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Short report

Analysis of the factors related to running time at different distances

Hitoshi Koda[1*], Yasuhiro Mitani[1], Toshimitsu Ohmine[1], Atsushi Ueda[1]

[1] *Department of Rehabilitation Sciences, Faculty of Allied Health Sciences, Kansai University of Welfare Sciences*

Abstract

【Introduction】 Running speed is often an advantage in athletic competitions, and running training is frequently conducted in various sports. The form during running is not always the same as that during short running; it has been reported that the acceleration phase at the start of running and the full-speed phase afterwards are different. The purpose of this study was to analyze factors related to running time at different distances.

【Methods】 The participants were 17 high school soccer players. The measurements were the 10 m time, 30 m time, knee flexion torque, knee extension torque, hamstring-to-quadriceps ratio (representing the ratio of flexion to extension muscle strength), and vertical jump height. Dashr-Blue laser module was used to measure the running time, and the sensors were placed at three locations: the start position, the 10 m point, and the 30 m point. Pearson's correlation coefficient was used to analyze the relationship between the 10 m and 30 m running time and other outcomes. The significance level was set at 5%.

【Results】 There was a significant negative correlation of H:Q ratio ($r = -0.54$, $p < 0.05$) with the 10 m time, and a significant negative correlation of vertical jump height ($r = -0.50$, $p < 0.05$) with the 30 m time. No significant correlations were found among other measurements.

【Conclusion】

The factors related to short running times differed depending on the distance. When training for instantaneous running performance, it may be necessary to set up a training program based on the running distance and requirements of the sports event.

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***Correspondence**
Hitoshi Koda
Department of Rehabilitation Sciences, Faculty of Allied Health Sciences, Kansai University of Welfare Sciences
E-mail:
h-koda@tamateyama.ac.jp

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Introduction

Running is an essential movement not only in track and field events but also in all the other sports. Running speed is often an advantage in athletic competitions and running training is frequently conducted in various sports. Running speed is expressed as the product of stride and pitch (leg revolutions per time)[1]. Therefore, in sports, training to increase the number of leg revolutions using ladders and other equipment, as well as training to expand the stride by stretching, jumping, etc., are used.

However, the form during running is not always the same; even in short running, it has been reported that the acceleration phase at the start of running and full-speed phase afterwards are different[2]. At the beginning of running, the runner needs to accelerate, which mainly requires pitch movements to increase the number of leg rotations, whereas stride movements are required during the running phase when the runner reaches the maximum speed. However, during short running, a series of movements are often mixed. Even within the same short race, the relevant factors may differ depending on the section of the race.

The knee flexion and extension torque represent lower limb muscle strength[3] and both of them play a role in running[4]. Vertical jumping, which is an indicator of jumping power that might affect the stride during running[5]. Therefore, the purpose of this study was to analyze factors related to running time at different distances.

Methods

The participants were 17 male soccer players (age: 15.9 ± 0.7 years, height: 167.6 ± 4.7 cm, weight: 57.6 ± 13.2 kg, playing experience: 6.3 ± 3.5 years) belonging to a high school team. Two players who had experienced pain four or more times in the past and were still experiencing difficulty with daily activities were excluded from the study because injuries were judged to have affected their running performance. All participants were informed of the purpose, methods, and expected disadvantages of the experiment, and their consent was obtained in accordance with the Declaration of Helsinki. The present study was conducted after obtaining approval from the institutional ethics committee (approval number: 22-40).

The measurements were the 10 m time, 30 m time, knee flexion torque, knee extension torque, hamstring-to-quadriceps (H:Q) ratio, which represents the ratio of flexion to extension muscle strength, and vertical jump height. The same examiner assessed each factor.

Dashr-Blue laser module (S & C) was used to measure the running time. This device can record the time when passing between the photoelectric tube and the reflector, and by using multiple sensors, it is possible to measure the time for each section. Because a previous study[6] reported that the maximum speed was reached at approximately 20 m from the start of running, a 30 m straight running path was secured for this study, and sensors were placed at three locations: the start position, the 10 m point, and the 30 m point. The participants were instructed to run 30 m at full-speed after sufficient preparatory exercise. The running times for the 10 m and 30 m sections were extracted from the obtained values. (Figure 1)

Torque machines (Biodex Medical Systems, Biodex Systems 3) were used to measure knee flexion and extension torques. In accordance with previous studies[7] on soccer players, the maximum constant-velocity knee flexion and extension torques were measured at 60 deg/sec in a sitting posture with the trunk fixed by a belt. Measurements were performed twice, once on each side, and the maximum value was used for the analysis. The H:Q ratio was calculated as the ratio of knee flexion to extension muscle strength.

Vertical jump height was measured using a digital vertical jump-measuring machine (Takei Kiki Kogyo, T.K.K. 5406). The participant was instructed to jump using the recoil of the upper and lower limbs and to perform a maximum vertical jump from a standing posture with the

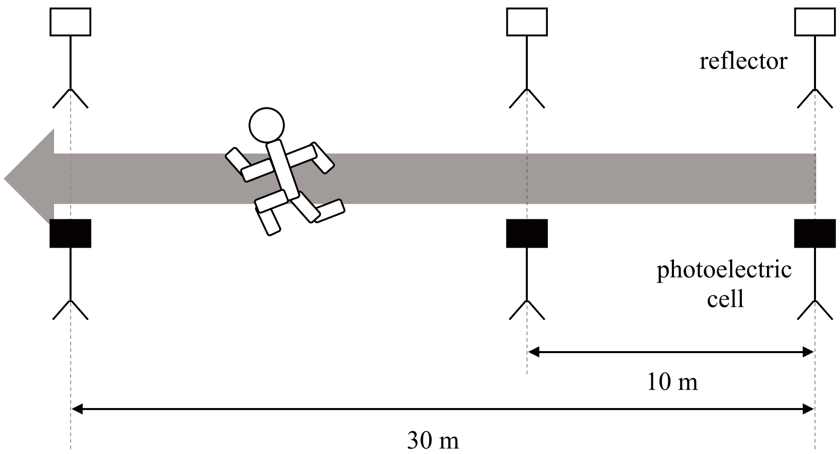

Figure 1. Measurement of the running time.
The sensors were placed at three locations: the start position, the 10 m point, and the 30 m point. The running times of the 10 m and 30 m sections were extracted from the obtained values.

legs shoulder-width apart. Measurements were taken twice, and the maximum value was used for the analysis.

Pearson's correlation coefficient was used to analyze the relationship between the 10 m and 30 m running time, knee flexion torque, knee extension torque, H:Q ratio, and vertical jump height. All analyses were performed using SPSS version 28. The significance level was set at 5%.

Results

For each of the measured values, 10 m time was 2.0 ± 0.1 s, 30 m time was 4.7 ± 0.2 s, knee flexion torque was 82.7 ± 22.2 Nm, knee extension torque was 167.5 ± 42.0 Nm, H:Q ratio was 51.2 ± 4.9, and vertical jump was 50.0 ± 7.1 cm. Statistical analysis revealed a significant negative correlation with 10 m time for H:Q ratio ($r = -0.54$, $p < 0.05$) (Table 1), and a significant negative correlation with 30 m time for vertical jump ($r = -0.50$, $p < 0.05$). No significant correlations were found between the other measurements.

Discussion

The current study analyzed the factors related to running time at different distances. The results of the analysis showed that the 10 m time was related to the H:Q ratio, and the 30 m time was related to the jumping ability.

During the full-speed phase of running, running speed tends to increase by expanding the stride[2]. Gabbett et al.[8] reported that not the strong force but the proper application of force to the ground, i.e., forward sprint force, is involved in the 100 m running time. Jalilvand et al.[5] noted that the vertical jump height tended to be more strongly correlated with the full-speed phase in short running. In the present study, the 30 m running time was also significantly related to the vertical jump height. Therefore, jumping ability was related to the 30 m running time required to reach full-speed sprinting.

A significant negative correlation of H:Q ratio was observed with the 10 m time. In previous studies[9], the H:Q ratio was reported to influence the occurrence of disorders such as torn muscles and anterior cruciate ligament rupture. Although this study cannot be considered speculative because the joint angles and muscle activities of the lower limbs were not measured, it is possible that the strong impact on the ground was repeated during the accelerated running phase of the 10 m section, suggesting that the muscle strength balance of the knee joint may have been involved. However, a study by Lockie et al.[10] showed a correlation between the 10 m time and vertical jump height, and the results might differ depending on the characteristics of the sports event.

On the other hand, no correlation was found between the knee flexion torque or knee extension torque and running time. Wagner et al.[11] reported that muscle strength in soccer players varies depending on the conditions of the measurement task, such as angular velocity. For muscle strength measurements in the present study, the angular velocity was set to 60°, in accordance with a previous study[7]. Because short running requires rapid leg movements at higher speeds, a correlation might have been observed if muscle strength values were measured at higher angular velocities. Hamner et al.[12] also reported that the quadriceps play the role of shock cushioning, whereas plantar flexors play the role of propulsion during running. Thus, each muscle plays a different role in running motion, and it is necessary to analyze the relationship of running time with the hip or ankle torques.

In summary, the factors related to short running times differed depending on the distance. When training for instantaneous running performance, it may be necessary to set up a training program based on the running distance and characteristics required by the sports event. However, this study was conducted only on one team, and, in future, we would like to increase the number of participants and conduct studies to examine the factors related to running speed.

Table 1. Correlation between running time and each measured outcome (n=17)

	Knee flexion touque	Knee extensor touque	H:Q ratio	Vertical jump
10m time	0.01	0.04	-0.54*	-0.46
30m time	-0.12	-0.08	-0.35	-0.50*

* $p < 0.05$

Conflict of Interest

The authors declare no conflict of interest.

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