A3-4 ID57

# BIOMECHANICS AND INJURY RISK FACTORS DURING RACE WALKING

**Qipeng Song[1], Zhengye Ding[12], Dewei Mao[1], Cui Zhang[1], Wei Sun[1]**

**[1]Shandong Sports Science Center, Jinan, Shandong, China**
**[2]Shandong Physical Education Institute, Jinan, Shandong, China**

The purpose of this study is to describe the biomechanical characteristics during race walking and identify whether the race walking rules could cause potential injury risks. Fourteen elite race walkers participated in this study. Rs-scan plantar pressure plate and three digital cameras were used to collect data during race walking and normal walking. Paired t-tests were used to detect the differences. The results showed that during race walking, the peak pressures of the lateral heel and medial heel, the displacements of the center of pressure, ankle dorsiflexion, plantarflexion, knee extension, hip adduction, foot eversion, ankle angular velocity, and average horizontal velocity were significantly larger than those during normal walking. The greater heel peak pressure and more ankle eversion may be the injury risks caused by the rules of race walking.

**KEY WORDS:** race walking, center of pressure, peak pressure

**INTRODUCTION:** Race walking has grown in popularity in recent years, and the 5 km and 10 km events are becoming increasingly popular for casual athletes (Francis et al., 1998). A number of walking enthusiasts have attributed the rising popularity of race walking to a decline in the popularity of jogging and a concomitant increase in the number of people who take part in exercise walking programs. This trend (Kummant, 1981) is presumed to be influenced by the widespread belief that race walking is a sport that provides opportunities for competition, as well as valuable health and fitness benefits, without significant risk of injury. Opposite to what the participants believe about race walking, researchers consider the sport to have a high risk of injury. Francis et al. (1998) conducted a study on a larger sample of 682 subjects and found that about two-thirds of all respondents reported that they had suffered one or more injuries during their race walking careers. Palamarchuk (1980) questioned 31 race walkers and concluded that the primary complaint was blisters of the heels and toes, followed by hamstring injuries and medial knee pain. As the nature and location of the injuries to the lower extremity are somewhat consistent with the biomechanics of the activity, some researchers attribute the injuries to the rules of race walking. The rules prescribed by the athletics governing body(i.e.,the International Association of Athletics Federation) stares that (a) an invisible (to the human eye) loss of contact occurs and (b) during the forward action, the advancing leg shall be straightened from the moment of the first contact with the ground until the vertical upright position. Payne (1978) found mediolateral force on the feet of race walkers, which is a potential knee injury factor. The extra forces were generated to strengthen the supporting leg and compensate for the lowered opposite hip and ipsilateral shoulder; these motions were done to abide by the rule of no knee flexion during midstance. Moreover, some researchers (Knicker et al., 1990) even recommended that changes should be made in the rule governing knee extension during initial impact with the ground.

Race walking represents an unusual form of human gait distinct from normal walking and running, one that has received little attention from sport scientists (Martin et al, 1987). Only a few studies have examined peak pressure, center of pressure (COP) (Soames, 1985; Lafortune et al., 1989), and temporal parameters such as total contact time and time to peak pressure (Soames, 1985) for race walkers compared with the large number of researchers investigating the normal kinematics and kinetics of normal human walking and running (e.g., Mac et al., 2003; Titianova et al., 2004; Willems et al., 2004). Therefore, there is limited understanding of the kinematic and kinetic aspects of race walking. The purpose of this study is to describe the biomechanical characteristics during race walking and identify whether the race walking rules could cause potential injury risks.

**METHODS: Subjects:** Fourteen elite race walkers (9 male and 5 female; age: 20.4±3.3 years [mean (SD)]; height: 173.1±7.8 cm; body mass 59.8±9.6 kg) were recruited. Subjects had no history of lower limb pathology at the time of the study or in the preceding six months. All subjects gave their informed consent. **Setting:** The plantar pressure plate (Rs-scan International, 2 m × 0.4 m × 0.02 m) was used to collect plantar data. Two rubcor tracks (5 m × 0.4 m × 0.02 m) were connected to the two sides of the plantar pressure plate to prevent the subjects from adjusting their walking style by aiming for the plate. Three 50 Hz digital cameras (Sony 9800, Japan) were placed approximately 5 m away from the right, left front, and right front of the pressure plate edge. These cameras were used to record the movement of the lower limb. **Protocol:** Race walkers walked on the plate in their training race walking speed and normal walking pattern, respectively. In the current study, only the right foot plantar data were collected (Goble et al., 2003), and a minimum of five valid trials were recorded and analyzed. Before testing, the subjects completed consent forms and were given sufficient time to warm up. **Data analysis:** Kinematic variables were calculated using the APAS (USA) software, and the kinetic variables were calculated using the Rs-scan software. Paired samples t-tests were conducted to compare the differences between race walking and normal walking.

**RESULTS:** Table 1 shows the comparison of the lower leg kinematic parameters between race walking and normal walking. The ankle dorsiflexion (P=0.003), ankle plantarflexion (P=0.002), ankle angular velocity (P=0.000), knee extension (P=0.000), hip adduction (P=0.038), foot eversion (P=0.013), and average horizontal velocity (P=0.000) during race walking were significantly greater than those in normal walking.

**Table 1 Comparison of the kinematic parameters between race walking and normal walking.**

| | Normal walking | Race walking | *P* |
|---|---|---|---|
| Ankle dorsiflexion (°) | 15.81±2.81 | 20.30±3.84 | 0.003** |
| Ankle plantarflexion (°) | 3.77±1.89 | 15.61±3.34 | 0.002** |
| Ankle angular velocity (°/s) | 36.06±11.96 | 73.53±19.39 | 0.000** |
| Knee flexion (°) | 39.95±10.40 | 25.47±7.93 | 0.182 |
| Knee extension (°) | 174.18±5.10 | 187.54±6.8 | 0.000** |
| Hip adduction (°) | 6.51±2.61 | 9.63±2.69 | 0.038* |
| Foot eversion (°) | 5.81±2.65 | 9.31±1.69 | 0.013* |
| Horizontal velocity (m/s) | 1.77±0.17 | 3.15±0.31 | 0.000** |

Figure 1b shows the mean COP path during race walking and normal walking. During race walking, the displacements of the COP in the anterio-posterior direction (86.75±1.59% foot length) and in the medial-lateral direction (28.76±7.30% foot width) were significantly greater (P=0.024, P=0.001) than those in normal walking (76.75±3.77% foot length; 21.82±4.54% foot width).

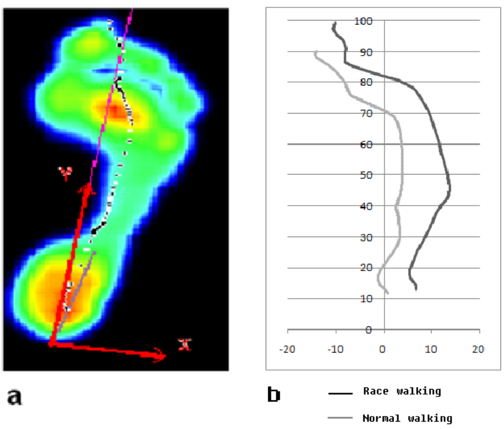


**Figure 1: (a) COP path; (b) Mean COP path**

Figure 2 illustrates that the largest peak pressures during race walking were found underneath the two heel areas (HM=51.27±10.80; Hl= 47.76±8.74). Conversely, the largest peak pressure during normal walking were found underneath the M2 and T1 (M2=44.83±5.02; T1=38.06±4.24) areas. T-test showed that during race walking, the peak pressure values of lateral heel (Hl) and medial heel (HM) were significantly greater (P=0.001; P=0.003) than those in normal walking.

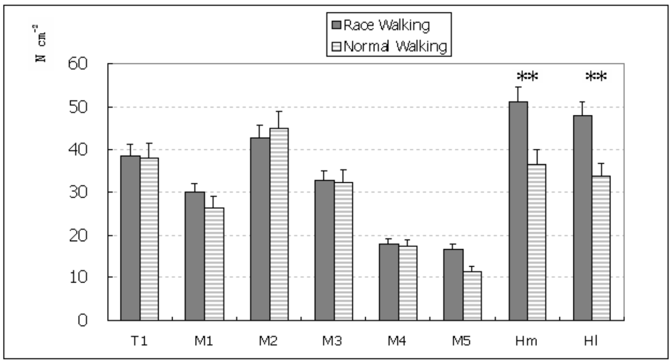


**Figure 2: Peak pressure of eight anatomical subareas**

**DISCUSSION: Peak pressure:** The highest peak pressures during race walking were found underneath the heel areas, with the values significantly greater than those in normal walking (Figure 2). Chiu and Shiang (1996) noted that when the foot and ground were in contact, the strength peak value emerged after the heel first contacted the ground. This strength peak value causes the figure vibrations of the lower limbs. Therefore, people usually adjust their gait status to avoid maximum pressure when they feel excessive pressure on the foot. During normal walking, people can bend their knee to cushion against the excessive pressure. However, the official race walking rules state that the supporting leg must be fully extended during its period of contact (Kitchen, 1981), which limits the cushioning by the knee joint during race walking. As our research found that the knee angle at the first contact phase during race walking was significantly greater than that in normal walking, we hold that the extended knee at the first contact phase is the main cause of the higher peak pressures in the heel areas during race walking.

**COP:** Our research showed that the antero-posterior displacement of COP during race walking was greater than that during normal walking. Figure 1 illustrates that the anterior COP points, instead of the posterior ones, contribute to the difference. Previous research (Heung-Youl Kim et al., 2006) assumed that plantarflexion when the foot leaves the ground could make a more anterior COP path. Our research found the same relationship. Based on the findings, a difference exists between the plantarflexion angles (P=0.002) during race walking and those during normal walking the moment the foot leaves the ground. We assumed that race walkers did more plantarflexion during race walking, which contributes to the greater antero-posterior displacement of COP.

We found a larger medio-lateral displacement of COP and more hip joint adduction motion during race walking. Figure 1 shows that the lateral COP points, instead of the medial ones, contribute to the difference. During race walking, athletes need to adduct their hip to sustain walking in a straight line to maintain large step length. We consider that the more lateral COP path yields to more adduction motion of the hip joint when the foot first contacts the ground. Previous researchers supported this idea. For example, Heung-Youl Kim et al. (2006) found that when COP shifts in the medio-lateral direction, changes are evident in the hip joint abduction-adduction.

**Potential injuries:** Our research found that the peak pressures of the heel areas were greater in race walking (Figure 2) and that the heel peak pressures could be a factor that could pose foot injuries (Willems et al., 2004). Based on our research, which agrees with Willems et al. (2004), the heel strike may generate strain in the midtibial musculoskeletal structures, and when the musculoskeletal system is overloaded, overuse injuries may occur. Moreover, Francis et al. (1998) supported our assumption, indicating that tibial stress syndrome is one of most common injuries of race walkers. Our research regards the high peak pressure of the heel areas as a potential risk factor of tibial foot injuries caused by the extended knee part of the rule of race walking.

Messier and Pittala (1988) and Willems et al. (2004) pointed out that increased eversion increases the risk of lower limb injuries. They argued that the excessive eversion could be associated with increased internal inversion moments. The invertor musculature attempts to control the motion may lead to excessive eccentric traction to the plantar flexor and invertor musculature, which originate in the medial and posterior regions of the tibia. Eversion during race walking was significantly greater than that during normal walking in our research. We consider eversion to be another risk factor for injuries. During race walking, the virtual flight phase is not allowed so athletes need to increase their step length to maintain their higher horizontal velocity. We consider that the ankle eversion motion is made to compensate for the hip adduction, which enables race walkers to walk in a straight line to generate a larger step length. Thus, this eversion may indirectly be caused by the race walking rule of no flight phase.

**CONCLUSION:** During race walking, the peak pressures of the HI and HM subareas, the displacements of the COP in the anterior-posterior, medial-lateral directions, ankle dorsiflexion, ankle plantarflexion, knee extension, hip adduction, foot eversion, ankle angular velocity, and average horizontal velocity were significantly larger than those during normal walking. Based on the findings, the extended knee causes the high peak pressure of the HI and HM areas. Greater ankle plantarflexion and hip adduction are the reasons for the larger displacement of COP in the anterio-posterior, medial-lateral direction. The greater heel peak pressure and more ankle eversion may be the injury risks caused by the rules of race walking.

**REFERENCE:**


Chiu Hung-Ta, Shiang Tzyy-Yuang, (1996). The cushioning effects of different thickness insole in various locomotion. *Physical Education Journal*, 21:207-217.

Francis P.R; Richman N.M; Patterson P,(1998) Injuries in the Sport of Race walking, *Journal of Athletic Training*; *33(2):122-129.*

Goble DJ, Marino GW, Potvin JR. (2003) The influence of horizontal velocity on interlimb symetry in normal walking. *Human movement science 22:271-283.*

Heung-Youl Kim, Shinji Sakurai and Jae-Han Ahn (2006), Errors in the measurement of center of pressure computed with force plate affect on 3D lower limb joint moment during gait, *International journal of sport and health science 5:71-82.*

Kitchen, B. (1981) Race-walking. Runner's world, 16(9):55-55.

Knicker A, Loch M. Racewalking technique and judging: the final report of the international athletic foundation research project. *New Stud Athl. 1990;5:3, 25-38.*

Kummant I, Racewalking gains new popularity. *Physical Sportsmed. 1981; 9(1):19-20.*

MacWilliams BA, CowleyM, Nicholson DE. (2003)Foot kinematics and kinetics during adolescent gait. *Gait and posture 17: 156-163.*

Lafortune M, Cochrane A, Allison W (1989) Selected biomechanical parameters of race walking *Excel 5(3):15-17.*

Martin P.E and Morgan D.M, (1987) The interaction of stride length, stride rate, and velocity in race walking *Arizona Journal of health, physical education and receation 28 (2): 4-7.*

Messier SP, Pittala KA. (1988) Etiologic factors associated with selected running injuries *Medicine and Science in Sports and Exercise 20:501-505.*

Palamarchuk R. Racewalking: a not so injury free sport. In:Rinaldi RR, Sabia ML, eds. *Sports medicine '80. Mt. Kisco, NY: Futura publishing Co; 1980:19-20.*

Payne AH. A comparison of the ground reaction forces in racewalking with those in normal walking and running. In:Asmussen E, Jorgensen K, eds. *Biomechanics VI-A. Baltmore, MD: University Park Press; 1978:293-302.*

Soames R.W (1985) Foot pressure patterns during gait *Journal Biomechanical Engineering 7 (2) :120-126.*

Titianova EB, Mateev PS, Tarkka IM. (2004) Footprint analysis of gait using a pressure sensor system. *Journal of Electro - myography & Kinesiology 2:275-281.*

Willems T.M, Delbaere K, Vanderstraeton G, De Cock A, Witvrouw E (2004), A prospective study to gait related risk factors for exercise-related lower leg pain *Gain and posture 23(1): 91-98.*

Willems T.M , Witvrouw E, Delbaere K, De Cock A, De Clercq D (2004) Relationship between gait biomechanics and inversion sprains: a propective study of risk factors. *Gait and posture 21:379-387*