Influence of Wearing Shoes on the Impact Force during Drop-jump

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Abstract: The purpose of this study was to investigate the vertical ground reaction force during drop-jumping in bare and shod conditions. Seven healthy men participated and performed the drop-jump from the box of the 45cm-height in barefoot (BARE) and shod (SHOD) conditions. The force variables at the contact were measured on the force plate. The maximum vertical ground reaction forces (MGRF), contact time (CT) and jump height (JH) were used. MGRF, CT and JH were not significantly different between BARE and SHOD conditions.

1 INTRODUCTION

In modern life style most of people living in developed countries wear shoes when they have walking, jogging, running and daily activities. Shock absorption of shoes can be achieved by thickness, stiffness, cushioning properties of midsole and insoles. Impact stress and calcaneal loading rates were significantly reduced by material moderation during the landing phase of the jump (Gross and Bunch, 1989). Insoles play a more important role in cushioning properties and the percentage of impact absorbed was different by properties of insole (Chiu and Shiang, 2007). Peak vertical GRF during landing activities was significantly greater for the normal and hard midsoles compared to soft midsoles (Zhang et al., 2005). Also, EMG studies show that muscle activity of plantar flexors is higher when wearing with unstable shoes as compared normal walking shoes during standing (Nigg et al., 2006) and walking (Koyama et al., 2012).

It seems that different shoe conditions affect the lower leg and foot at the contact phase of ground during the running movement. However, only a small number of studies have been compared between barefoot and shod conditions during high impact force activities other than running. The influence of wearing shoes as compared with barefoot condition on the impact force during high GRF landing movements has not been clear yet. Therefore, the purpose of this study was to investigate the shock absorption function and force enhancement of the foot during the drop jump performance in shod and barefoot condition.

2 METHODS

Seven healthy men (age, 21.3±0.8 years; height, 1.72±0.05 m; body mass, 63.1±10.2 kg; mean±SD) volunteered to participate in this study. No participants were taking medications nor did they have any injuries in feet and legs within a year.

They drop-jumped from the box of 45cm-height in barefoot (BARE) and shod (SHOD) conditions. The drop jump was performed as stepping off from a height of the box to the ground, then quickly jumping up as high as possible. Participants were instructed to naturally contact with the both feet within the area of the force plate.

The force variables at the contact during the drop-jump were measured on the force plate. The sample frequency of the force platform was set at 1 kHz. The maximum vertical ground reaction force (MGRF), contact time (CT) and jump height (JH) were analysed. By measuring the FT from the force record on the force plate, the vertical take-off velocity (Vv) of the centre of gravity was calculated with the following equation:

$$Vv = 1/2 \cdot FT \cdot g,$$

where g is the acceleration of gravity (9.81 m/s2). Then, jump height (JH) was calculated with the following equation:

$$JH = Vv2 \cdot (2g)^{-1}.$$

MGRF was normalized by body weight. The mean of the 3 measurements was used for further analysis.

3 RESULTS

The representative GRF curves during the drop-jump at both foot contacts were compared between BARE and SHOD conditions. Figure X shows two typical GRF time series data in two conditions.

MGRF, CT and JH were not significantly different between BARE (MGRF; 60.2±12.5 N/kg, CT; 0.24±0.04 s, JH; 22.4±4.42 cm) and SHOD (MGRF; 58.4±11.7 N/kg, CT; 0.24±0.04 s, JH; 21.7±4.93 cm).

4 DISCUSSIONS

This study showed that the drop-jump performance in BARE and SHOD conditions was similar in the landing impact force, contact time and jump height. The drop jump movement is known as the typical single action of stretch-shortening cycle (SSC) exercise.

When compared with shod and barefoot condition, the impact force in shod running was higher than that of barefoot running (Lieberman et al., 2010). This is because the foot was contacted with rearfoot in shod condition, but with forefoot in barefoot condition. In case of the drop-jump, the foot contact was similar in both conditions. During the drop jump, the force production in a concentric contraction phase of the jump should be stronger when it immediately proceeds with an eccentric contraction of the same muscle. This pre-stretch conditioning of lower limb muscles occur in particular knee extensors and ankle plantar flexors during the drop jump (Dvir, 1985a). The stretch reflex elicited during eccentric phase of muscle contraction may play an important role in controlling subsequent muscle stiffness and elastic energy store, and thus enhancing concentric muscle mechanical power production during SSC muscle performance. High muscle activity during the eccentric phase on the contact plays an important role in storing elastic energy, and this stored elastic energy can be reutilized for production of high power during the concentric phase on the contact (Viitasalo et al., 1998). In the barefoot condition the foot may naturally use these SSC functions in lower limb and foot joints, while in shod condition elastic material of the shoes may help to enhance the performance.

This result suggests that in order to improve the SSC functions, exercises with barefoot may be effective. However, exercises with barefoot should be carefully planed because they can be very easy to overcome the limited functions of the foot and leg muscles.

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