Functional Footwear Design

Kenta Moriyasu

ASICS Corporation, Institute of sport science

Sports footwear plays an mportant role in preventing injuries and enhancing performance in various scenes. Footwear is composed of various parts made of knitted fabric, resin, foam material, rubber, and so on. It has been said that eight required functions, cushioning, stability, flexibility, fitting, lightness, air permeability, durability and grip must be considered in the footwear design process. Material and structure of the component parts is designed to meet the required functions.

In the case of running shoes, one of the most important functions is stability to prevent injury. Pronation, which consists of calcaneous eversion, medial arch deformation, and tibial internal rotation, occurs during running. Control of excessive pronation is essential to prevent running injuries. In our previous studies, it was clarified that heel eversion and tibial internal rotation angles could be indices of rear- and mid-foot sole stability through running motion analyses (Nishiwaki et al. 1998).

Within the above eight functions, grip property is especially linked to both injury occurrence and performance. High grip can reduce a risk of slip-related fall accidents and produce kicking force in the movement direction efficiently. In general, to evaluate grip property in footwear, ground reaction forces (GRFs) in horizontal and vertical directions and pressure distribution are measured by using the force plate and sensor sheet, respectively. The GRFs obtained from the force plate show the resultant forces in the whole contact area during stance phase as shown in Fig.1. It is difficult to understand for the design of any local positions on footwear because the plate cannot detect GRF distributions.

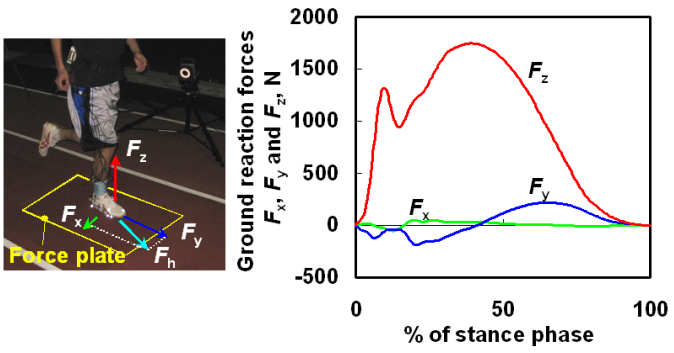
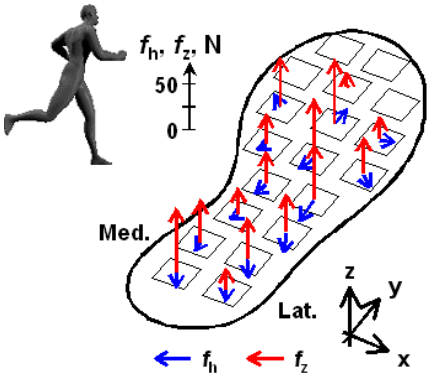
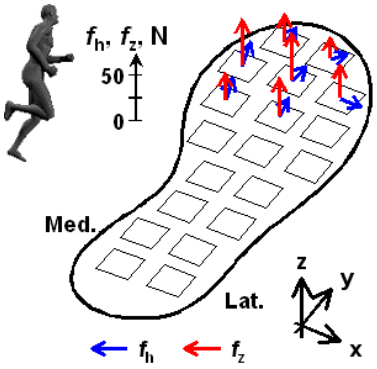


Figure 1 example of ground reaction forces histories

Particularly, in case of the footwear design considering grip property, GRF distributions will provide useful information regarding the position in the contact area where high grip property is needed. By using the sensor sheet the reaction force distribution in the only vertical direction can be measured. However, horizontal GRF distributions cannot be detected by the conventional techniques. In order to detect the distributions, a specific shoe mounted with miniature triaxial force sensors (sensor shoe) has been developed (Moriyasu et al. 2010). The sensor shoe mass is 270.0 g, which is almost equal to a commercial running shoe. By using the sensor shoe, GRF distributions can be simultaneously measured in the contact area under various conditions such as cutting movement, side step, running/walking on slope and so on as shown in Fig.2.



(a) Foot flat phase



(a) Heel rise phase

Fig.2 Example of ground reaction force vectors distributions during running

This technique will provide useful information in the designing process of shoe sole structure and the tread pattern.

In this presentation, functional footwear designing examples considered the above functions will be introduced. Furthermore, experimental studies for grip design will be reported.

References

Nishiwaki T., and Nakabe N., 1998. Numerical simulation of foot joint kinematics for evaluation of shoe stability, Proceeding of SAMPE Symposium, 6(2), 779-782Moriyasu K., Nishiwaki T., Yamaguchi T., Hokkirigawa K., 2010. New technique of three directional ground reaction force distributions. Footwear Science, 2(2), 57-64