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Metatarsal strapping tightness effect to vertical jump performance

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ABSTRACT

The study investigated the effect of metatarsal strapping on vertical jump performance and evaluated the difference in lower limb kinematics and electromyographic signal (EMG) between different strapping force levels. Twelve male callisthenic athletes completed single vertical jump from a squat posture with hands on hips under three conditions as non-strapping (NS), moderate strapping (MS) and high strapping (HS) round metatarsals. Ground reaction force (GRF) was recorded with KISTLER force platform to calculate the vertical jump height. Angles of ankle, knee and hip were measured with VICON motion analysis system and EMG data were recorded with mega6000 system. Data showed that jump height was significantly higher under HS than NS condition. Compared with NS, ankle inversion decreased significantly during take-off and external rotation increased significantly during landing with MS. Significant difference was also found in the muscle activity of tibialis anterior between non-strapping and strapping conditions.

1. Introduction

Human body compression equipment has been widely used among athletes of all levels as a way to improve performance. For example, De Glanville and Hamlin (2012) indicated that well-trained endurance athletes who wore full-leg-length compressive garment achieved a substantially higher

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average power output in the subsequent 40-kM cycling time trial. Kraemer et al. (1998) noted that compression shorts effectively reduced the muscle oscillation upon impact during landing and increased joint position sense; consequently, the mean power output during repetitive maximal jump was enhanced. Single countermovement jump height of experienced athletes wearing thicker compressive shorts with additional elastic force increased significantly by 2.4 cm than that of the control (Doan et al., 2003). Wearing below-knee compression stockings has shown to improve running performance of moderately trained athletes (Kemmler et al., 2009). Also, one work reported that recreational athletes completed 5-km running race faster with elastic tights (30 mmHg) at ankle by extending stride length (Chatard, 1998).

All these works reported on compressive interventions were applied to lower limb joints as hip, knee and ankle; no systematic work has been conducted similar approach on the metatarsophalangeal joint (MTP), probably due to the difficulty with its smaller anatomical structure and muscle group around such as flexor digitorum longus or extensor digitorum longus. MTP is known to play an important role in push-off/take-off as the distal segment to resist external moment produced by ground reaction force (GRF) during locomotion (Goldmann & Brüggemann, 2012). Previous studies reported that the peak MTP plantar flexion moments were about 60 Nm and 110 Nm during running and sprint, respectively, and this moment was greater than 100 Nm during long jump (Stefanyshyn & Nigg, 1997, 1998).

Research works on MTP began to attract particular attention since mid-1990s, in early works; Stefanyshyn and Nigg (1997) investigated energy generation and absorption at this joint during running. The authors indicated that MTP absorbed energy whereas generated no or very little energy during take-off since the joint remained to be dorsiflexion almost throughout the stance phase and could not transform to plantar-flexion until the toes off the ground (Stefanyshyn & Nigg, 1997). Another work showed that MTP absorbed, on average, 24 J energy during one-legged vertical jump, and the jump height would increase approximately 3.5 cm with a body mass of 70 kg for such amount of energy (Stefanyshyn & Nigg, 1998). Base on this case, reducing energy absorption at MTP may potentially be a viable approach to enhance performance. Research on intervention at metatarsals such as footwear modification has been reported to be helpful in reducing energy loss at this joint. One means is to increase midsole longitudinal bending stiffness by inserting a carbon fiber plate throughout the full length of the midsole. Stefanyshyn and Nigg (2000) stated that the vertical jump height could be increased significantly when wearing shoe with stiffer midsole on account of the decreased energy absorption at MTP, whereas energy generation and absorption at ankle, knee, and hip joints were not influenced by the midsole stiffness. Similarly, Roy and Stefanyshyn (2006) reported that stiffened MTP improved running economy without the reduction of energy loss, which appeared to be associated with the principle of optimizing musculoskeletal system. Athletes are capable of manipulating equipment to optimize contractile properties of the muscles such as relationship of force–length and force–velocity leading to performance enhancement (Nigg, Stefanyshyn, & Denoth, 2000). However, research by Toon, Vinet, Pain, and Caine (2011) has shown that sprinters in various selective-laser-sintered shoes performed best in medium-stiffness shoe for squat jumps and in maximum-stiffness shoe for bounce drop jumps. In addition, one work demonstrated that, in order to adapt gait with intervention at metatarsals; ankle and knee angles would change notably (Wu, Ji, & Jin, 2001). Moreover, Laroche, Pozzo, Ornetti, Tavernier, and Maillefert (2006) concluded a negative relationship between maximal knee and hip flexion and underlying MTP dorsal flexion range of motion during walking.

Evident from these published works, it is highly likely that sports performance can be improved through properly intervening at metatarsals with an appropriate mechanism. Meanwhile, interventions may also induce compensatory motions of ankle, knee and hip. Different from wearing compression garments or modifying shoe midsole stiffness, this study adopted a much simpler method of strapping the metatarsals with elastic compression bandage to explore the effect of metatarsal strapping on vertical jump height and lower limb kinematics. To link muscle activity and jump height, electromyography (EMG) of four main lower limb muscles were measured. It was hypothesized that metatarsal strapping would not greatly alter lower limb kinematics; but increased metatarsal strapping level would increase vertical jump height and decrease the total intensity of lower limb muscular activity, leading to positive effects.