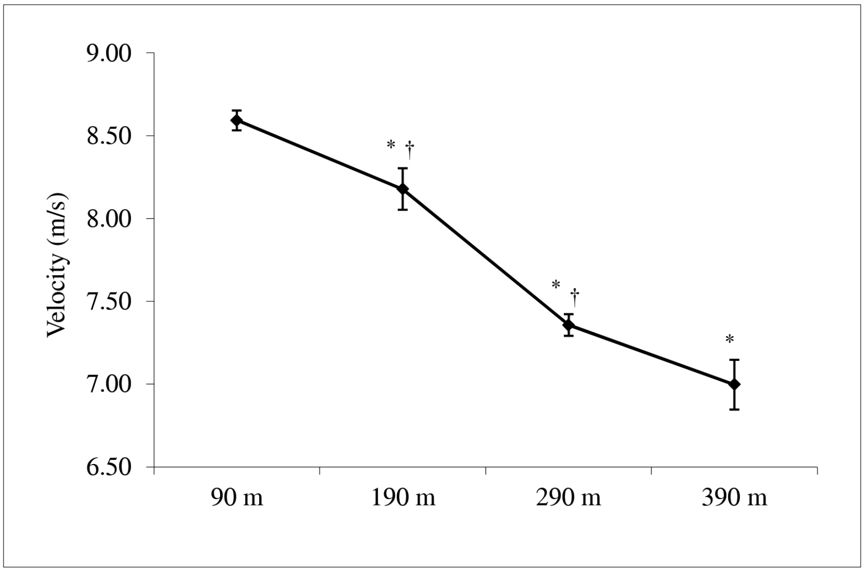


Figure 3. **Change of running velocity in different points of distance**

Note. * – significantly different from 90 m point values ($p \leq .05$), † – significantly different from previous measurement values ($p \leq .05$).

the second one. Meanwhile, athletes who ran the first half of the distance on the third and second tracks overcame it only 2.89 ± 0.30 and 2.63 ± 0.36 seconds faster than the second one. Time difference between the first and second distance halves of athletes started in the fourth track was statistically significant ($p < .05$) higher than others who started on other tracks. The correlation between the result of the first running half and the number of the track was –.59. And average correlation between the time difference of the first and the second running halves and the number of the track was .55.

Analysing the change of running velocity (Figure 3), we can see that running velocity after 90 m was 8.59 ± 0.06 m/s, and at 190 m range it decreased to 8.18 ± 0.13 m/s ($p < .05$). The biggest slowdown (0.82 ± 0.12 m/s) was between 190 and 290 m ranges. There running velocity decreased from 8.18 ± 013 m/s to 7.36 ± 0.07 m/s ($p < .05$). In the last running range velocity of athletes decreased to 7.00 ± 0.15 m/s, but compared to the velocity of 290 m, this decrease was not statistically significant ($p > .05$).

Stride length (Figure 4) in 90 m was 2.25 ± 0.03 m and in 190 m 2.22 ± 0.03 m. Decrease was not statistically significant ($p > .05$). The maximum decrease of stride length was observed between 190 and 290 m where the stride length was 2.08 ± 0.03 m ($p < .05$). In the last running range the stride length decreased to 2.02 ± 0.04 m ($p > .05$).

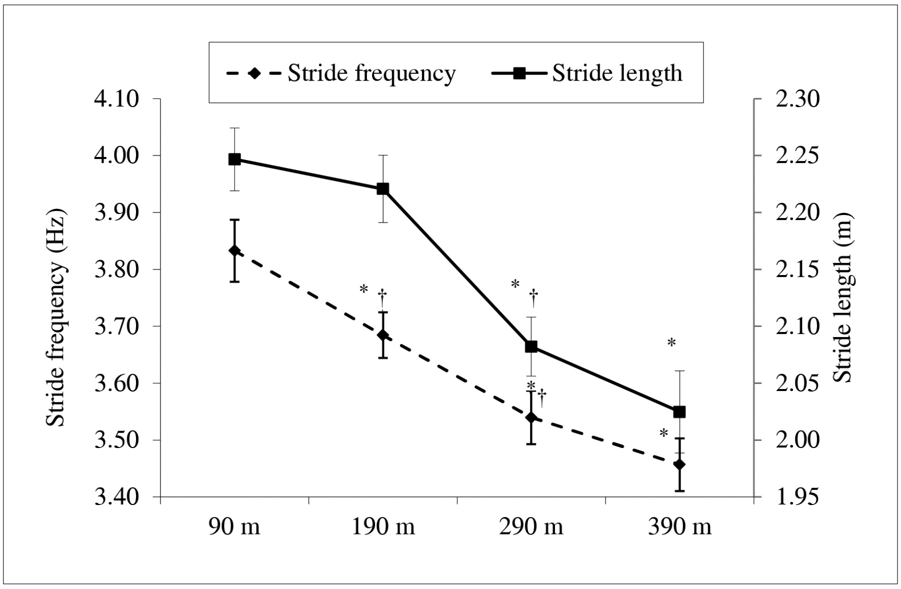
In the first distance range, i.e. 90 m, the stride frequency (Figure 4) was 3.83 ± 0.05 Hz. Later it gradually decreased. At 190 m it decreased to 3.68 ± 0.04 Hz, and at 290 m – to 3.54 ± 0.05 Hz. These decreases were statistically significant ($p < .05$). In the last running range the stride frequency decreased to 3.46 ± 0.05 Hz, but it was not statistically significant ($p > .05$).

Duration of support at 90 m was 0.119 ± 0.001 s and till 290 m it become longer ($p < .05$) and later remained almost unchanging. Duration of flight at 90 m was 0.153 ± 0.004 s, later reduced to 0.148 ± 0.003, and unchanged till 290 m, at 390 m it increased to 0.153 ± 0.004 s. There were no statistically significant differences between the flight phase values (Figure 5).

As can be seen from Table 1, the biggest percentage of change in the running velocity was between 190 and 290 m of the distance. The total percentage decrease of running velocity was 18.42 ± 2.17%. The maximum stride length reduction was also observed in the range between 190 and 290 m (6.11 ± 1.28%). Total decrease of stride length was 9.71 ± 1.88%. Stride frequency decreased during the whole distance. The largest decrease was in the range between 190 and 290 m (3.89 ± 0.96%). Total decrease of stride frequency from 90 to 390 m was 9.64 ± 1.49%. Support time most increased from 90 to 190 m (12.24 ± 2.19%), and total (from 90 to 390 m) change of support time was 17.73 ± 2.82%. Duration of flight from 90 m to 190 m fell by 2.61 ± 1.24%, then it began to grow and the biggest change was from 290 m to 390 m, where it increased to 3.85 ± 2.21%.

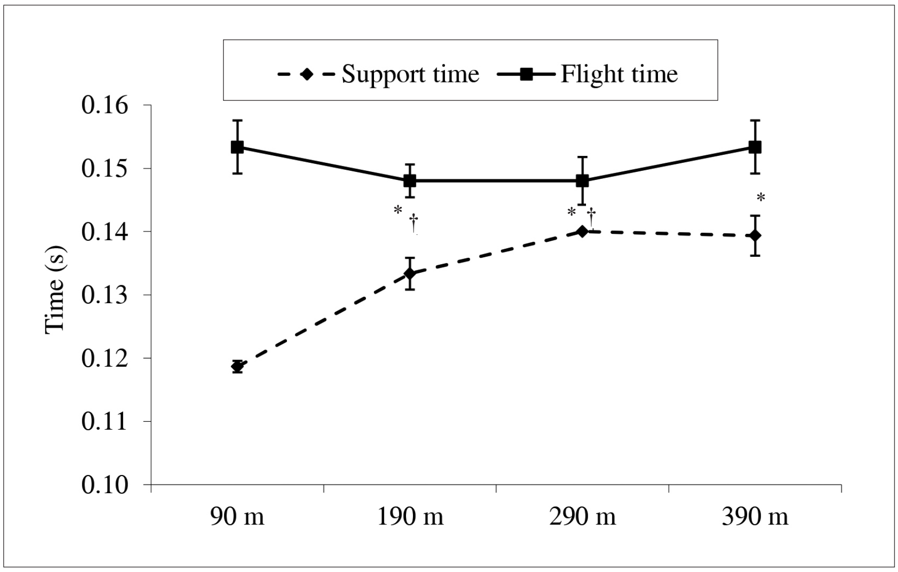
As we can see from Table 2, the change of stride length and stride frequency had the greatest influence on running velocity.

Figure 4. **Change of stride length and stride frequency in different points of distance**



Note. * – significantly different from 90 m point values ($p \leq .05$), † – significantly different from previous measurement values ($p \leq .05$).

Figure 5. **Change of duration of support and flight in different points of distance**



Note. * – significantly different from 90 m point values ($p \leq .05$), † – significantly different from previous measurement values ($p \leq .05$).

Parameters	90–190 m	190–290 m	290–390 m	90–390 m
Velocity	–4.76 (1.62)	–9.81 (1.32)	–4.72 (2.45)	–18.42 (2.17)
Stride length	–1.04 (1.38)	–6.11 (1.28)	–2.55 (2.10)	–9.71 (1.88)
Stride frequency	–3.71 (1.24)	–3.89 (0.96)	–2.19 (1.52)	–9.64 (1.49)
Support time	12.24 (2.19)	5.56 (2.10)	–0.48 (2.26)	17.73 (2.82)
Flight time	–2.61 (1.24)	0.36 (3.00)	3.85 (2.21)	0.52 (2.80)

Table 1. **Percentage change of running velocity and stride parameters between the different points of distance**

Range of distance	Stride length	Support time	Flight time	Stride frequency
from 90 m to 190 m	.689	.102	–.537	.589
from 190 m to 290 m	.759	.095	–.067	.423
from 290 m to 390 m	.784	.028	–.125	.559
from 90 m to 390 m	.779	–.230	–.508	.606

Table 2. **Correlations between the percentage change of running velocity and percentage change of stride parameters between at different points of registration**

DISCUSSION

400 m runners, who are generally medium to tall in height and physically strong in build, fall into two distinct categories. One group includes the athletes who have a speed base and the other – athletes who have an endurance base. It has also been suggested that the two groups should have distinct tactical approaches to running 400 m. It was thought that the speed-based athlete ran a fast first half of the race and then "held on" for as long as possible, hoping that fatigue would not slow him/her too much before the completion of the race. The endurance-based athlete would run differently, with a more even paced race, the time of the first half of the race being roughly similar to the time of the second half (Schiffer, 2008).

Obviously the sprinter type has the advantage through the early stages; however, if he or she is not trained properly, this advantage can melt away in a hurry toward the end of the race. The endurance type will definitely have an advantage from the 300 m mark to the finish (Hart, 2000).

The success of the sprinter-type 400 m runner is usually explained by the fact that it is easier to develop speed endurance in sprinter types than speed capacities in endurance-type athletes. Generally, it can be assumed that 400 m runners should maintain an average velocity that corresponds to 94% of the best athlete's 200 m result (Jarver, 2005).

Comparing velocity change dynamics of our surveyed athletes who ran indoor with similar performance athletes who ran in the stadium (Gajer et al., 2007) we found out that running indoor maximum decrease of velocity is between 190 and 290 m (9.81 ± 1.32%) while running in the stadium the largest decrease is in the last 100 meters. Total velocity decrease of our surveyed athletes was 18.42 ± 2.17, other authors in similar works found from 14 to 19% (Bruggemann et al., 1999) and more than 20% (Gajer et al., 2007). Similar situation exists with the change of stride length.

Most of our surveyed athletes chose sprinter run tactic because the difference between the first and second halves of range on average was 3.02 ± 0.21 s. The reason for this selection may be the peculiarity of indoor 400 m running. Athletes run on their own track indoors only the first half of the range, and later everyone runs on the first track. Therefore it is very important to start in a good position because later is very difficult to overtake an opponent in rather sharp turns and quite short lines.

Running velocity of all our surveyed athletes decreased during the whole race distance. Particularly large decrease was observed in the second half of the range. This could be influenced by the choice of running tactics, the track on which athlete runs the first half of the range, and the resulting tiredness. Generally it is assumed that the energy supply in the 400 m running is anaerobic, but findings of various researchers on the percentage contribution of anaerobic and aerobic energy mechanisms are different. This can be influenced by gender, type of athletes (sprinters or endurance representatives), different research methodologies, and level of athlete's skills. The aerobic contribution increases as a consequence of the extended duration of the race, being 24% for a performance of 44 s, 33% for 48 s and 43% for 52 s. Researchers found that the increased pH level in the first 150–200 meters inhibits aerobic energy generation mechanisms in the II type muscular fibres during further running (Arcelli, Mambretti, Cimadoro, & Alberti, 2008). After running athletes' lactate concentration is increased from 20 to 25 times comparing to resting state (Schwellnus, Nicol, Laubscher, & Noakes, 2004).

The radius of turn is less; the decrease of maximum athletes' velocity is higher. Difference between the results of athletes running in the 1 and 8 tracks was 0.35 s (Quinn, 2009). We believe that running indoor where turning radius is less, loss of velocity is also significant. This is also demonstrated by our research results which indicate that the difference between the first and the second halves of range running in the fourth track was bigger because in the first half of the range athletes could meet faster because of the geometry of the track.

CONCLUSIONS

It was found that athletes' choice of running tactics in 400 m event depended not only on athletes' preparation type (sprint or endurance), but also on the conditions in which the athlete starts (indoor or outdoor), and on the number of track on which the athlete starts.

The maximum change of running velocity and stride length during the indoor running was observed in the second half of the range, while the stride frequency decreased gradually during the entire range. Change of support time had greater impact for stride frequency than change of flight time. Change of stride length had the greatest influence on running velocity.

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