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Arches and Points in the Foot of Running Athletes

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Abbreviation

MLA: Medial Longitudinal Arch; LLA: Lateral Longitudinal Arch; ATA: Anterior Transverse Arch; DTML: Deep Transverse Metatarsal Ligaments; IAP: Intra-Abdominal Pressure

Commentary

From the clinical point of view, the stability of lumbopelvic region would be important [1]. Consequently, the mechanism of the movement in the ankle and foot needs to be explored. The foot core system includes three factors in the following.

Which are i) **neural Neural subsystem**: There are musculotendinous receptors, local, global ligamentous receptors and plantar cutaneous receptors.

ii) **active Active subsystem**: Intrinsic foot muscles with local stabilizers and extrinsic foot muscles with global movers are involved in the regulation.

and iii) **Passive subsystem**: Passive subsystems. Bones of the arches in foot half dome, plantar fascia and ligaments have mutual relationship. These three subsystems can They can interact to produce adequate foot core system, providing the flexibility and stability to cope with various demands for changing environments [1,2]. In detail, i) has musculotendinous receptors, local and global ligamentous receptors, ii) has bones of the arches of plantar fascia ligaments, iii) has intrinsic foot muscles and extrinsic foot muscles.

There are important arches in the foot, including medial longitudinal arch (MLA), lateral longitudinal arch (LLA) and anterior transverse arch (ATA). For ATA, five metatarsal heads and ligaments are involved [3]. MLA and LLA are formed in the sagittal plane from the forefoot to the rear foot, while ATA is formed in the coronal plane. Anatomically, foot consists of 3 parts, forefoot, midfoot and rearfoot. ATA is situated between forefoot and midfoot. According to the previous studies, forefoot has rather frequent functional impairment or disorder [4]. These episodes have painful medical history and relationship with superior sprint performance [5]. Thus, detail research of the forefoot and ATA will be necessary for sport performance and clinical practice.

In accordance with ATA, there are important ligaments in the foot, deep transverse metatarsal ligaments (DTML). They are a series of 4 short ligamentous bands, which run across and connect together the heads of the metatarsal bones [6]. DTML is very strong, and plays a crucial role in stabilizing 5 metatarsal bones and manipulating the transverse arch deformation of the foot [6].

From athletic walking and running, there are three crucial points of the foot in addition to three arches (Figure 1) [7]. These names were originated from Japanese characteristic word, which were explained using English technical terms as follows: i) UNA means U: uchi (medial) + NA: naka (inside). This point is at the center of the gravity of the body when man is standing freely with relaxed posture. ii) UMA means U: uchi (medial) + MA: mannnaka (middle). This point is at the MAP joint of the first finger of the foot, which is called as sole hallucal area (thumball, football). iii) SOMA means SO: soto (lateral) + MA: mannnaka (middle). This point is at the MAP joint of the fifth finger of the foot [8].

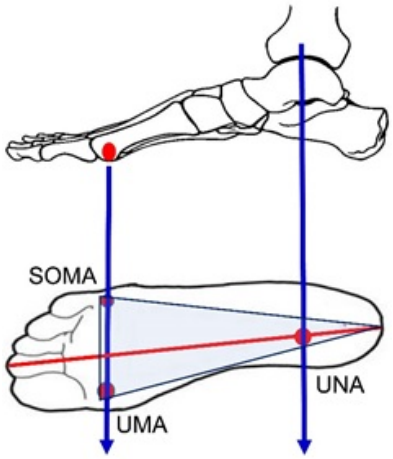

Figure 1: Relationship of important arch and point in the foot.

When the center of the gravity is situated just above the tibia, a human is standing on the position of UNA [8]. For this situation, a person can relax without any muscular tension which always controls the posture in natural position [7].

When a person is standing without muscular tension, he can feel that the weight is flatly supported by the triangle in the Takaoka [8] (Figure 1). Thus, the center of gravity would be located at the position of UNA. Further, the front side of the triangle matches the ATA anterior transverse arch (ATA). The back vertex of the triangle is located at the back of the heel [7]. There has been another concept of triangle, where the vertex is just under the center of the calcaneus. In such case, the body's center of gravity tends to be moved rather

forward, and the proportion of the weight supported by the ATA will increase.

For practice and research of sports medicine and athletic, authors have given various educational lectures and workshops [9]. The subjects were healthy subjects, masters athletes, paralympic athletes and others [10,11]. Among them, anatomical and physiological fundamental theory in walking and running have been presented [12].

Regarding grounding of walking and running, it is rather better to put the MP joint perpendicular to the traveling direction in the light of foot structure [13]. There are some reasons as follows: i) The distortion is reduced, ii) The biased load on the toes is alleviated, iii) The arch also functions sufficiently and iv) The power is transmitted without waste. Specifically, when the second finger is oriented in the traveling direction, the directionality of the foot will coincide with higher effectiveness [14].

There is a middle line through second fingertip and the most rear point of the ankle (Figure 1). This direction has seemed to be the center line of the plantar foot in several previous reports [15,16]. Femery et al. analyzed footprint from a normal foot. Foot axis is through the 2nd finger and the bottom of the heel. Metatarsal line and midfoot line were in parallel, and the length ratio of the metatarsal line vs midfoot line was almost 3 vs 1. The footprint was measured and the midfoot width calculated. The normal foot width is 25 mm (SD 1.7) for men and 20.5 mm (SD 4.5) for women [16].

Thus, the human foot has excellent anatomical and physiological function. It has an effective axis and has an appropriate dome-type structure. This plays an excellent role in reducing impact force and load during walking and running by the presence of moderately functional deformation [15,16].

Functional mechanism of the foot and the stability of lumbopelvic region have mutual close relationship [17]. Recently, the importance of intra-abdominal pressure (IAP) has been advocated in sports management at Stanford University [18]. IAP theory and practice seemed to be effective, and we added them into our lecture and workshop. Authors have advised how to walk and jog at a position where both hands are forward and the abdomen is stretched tightly. Then, the participants became able to make soft and flat grounding without consciousness.

When the position of the waist becomes low and the center of gravity remains, flat grounding would be possible. On the contrary, if the back is rounded, grounding from the foot toe would be observed and not changed. In other words, by pulling up the sternum upwards and applying stomach pressure to stretch your stomach, soft and flat grounding becomes possible.

In summary, we described the foot core system influencing the stability of lumbopelvic region, where there are three arches and three important points included. Authors continue to recommend safer flat grounding way to athletes, which would minimize the sports injury in the future.

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