**ORIGINAL RESEARCH PAPER**

# RELATIONSHIP BETWEEN LOWER LIMB ISOKINETIC STRENGTH AND 60m SPRINT RUNNING TIME

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## Abstract

*Aim: The purpose of this study was to investigate relationship between lower limb isokinetic strength and 60m sprint running time. Subjects: 9 male competitive Estonian sprinters (age 20.7 ± 2.6yrs, height 181.2 ± 5.7cm, mass 76.0 ± 7.1kg) volunteered to participate in the study. Methods: Peak torque of ankle plantar flexion, ankle dorsalflexion, knee and hipextension and flexion were measured with HUMAC NORM isokinetic dynamometer in angular speeds 60, 180 and 240°/s. The sprint performance, 60m from blocks (7.10 ± 0.13 sec), was fixed in competition conditions during the winter season 2013. The isokinetic testing took place shortly after the competition season. The correlations between relative isokinetic peak torque values corrected with body mass and sprint times were calculated. Results: Statistically significant relationship was found between isokinetic strength of ankle dorsiflexion, knee extension, hip extension and sprint running time. Statistically strongest relationships were found between average peak torque (Nm), average relative peak torque (Nm/kg) of hip flexion at 180°/s (r=-0.737; r=-0.818), at 240°/s (r=-0.719°/s; r=-0.805°/s) and sprint running time. Statistically less significant relationships were found between average peak torque, average relative peak torque of knee extension at 60°/s (r=-0.746; r=-0.679) and sprint running time. Statistically significant relationships werealso found between average peak torque of ankle dorsiflexion at 60°/s (r=-0.708), at 240°/s (r=-0.682) and sprint running time. No statistically significant relationships were found between isokinetic strength of ankle plantar flexion, knee flexion, hip extension and sprint running time. The main finding of the study is that in addition to extensors also dorsiflexors ankle stabilizers play a significant role in sprint performance.*

***Key words**: isokinetic strength, peak torque, 60m running, lower limbs strength.*

## Introduction

Muscle strength is highly important factor in sprint running (Delecluse et al. 1994, Dowson et al. 1998, Olmo & Castilla 2005). Good running speed isneeded not only for sprint running but for various sports (Cronin& Hansen 2005, Sugisaki et al. 2011). Despite the actuality and importance of this topic, the literature covering the relationship between muscle strength and sprint running performance is limited (Dowson et al. 1998). Many previous studies focus on relationships between acceleration phase (until 40m) and isokinetic strength (Bračič et al. 2011, Cronin& Hansen 2005, Dowson et al. 1998, Nesser et al. 1996, Sugisaki et al. 2011), but not for classical sprint running distances. In addition, there is lack of studies investigating relationship between isokinetic strength and sprint running time where sprint running time is registered in competition situation.

The lower limb muscles need to carry out the most important role in the production of speed during sprint running. For sake of investigating each joint muscle correctly we need to use isokinetic dynamometer. Isokinetic dynamometer enables to measure each joint's movement strength at different angular velocity, while velocity is held constant through the range of movement. (Baltozopoulus & Brodie 1989). Most of previous studies have investigated relationship between strength of knee flexion, extension and sprint running (Alexander 1989, Bračič et al. 2011, Cronin & Hansen 2005, Delecluse et al. 1994, Dowson et al. 1998, Farrar & Thorland 1987, Nesser et al. 1996, Olmo & Castilla 2005). In addition, there are studies investigating relationship between isokinetic strength of ankle (Alexander 1989, Delecluse et al. 1994, Dowson et al. 1998, Inal et al. 2012, Nesser et al. 1996) and hip joint muscles and sprint running performance (Alexander 1989, Blazevich & Jenkins 1998, Dowson et al. 1998, Farrar & Thorland 1987, Guskiewicz et al. 1993, Nesseret al. 1996). Inal (2012) has investigated the relationship between isokinetic strength of ankle inversion and eversion. Using different angular velocities in testing, we can define slow, medium and high speed tests. (Brown 2000). Isokinetic studies usually find relationship between isokinetic strength and running speed using angular 60°/s (slow) - 300°/s (high) (Cronin & Hansen 2005, Cronin et al. 2007, Farrar & Thorland 1987, Olmo & Castilla 2005). Some studies have used greater speeds as 450°/s (Nesser et al. 1996) and 480°/s (Blazevich & Jenkins 1998).

The purpose of this study was to investigate relationship between lower limb isokinetic strength and 60m sprint running time. Previous studies have found that the relationship between muscle strength and running performance are usually weak (Cronin & Hansen 2005, Cronin et al. 2007, Dowson et al. 1998). Most of previous studies have admitted that the findings about the relationship between isokinetic strength and running performance are conflicting. The major reasons for these conflicting results could be that first, different authors have not studied the same isokinetic parameters and the studied running distances have been different. Second, the studies investigating relationship between isokinetic parameters and running performance are often using athletes from other sport fields, which make it difficult to generalise these results for competitive sprinters. Third, sprinters are heterogeneous by anthropometrical and strength parameters, which makes it difficult to develop universal predictors for running performance. Forth, the studies have often been performed on a small and homogeneous sample of athletes.

**Methods**

The study was conducted on 9 male Estonian national level sprinters (age 20.7 ± 2.6yrs, height 181.2 ± 5.7cm, mass 76.0 ± 7.1kg). Average 60m sprint running time was 7.10 ± 0.13sec. The sprint performance, 60m from blocks was fixed in competition conditions during the winter season 2013. In this study the sprint performance of an athlete was defined as the seasonal best time of each athlete. All competitions were part of Estonian Athletics Federation official competition calendar. Electronic timing system was used to measure the sprint time and the rules of international athletics federation were enforced by certified referees. The isokinetic testing took place shortly after the competition season.

A HUMAC NORM (Computer Sports Medicine, Inc. Stoughton, MA, USA) wasused to assess the average peak torque (Nm) and average relative peak torque (Nm/kg) of ankle plantar flexion, ankle dorsiflexion, knee and hip extension and flexion of both legs were tested accordingly. All tests procedures, dynamometer settings and securing of subjects to seat and measurement arms were carried out in accordance with the HUMAC NORM user manual. Ankle plantar and dorsiflexion tests were performed in the “Modified Seated” (supine) position, knee extension and flexion tests in seated position and hip extension and flexion tests in lying position.The axis of rotation of the dynamometer lever arm was aligned with the anatomical axis of the joint being tested, as described in the HUMAC NORM test manual. The “gravity correction” features were used in all tests to avoid gravity effect of limb weight. All joint movements were tested concentrically at velocities 60 (slow speed), 180 (medium speed) and 240˚/s (high speed). At each test velocity, the subject performed 4 submaximal warm-up trials followed by 5 (60 and 180˚/s) or 15 (240˚/s) maximal test trials after 30 seconds recovery. A recovery period of 60s between test velocities, 5 minutes between body sides and 10 minutes between different joint actions was used.

## Analysis

Descriptive statistics was expressed as mean ± standard deviation (SD) (table 1). Results were statistically analysed using Excel. A Pearson correlation analysis (table 2) was used to estimate relationship,significance level for all tests was set at $p<0.05$.

## Results

The average peak torques and relative peak torques are shown in table 1.

**Table 1**

Isokinetic data of the ankle, knee and hip joints at different velocities (n=9; mean±s)

| *Muscle action* | *Velocity ( degree)* | *Peak torque (Nm)* | *Peak torque (Nm/kg)* |
|---|---|---|---|
| *Ankle* | | | |
| Plantar flexion | 60 | 126±31.9 | 1.66±0.39 |
| | 180 | 80±13.9 | 1.06±0.19 |
| | 240 | 77±15.1 | 1.02±0.21 |
| Dorsiflexion | 60 | 34±3.8 | 0.45±0.04 |
| | 180 | 30±6.8 | 0.39±0.07 |
| | 240 | 31±7.4 | 0.40±0.07 |
| *Knee* | | | |
| Extension | 60 | 254±31.7 | 3.45±0.42 |
| | 180 | 185±28.9 | 2.46±0.27 |
| | 240 | 161±28.6 | 2.14±0.27 |
| Flexion | 60 | 155±21.2 | 2.16±0.37 |
| | 180 | 120±22.5 | 1.65±0.28 |
| | 240 | 108±22.8 | 1.47±0.28 |
| *Hip* | | | |
| Extension | 60 | 414±96.0 | 5.43±1.01 |
| | 180 | 314±82.2 | 4.08±0.81 |
| | 240 | 262±71.9 | 3.48±0.86 |
| Flexion | 60 | 206±29.0 | 2.73±0.32 |
| | 180 | 155±26.4 | 2.05±0.23 |
| | 240 | 139±21.2 | 1.86±0.20 |

*Peak torque (Nm)*

Results of correlation analysis are shown in table 2. Statistically significant relationship ($p<0.05$) was found between sprint running time and:average peak torque of ankle dorsiflexion; knee extension at low speed; and hip flexion at high speed. No statistically significant relationship was found between running time and:average peak torque of ankle plantar flexion; knee flexion; and hip extension.

**Table 2**

Relationships between the peak torque, relative peak torque and sprint running time (n=9)

| *Muscle action* | *Velocity (degree)* | *Peak torque (Nm)* | *Peak torque (Nm/kg)* |
|---|---|---|---|
| *Ankle* | | | |
| Plantar flexion | 60 | -0.045 | 0.164 |
| | 180 | 0.048 | 0.274 |
| | 240 | 0.068 | 0.295 |
| Dorsiflexion | 60 | *-0.708** | -0.409 |
| | 180 | -0.566 | -0.491 |
| | 240 | *-0.682** | -0.651 |
| *Knee* | | | |
| Extension | 60 | *-0.746** | *-0.679** |
| | 180 | -0.658 | -0.646 |
| | 240 | -0.607 | -0.604 |
| Flexion | 60 | -0.267 | -0.034 |
| | 180 | -0.267 | -0.071 |
| | 240 | -0.344 | -0.215 |
| *Hip* | | | |
| Extension | 60 | -0.392 | -0.202 |
| | 180 | -0.500 | -0.454 |
| | 240 | -0.527 | -0.474 |
| Flexion | 60 | -0.614 | -0.437 |
| | 180 | *-0.737** | *-0.818** |
| | 240 | *-0.719** | *-0.805** |

*p< 0.05

*Relative peak torque (Nm/kg)*

After taking into account body weight, the statistically significant relationship ($p<0.05$) was found between sprint running time and:relative peak torque of knee extension at low speed; and hip flexion at high speed.No statistically significant relationship was found between sprint running time and:relative peak torque of ankle dorsiflexion; ankle plantar flexion; knee flexion; and hip extension.

## Discussion

Similarly to the study of Alexander (1989) we find statistically significant result between ankle dorsiflexion and sprint performance. He found this result in eccentrical regime, while we tested athletes at concentrical regime.

Unlike in previous studies, which did not find statistically significant relationship between ankle dorsiflexion and running time (Dowson et al. 1998, Inal et al. 2012, Nesser et al. 1996), we find the relationship to be statistically significant. After taking into account body weight (relative peak torque), we did not find any of the relationships to be statistically significant. Similarly to the study of Dowson et al. (1998), we found that after taking into account the body weight of a sprinter, no statistically significant relationship could be found between torque of ankle muscles and running performance.

In general, the sprint coaches see that the ankle plantar flexion has a more important role than ankle dorsal flexion in sprinting. This is also confirmed by every day training practice where lot of attention is paid on plantar flexors. It should be also kept in mind that the balance between plantar and dorsiflexors very important, the ratio of plantar and dorsiflexion should be 30-40% in peak torque at 60°/s. The balance of plantar flexion and dorsiflexionis more important for sprinters and for jumping events (So et al. 1994).

This study found the strongest relationship between knee extensionat 60°/sand 60m running time. The strength of the correlation was highest with knee extension at 60°/s (r=-0.746) compared to other statistically significant relationships with peak torque. Previous studies (Alexander, 1989, Dowson et al. 1998) have found the same result that there is a relationship between peak torque and running time, but at higher speeds (150°/s, 240°/sand 230°/s), at lower speed (60°/s) no statistically significant relationship has been found (Dowson et al. 1998). In this study the correlation coefficient at 180°/s (r=-0.658) and 240°/s (r=-0.607) was not significant at the 5% threshold ($p<0.05$, r=-0.666), but were significant at the 10% threshold. Hence, we can confirm that there is a positive relationship also at higher speeds between peak torque and running time. The results of this study do not confirm the findings of Cronin & Hansen (2005), Dowson et al. (1998), Nesser et al. (1996) that at higher speeds knee extension and running performance are related. Similar trend to ankle dorsiflexion was found in knee extension.

By taking into account body weight (relative peak torque), all the relationships with running time became weaker. Our findings are in line with the findings of Dowson et al.(1998), where relative peak torque of knee muscles and running time relationship was weaker than the relationship between absolute peak torque of knee muscles and running time.

The findings of this study are in line with the findings of Nesser et al.(1996), where statistically significant relationship was found between peak torque of hip flexion at speed 180°/s and running performance. Our results also overlap with the ones of Blazevich et al. (1998), indicating that in all speeds (60°/s, 270°/s and 480°/s) the hip flexors strength was more important factor for sprint performance than hip extensors strength. While for ankle and knee the relationship became weaker after taking into account the body weight, the relationships became stronger for hip flexors after taking into account the body weight.The results of our study are well in line with the study of Guskiewicz et al. (1993), where the strongest relationship was found between relative peak torque of hip strength and running speed ($p<0.01$).It should be emphasised that the peak torque of hip extension at 60°/s was 414±96.0 Nm in this study, which is significantly higher than in previous studies, for example228 ± 35.6 Nm in Dowson et al. (1998) and 282±56.1 Nm in Nesser et al. (1996).

The limitation of our study is that there was a short time distance between measuring the sprint performance and measuring the isokinetic parameters. However, the advantage of our study is that the sprint performance was measured in competition conditions, national level track and field athletes specialising on sprint and strength disciplines formalised the test group, and wide set of isokinetic parameters was studied.

**Conclusions**

This study found the strongest relationship sprint running time and peak torque of knee extension at the velocity of 60°/s and relative peak torque of hip flexion at 180°/s. According to our study the most important peak torque parameters for sprint running are ankle dorsiflexion, knee extension and hip flexion. Our study found that the relationships between some isokinetic strength parameters that are perceived to play an important role in running (plantar flexion and knee flexion) and sprint performance are weak. The main finding of the study is that in addition to extensors also dorsiflexors as ankle stabilizers play a significant role in sprint performance. This indicates that attention should be paid in addition to big muscle groups also to ankle stabilizers in sprint training.

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