NEW FITTING DESIGNING METHOD BASED ON BAREFOOT DEFORMATION

Tsuyoshi Nishiwaki
ASICS Corporation

INTRODUCTION

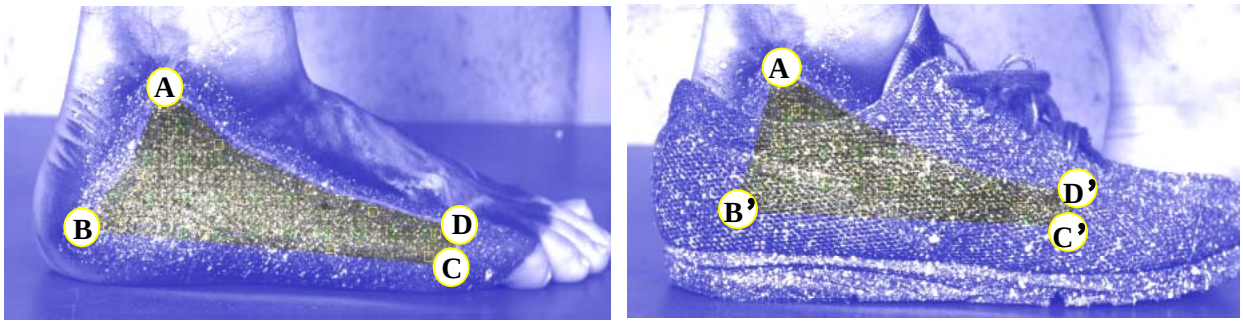
It has been said that running shoes have a number of requirement properties, such as cushioning, stability, flexibility and so on. Especially, fitting is one of the most important properties that runners can directly feel. The important point to note is that necessity of the fitting property is independent of runner's skill. At present, the design of the fitting property has been equivalent with the geometry design for shoe last. However runner's foot largely deform in running. This indicates that the foot deformation must be considered in the designing process for the fitting. The fitting property depends on shoe upper structure and material, because of many contact areas between foot and upper. So it is very important to grasp the deformation behaviors of foot and upper in running. In general, the upper is constructed by knitted fabrics with an anisotropicity and zero compressive modulus. Therefore it is very difficult to measure the upper deformation by using the conventional methods, motion capture system, numerical simulation and so on. In this research, we measured strain distribution on shoe upper in running by using the un-contact typed 3-dimensional strain measuring system. Under the same condition, the strain distribution on barefoot is also measured. The quantitative fitting evaluation method based on the fitting parameter is proposed. This fitting parameter is defined as the difference between the barefoot and shoe upper strain distributions in running. After checking the validity of the proposed evaluation method, the practical designing example of running shoes is introduced.

FITTING EVALUATION METHOD

For strain distribution measurements, ARAMIS system (GOM mbH) which has 2 CCD cameras was used. At first barefoot strain distributions in both the medial and lateral sides were measured, then upper strain distributions in both the sides were measured under 45mm heel up condition as shown in Fig.1. Here, the measurement areas,ABCD in Fig.2(a) and AB'C'D' in Fig.2(b) were completely the same. By this definition of the measurement area, both the barefoot and upper strain values at the same coordinate in measurement area can be directly compared.

Fig.1 Photograph of CCD camera configuration and heel up condition.

It was defined that the fitting parameter was given by



(a) Target area on barefoot (b) target area on shoe upper

Fig.2 Target area definition in the lateral side

the following equation.

$$\mathbf{FP} \equiv \sum_{i=1}^{N} \left[\frac{\left|(\varepsilon_{x0})_{i'}\right| \sqrt{\left\{(\varepsilon_x)_i - (\varepsilon_{x0})_{i'}\right\}^2}}{\sum_{i'=1}^{N'} \left|(\varepsilon_{x0})_{i'}\right|} + \frac{\left|(\varepsilon_{y0})_{i'}\right| \sqrt{\left\{(\varepsilon_y)_i - (\varepsilon_{y0})_{i'}\right\}^2}}{\sum_{i'=1}^{N'} \left|(\varepsilon_{y0})_{i'}\right|} \right] \qquad \text{Eqn.1}$$

Here, $(\varepsilon_x)_i$ and $(\varepsilon_{x0})_i$ denote the x-directional normal strain at coordinate i on upper and barefoot, respectively. X and Y correspond to foot length and height directions. Namely large FP indicates the poor fitting upper which has quite different strain distribution with barefoot. Upper with good fitting defined as small FP value is that the upper can follow the foot deformation in running.

In order to check the validity of this evaluation method, we measured the FP values of five typed shoes with the different upper structures and compared the results with sensual experimental results. Both the results have the same tendency. Consequently the validity of this quantitative evaluation method was confirm.

PRACTICAL DESIGNING EXAMPLE

In the above measurements of barefoot deformations, it was found that the strain distributions in the medial and lateral sides of barefoot was not uniform, moreover these strain distributions were quite different. Medial and lateral the strain distributions have border between large and small maximum principle strain fields. Considering these barefoot results, the new upper design called as *Biomorphic Fitting Systems* (B.F.S.) is proposed. Basic concept of this new fitting system is the interruption of strain continuity in the foot length direction. As already mentioned, knitted fabric has 0 compressive modulus. In case that the foot with various strain distribution is wrapped by the conventional one piece upper, some wrinkles on the upper are caused. This is main reason which reduce the fitting. In order to delete the wrinkles stretchable materials shown in hatched areas in Fig.3 are inserted to the above border positions obtained from barefoot measurements. It was quantitatively confirmed that the fitting of the running shoes with B.F.S was much better than the conventional ones. On the other hand these stretchable areas are vertically reinforced by resin parts. This reinforced stretchable area can improve both the fitting and the lateral stability in running.

(a) Medial side (b) Lateral side

Fig.3 New running shoes with B.F.S. Hatched area