# EFFECT OF SHOES AND TIGHTS WITH THE SUPPORT FUNCTION ON SUPPORT LEG DURING RUNNING

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The study aimed to clarify the effect of shoes (WS) and tights (BT) with the support function on support leg during running. The subjects, eight female Japanese runners, ran for 1-min periods on a treadmill. Motion, electromyography (EMG), acceleration and angular velocity were recorded. The following results were obtained: 1) there was difference in the pronation angle between support shoes and non-support shoes. 2) There was difference in angle of lower leg in frontal plane between support shoes and non-support shoes. 3) Combination of WS and BT might decrease angle of the foot and shank in frontal plane and stabilize the trunk, but the effect varies depending on subjects.

**KEY WORDS:** shoes, tights, pronation angle

**INTRODUCTION:** Pronation is observed during running, which is the eversion movement of the part of the foot, internal rotation of the leg and transformation of the arch of foot. Pronation is required to move body weight smoothly and to absorb shock at the time of landing. Pronation of ankle and varus and valgus of knee would occur simultaneously, which are known as one of causes of running injuries (McClay & Manal, 1997). Excessive pronation of subtalar joint during the support phase of running is linked with various injuries of the hip, knee, Achilles tendon, and foot (Brody, 1980; Hlavac, 1977; James, Bates, & Osternig, 1978; Segesser & Nigg, 1980; Taunton, Clement, & McNicol, 1982). The companies making sport goods have developed shoes and tights with support function to prevent excessive pronation of the ankle joint and varus and valgus of the knee joint. Research intended to influence the design of running shoes has focused on both medial and lateral stability in an attempt to control excessive rearfoot movement (Bauer, 1970; Krahenbuhl, 1974). However, no study has been found cross over effect of shoes and tights in running mechanics. The purpose of this study was to clarify the effect of shoes and tights on support leg during running.

**METHODS:** The subjects were eight female Japanese runners (height: 1.55 ± 0.03 m; body mass: 54.6 ± 6.0 kg). They were asked to run at 8.0 km·h-1 for 1min on a treadmill (Ohtake Root Kogyo, Japan) under four different conditions in combination of shoes with (WS) and without function to prevent pronation (NS) and tights with (BT) and without function to prevent varus and valgus of the knee joint (NT). Testing order for each subject was randomized to neglect order effect. Acceleration and angular velocity of head and shank were recorded at 1000 Hz by inertia (acceleration and gyro) sensors (4 assist) which were attached to forehead and bottom of shank for minimizing vibration. Acceleration data were low-pass filtered using a Butterworth digital filter at 20 Hz. The instants of landing and take-off were recognized by the vertical component of the acceleration data. An index of shock absorption was calculated by the ratio of the maximum value of the acceleration of the head to the maximum value of the acceleration of the shank. Running motion in sagittal and frontal plane was recorded using two high-speed cameras (Casio EX-100PRO) at 240 Hz. Two dimensional coordinates of six reflective markers attached to body landmarks: toe, metatarsophalangeal joints, upper and lower part of the heel, lateral malleolus and condyle were obtained by digitizing automatically using video analysis software (Frame-Dias IV, DKH, Japan). The pronation angle was defined as the angle between the vector of the heel obtained upper and lower heel markers and vertical line in frontal plane. All variables were averaged for 10 running cycles from the final 30s of the 1-min running in each condition. The shank angles in frontal and sagital planes were obtained by integrating angular velocity of the gyro sensor attached on shank. Movement of the waist substituted of the movement of center of gravity was obtained from Motion senser (Casio) attached on sarum (Otani et al., 2016). Differences between the conditions were tested using two-way factorial ANOVA. The level of statistical significance was set at 5%.

**RESULTS:** Figure 1 shows angle of the foot in the frontal plane in each condition. No significant difference was found in angle of the foot. Angle of the foot in WS*BT condition and WS*NT condition were smaller than NS*BT condition and NS*NT condition except subject 1 and 3. Figure 2 shows change in pronation angle during 0-60% of the support phase in each condition. Its angle in WS*BT, WS*NT, NS*BT, and NS*NT were 8.5 ± 2.1, 8.9 ± 2.8, 9.0 ± 2.4 and 10.1 ± 4.7 deg, respectively. No significant difference was found in change in pronation angle pronation angle. Change in pronation angle in WS*BT condition of subject 1, 2, and 4 were the smallest but subject 6 was the smallest. Figure 3 shows angular velocity of the shank in frontal plane in each condition. Figure 3 shows angular velocity of the shank in frontal plane in each condition. Significant differences were observed between NS*BT condition and NS*NT conditions during 17–19% ($r = 0.94$, $p < 0.05$). In subject 2, 3, 4, 5, 7 and 8, the angular velocity of the shank decreased during 0–15% of the support phase, and then increased during 15–60% of the support phase. But the angular velocity of subject 1 and 6 increased during 0–10% of the support phase, and then decreased during 10–60% of the support phase. Figure 4 shows angle of shank in frontal plane each condition. Angular variation in WS*BT condition and NS*BT condition were smaller than WS*NT condition and NS*NT condition. No significant difference was found in angle of the shank in frontal plane each condition. Angle of shank in frontal plane in WS*BT condition and NS*BT condition were smaller than WS*NT condition and NS*NT condition except subject 1 and 6. Figure 5 shows lateral movement of the waist in each condition. Its distance in WS*BT, WS*NT, NS*BT, and NS*NT were 1.8 ± 0.7, 1.8 ± 0.6, 2.0 ± 0.6 and 2.2 ± 0.5 cm, respectively. No significant difference was found in lateral movement of the waist. Lateral movement in NS*NT condition of subject 2, 5, and 7 were the largest but subject 1 was the smallest.

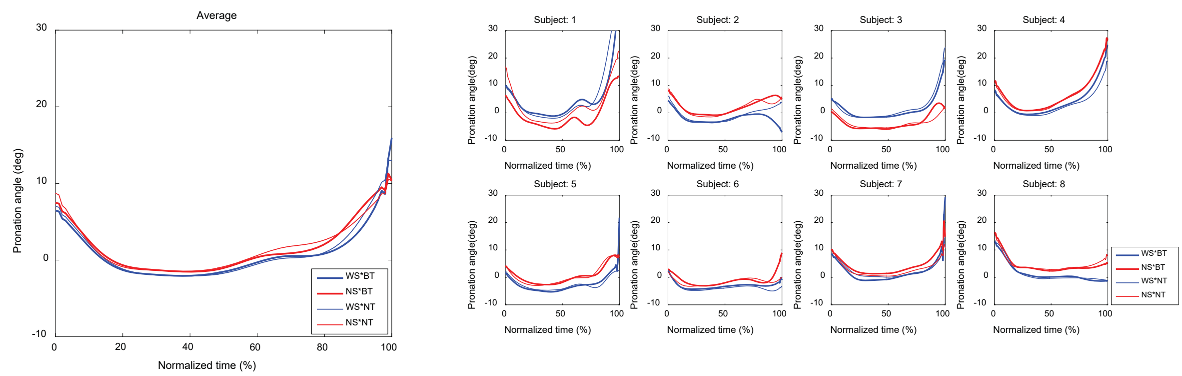


**Figure1 Angle of the foot in the frontal plane in each condition**

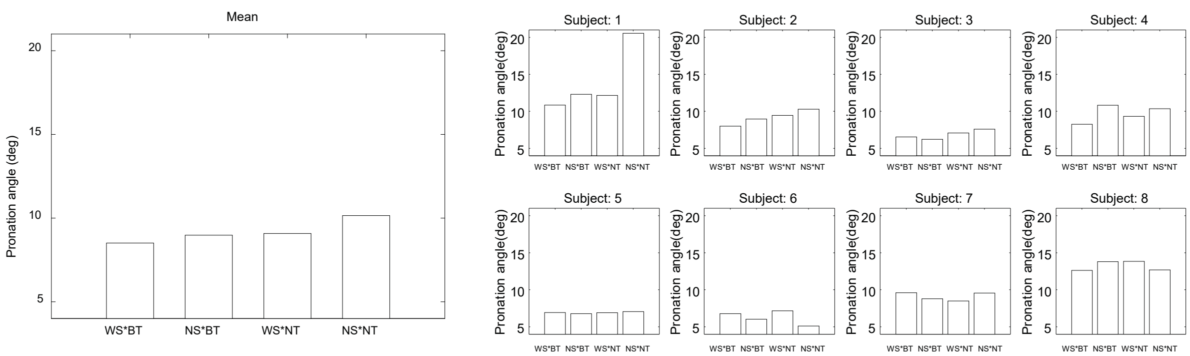


**Figure2 Change in pronation angle during 0-60% of the support phase in each condition**

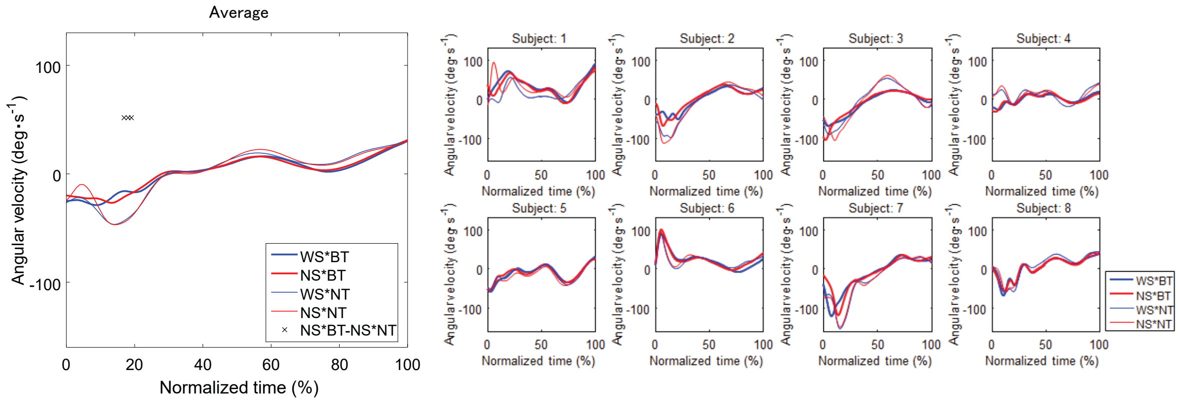


**Figure3 Angular velocity of the shank in frontal plane in each condition**

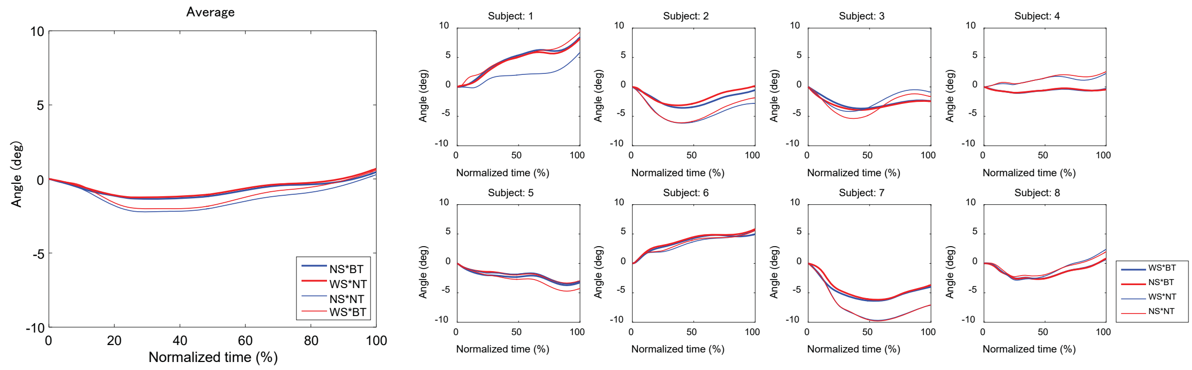


**Figure4 Angle of shank in frontal plane each condition**

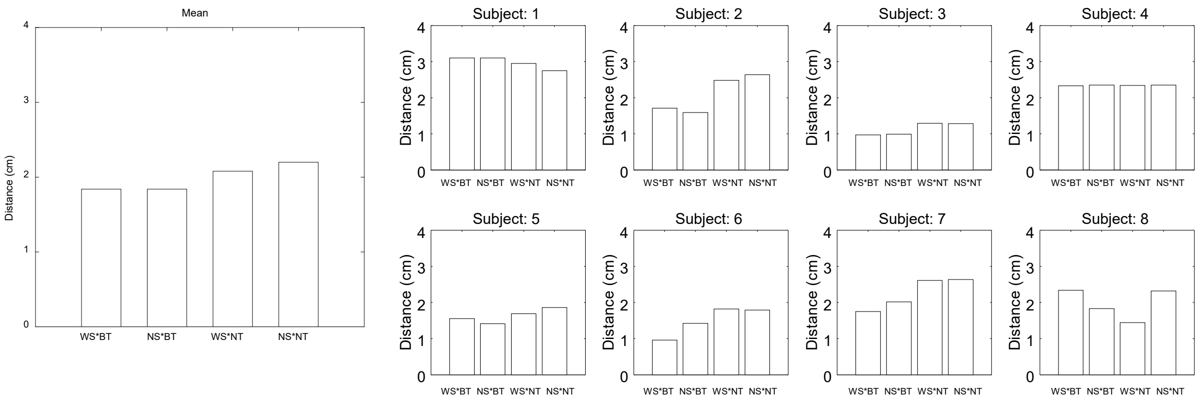


**Figure5 Lateral movement of the waist in each condition**

**DISCUSSION:** Pronation angle might change depending on shoes, and which is varied among individuals. This suggests that there was a difference of effect of shoes on pronation angle. Angle of shank in frontal plane might change depending on tights, and which is varied among individuals. This suggests that there was a difference of effect of tights on angle of the shank in frontal plane. These findings suggest that Combination of WS and BT might decrease angle of the foot and shank in frontal plane. Furthermore, the trunk was stabilized by the decrease in lateral movement of the waist, but the effect varies depending on subjects. Nigg (1998) report that study using 12 subjects and 5 inserts with identical shape but different materials showed typically small, nonsystematic changes in foot and leg alignment and movement. Inserts produced for some subject–insert combinations a reduction in foot and leg movement, for others a reduction in foot movement and an increase in leg movement, and for a third group an increase in foot movement and a decrease in leg movement. The results of this study indicate that use of an insert/orthotic is subject specific.

It is assumed the most suitable combination varies among individuals in shoes and the tights in our study. However, further research may reveal a combination of shoe and tights function that is effective for more runners.

**CONCLUSION:** Pronation angle might change depending on shoes. Angle of shank in frontal plane might change depending on tights. Combination of WS and BT might decrease angle of the foot and shank in frontal plane and stabilize the trunk. But the effect varies depending on subjects. From an anatomical and biomechanical point of view, it is necessary to consider the functions of shoes and tights that are effective for more runners.

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