EFFECT OF SHOE INSOLES ON BACK STRENGTH

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Recently, many types of insole in the market claim their effectiveness for improving sports performance without having clear evidence. The present study aimed to clarify how the shape of shoe insoles and the foot alignment affect the maximum muscle strength (back strength). Thirty two healthy university athletes (171.7±4.54 cm, 70.3±5.95 kg) participated in this study, and measured their 3D foot shape and back strength in 3 conditions (barefoot and two types of insole which has different structures). The back strength was significantly increased when wearing an insole with specific hind foot support (DELTA) than those of the other two conditions. The DELTA insole was found to restrict foot pronation, and add the height on foot longitudial arch.

KEYWORDS: insole, back strength, calcaneus angle, foot arch

INTRODUCTION: It often advertised that various advanced functionalities are added in new sports shoes in the market. However, in most cases, it is quite uncertain that whether these are just gimmicks or might work to improve some aspect of sports performance. Among these additional functionalities, "insoles" did not gather much attention from researchers as an effective tool to improve sports performances.

To date, the majority of researches on insoles have been conducted on clinical aspects of lower limb chronic disorders, and aimed at lowering the knee joint loading recognized as a risk factor of osteoarthritis of the knee. Sawada et al. (2016) examined how the lateral wedged insoles control the knee loading during normal gait. Also, Jones et al. (2013) investigated the effect of valgus knee braces on the knee loading in patients with osteoarthritis.

Recently, many types of insole in the market come to claim their effectiveness for improving sports performance. Although there are a few studies examined minor effect on sustainable balance (Hamlyn et al., 2012), the effectiveness is still very trivial and there is no clear evidence supporting the novel functionalities of insoles on some dynamics aspects of sports performances. It can be expected that some types of insoles have a clear positive effect on more drastic nature of human action such as maximal force exertion if these insoles have actual functionalities (more than gimmicks). However, no attempts have been made to examine the effect of insoles on maximal force exertion.

In the present study, a novel attempt was made to clarify the immediate effect of insoles on maximum muscle strength exertion. Among many types of muscle strength exertions, back strength was chosen as a good indicator representing maximal muscle strength of whole body. The purpose of the present study, therefore, was to clarify the effect of two types of insole on maximum muscle strength exertion (back strength). We hypothesized that 1) insoles provide more stable footing thereby improving back strength and 2) insoles are more effective for people who have malalignment of foot.

METHODS: Thirty-two healthy male university athletes who belonged to a university baseball club (171.7±4.5 cm, 70.3±6.0 kg) participated in the present study. First, three-dimensional foot shapes of each participant were measured using a 3D foot scanner (Dream GP Inc., Japan).

Maximal (1RM) back strength was measured using a specially made test dynamometer (Figure 1). This dynamometer allowed measuring the time series change of back strength and foot pressure of both feet simultaneously. These two variables were measured in three conditions including barefoot and two types of insole, each of which has a different structure: AUTO insole (AUTO) and DELTA insole (DELTA) (Figure 2). AUTO is a common readymade insole designed to support of foot arches separately. In contrast, DELTA was designed to serially support three arches (sustentaculum tali support; medial arch, cuboid support; lateral arch, posterior transverse arch support) in the hind foot. Trials were conducted in a randomized order, and were separated by 1 min. rest.

Figure.1. Dynamometer for back strength combined with plantar pressure mat (left) and three-dimensional foot scanner(right).

Additionally, from the ranking on how much the participants increased the back strength with insoles, the top 10 participants were extracted as responders (R group) and the bottom 10 participants were classified as non-responders (NR group). For these participants, 3D foot shapes were measured again in barefoot conditions and two insole conditions. Foot arch index (the ratio of foot length against navicular height) and inward inclination of calcaneus within the frontal plane were measured and compared between three conditions.
Student t test with Bonferroni correction was used for comparisons. Significant level was set at P < 0.5 % for all analyses.

RESULTS: Table 1 summarizes the average values of maximum back strength. Significant differences were observed for the maximum back strength between DELTA and the other two conditions (vs. barefoot; p<0.01, vs. AUTO; p<0.05).

Table 1. Mean Back Strength in Three Conditions.

	Back strength (N)		SD
Barefoot	1351.7		252.5
AUTO insole	1386.0	**	244.2
DELTA insole	1454.0	*	265.9

*: p<0.05
**: p<0.01

Table 2 shows the average values of maximum back strength of R and NR groups. There were no significant differences among three conditions in NR group. In contrast, the maximum back strength in R group was reinforced significantly by wearing DELTA (vs. barefoot; p<0.01, vs. AUTO; p<0.01).

Table 2. Mean Back Strength of Responders and Non-responders in three Conditions.

	Responder		Non-responder	
	Back strength (N)	SD	Back strength (N)	SD
Barefoot	1263.9	387.4	1340.0	131.4
AUTO insole	1378.0	333.1	1302.3	172.1
DELTA insole	1543.8	374.4	1291.4	147.6

**:p<0.01

Figure 2 shows the mean foot arch indexes of three conditions. Both R and NR groups showed significantly higher foot arch indexes than those of bare foot when wearing insoles.
The Figure.3 shows mean inward calcaneus angle of three conditions. There were significant changes for the inward calcaneus angle of R group when they wear DELTA (vs barefoot; p<0.01, vs AUTO; p<0.01).

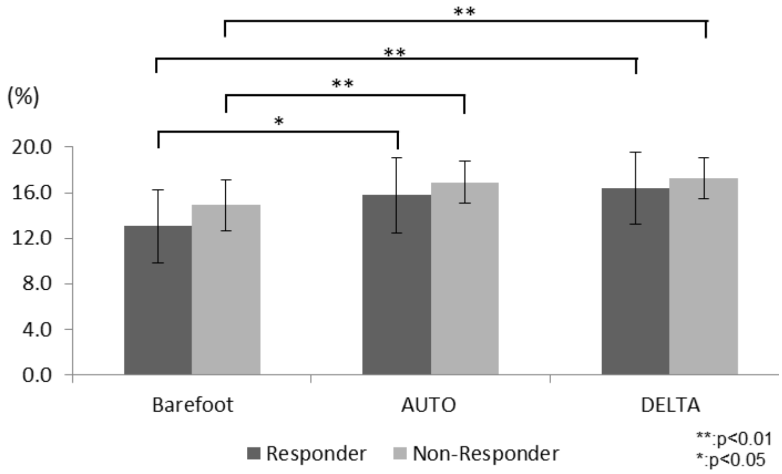

Figure 2. Mean foot arch index of R and NR groups in three conditions.

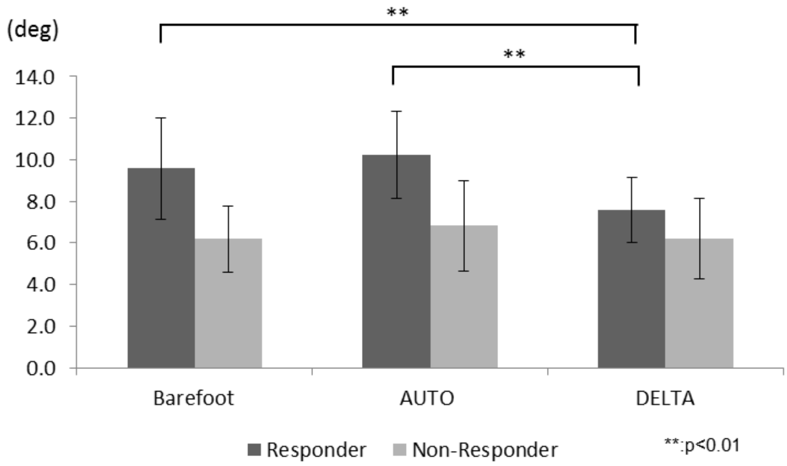

Figure 3. Mean inward calcaneus angle of R and NR groups in three conditions.

DISCUSSION: In the present study, we aimed to clarify the effect of insoles on the back strength exertion. Compared to barefoot, significant increase of the average back strength was consistently observed in two insole conditions (AUTO and DELTA insoles). From this given result, our first hypothesis was supported. Moreover, participants who well responded to the use of insoles and substantially increased their back strength tend to have lower foot arch index and larger inward calcaneus angle of the foot and their foot alignment improved significantly by wearing DELTA insoles. This result also supports our second hypothesis that the alignment of the foot would have a substantial impact on the effect of insoles.

To the best of our knowledge, the present study was the first to demonstrate clear positive effect of insoles on maximum strength extension. Both types of insoles significantly increased the back strength than that of barefoot condition, however, the effect of DELTA insole was even significantly larger than that of AUTO insole. Thus, it can be assumed that unique features given in DELTA insole (serially support three arches in the hind foot) may account for its emphasized effect on the back strength.

Through careful check of the effect of insoles, we succeeded in extracting two subgroups (R and NR groups). R group was characterized as larger inward calcaneus angle and smaller foot arch index in barefoot condition (Figure 2). Clinically, it has been said that the pronated, low arch foot tends to be instable, thereby being a limiting factor for strength exertion such as back strength. This common view was supported by the finding that DELTA insole significantly improved this malalignment of the foot and increased the back strength in R group (Figure 3). The DELTA insole likely provided them greater stability of the foot. Therefore, the participants in R group may have achieved more stable footing for the back strength exertion by wearing DELTA insole.

Interestingly, there was no clear effect of DELTA insole on the participants having non-pronated foot (NR group). This finding suggests that the effect of insoles is dependent on individual foot alignment in particular for inward calcaneus angle. Insoles may not be effective for individuals who have no malalignment in the foot structure.

CONCLUSION: In the present study, it was found that DELTA insoles are an effective tool for improving back strength exertion. The effect of insoles was dependent upon individual foot alignment. One insole with a specific hind foot support was found to recover foot malalignment (pronated, low arch foot), thereby helping to increase back strength.

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