# ANALYSIS OF LOWER LIMB MOVEMENT IN ELITE FEMALE RACE WALKERS UNDER NEW RULES

**Derong Zhang and Xiyuan Cai**
**Tianjin Institute of Physical Education, Tianjin, People's Republic of China**

**KEY WORDS:** race-walking, elite player, technical generality

**INTRODUCTION:** In 1996, the rules for race-walking were revised under NO.191 of International Competitive Rules of Track and Field. There were substantial differences in content from previously established guidelines. The changes are as follows: First, only referees can determine the disqualifying technique of race-walkers. Secondly, with every step, the leg must be straight when it comes in contact with the ground and must remain in a locked state until the vertical-supporting phase. This stage is defined as when the player's body is vertical with ground. However, this was not defined in the original rules (Zong and Lu, 1997). Due to these changes, techniques available for race-walking have to be reviewed. Moreover, strict adherence to the new technique is the key for athletes to avoid disqualification. The purpose of this paper was to analyze the technique generalities of lower limbs of elite race-walkers based on biomechanical principles and to provide information to coaches and athletes for improvement in performance.

**METHODS:** The subjects for this study included elite female race-walkers who ranked from 1 to 7 in l0km race-walking item in the 8th China National Sport Games. A high-speed cine-camera (Chunfeng-16, China), operating at 120 frames/second, was used to record the single-step techniques of the lower limb of the subjects at the distance 4.5km from the start line. The distance of the camera to the movement plane was 13.5m. The film materials were then digitized and analyzed on the motion analysis system (TYF-2, Japan) to provide detailed kinematics information including joint angles of the subjects.

**RESULTS:** The knee angle of the supporting leg was 181.1±2.1°, 185.7±3.4° and 46.5±3.8° for hitting ground, vertical position and pushing-off respectively. The ankle joint angle of the supporting leg was 112.7±2.4°, 116.8±1.3°and 134.9±4.1°for hitting ground, at vertical position, and pushing-off. The knee joint angle of swing leg at the vertical support phase was 100.9±5.6°. The duration of the leg at the vertical position was 157±5ms. The landing technique was described as heel hitting ground and ankle dorsiflexion. The pushing-off technique was described as tip of the toe in push-off phase, which was different from the running technique and therefore was not disqualified by the referee. Consequently, the techniques observed were deemed correct.

**DISCUSSION:** Airborne disqualification and bent leg disqualification are both characteristic of race-walking competition (Li & Li, 1997). The landing technique observed in this study was with the heel in contact with the ground followed by ankle joint dorsiflexion. The pushing-off technique was defined as use of the tip of the toe in final push-off phase. According to Zong and Sai (1992), the time required for human eye to identify whether or not the knee joint is straight at the vertical support phase is at least 42ms. Therefore, it is necessary for athletes to keep the supporting leg straight at the vertical support phase for at least 84ms. This study found that the subjects kept their supporting leg straight during the vertical support phase for 157ms. In terms of new competitive rules, the front leg, when in contact with the ground, must be straight until vertical support phase. When the supporting leg is pushing off, a suitable knee angle is beneficial to the following swing action and also to relax the quadriceps femoris that are still contracted. However, if the shank and thigh bend too much and too early, the referee could decide that the athlete is running. On the swing phase, if the knee angle of the swing leg is too wide, the swing radius and energy required for the lower limb rotation would increase, and the angular speed would decrease. This would not benefit moving the center of gravity forward. Therefore, maintaining a suitable knee angle of the

swing leg is important for smooth walking technique. The average knee angle of supporting leg, found in this study was 181±2.1° when in contact with the ground. It was 185.7±3.4° when in the vertical support position and 146.5±3.8° when in the pushing-off phase. The duration from supporting leg from contact with the ground to reaching the vertical position was 72.8±7.3ms. The data shows that when leg came in contact with the ground, the knee joint of the elite race-walkers was already straight, meeting the requirement of the new competitive rules.

The study shows that the smallest knee angle of the swing leg was 100.9±5.6°, indicating the lower and more stable swing in elite race-walking athletes.

The ankle angle changed during the pushing-off movement in which the athletes exerted forces against the ground. Observation showed that in all subjects, the front leg landed with the heel contacting the ground and the ankle joint in dorsiflexion. This technique is necessary for adequate ground contact with a straight leg, and also is economical from the point of energy expenditure. It also involves a practical application. Firstly, the ankle joint dorsiflexion causes the triceps surae and heel tendon to contract, increasing stored energy. During forward momentum, the leg extension and ankle joint plantar flexion occurs and the energy stored in the heel tendon will be released and changed into kinetic energy to propel the body forward rapidly. On observation, it was found that the tip of the toe was off the ground later than the sole of the foot. If the ankle joint maintained flexion, the take-off phase would be accomplished by the tip of the toe breaking the contact with the ground, and this in turn, decreased the airborne time. If sole of the foot breaking the contact with the ground achieved the takeoff phase, body airborne time would increase. Therefore sustaining a suitable ankle angle of the contact leg would save energy, reduce the airborne time and help meet the requirements of the new competitive rules. In general, the techniques that were observed from this study would help bring about better performance. The new methods included heel coming in contact with the ground in advance and the ankle joint dorsiflexion during landing, and tip of the toe used in pushing-off during takeoff. These innovations meet the requirements of the new race-walking rule. This study revealed that the ankle angle was 112.7±2.4, 116.8±1.3°, and 134.9±4.1° for the phases of heel contacting the ground, leg vertical support and pushing-off respectively for elite female race walkers in China.

**CONCLUSION:** 1. For the elite female race walker, the knee angle is 181.1±2.1° when heel contacts the ground and 185.7±3.4° when leg is in vertical support. These calculations indicate that the front leg is in a locked state at the moment the heel is in contact with the ground. It lasts for 157ms until supporting leg reaches the vertical position. This is a feasible technique that helps meet the new competitive rules. 2. Landing with the heel in contact with the ground and the ankle joint in dorsiflexion, and the takeoff with tip of the toe pushing-off finally, are techniques to perform race walk that are compatible with the new competitive Rules.

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