MECHANISM OF LEG STIFFNESS ADJUSTMENT FOR CHILDREN LANDING ON SURFACES OF DIFFERENT STIFFNESSES

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According to the papers, humans do adjust their leg stiffness to accommodate changes in stride frequency or surface stiffness, while hopping in places or running forward. The purpose of this study was to determine the mechanism by which humans adjust leg stiffness during drop landing on surfaces of different stiffness. Kinematic and kinetic data were acquired simultaneously, and then the Inverse Dynamics method was used to acquire the horizontal forces, vertical forces, and the net muscle joint moments in the three lower extremity joints. The quantitative results of the present study might generate more knowledge about the motor performance and the importance of landing to be considered while teaching, coaching and training children.

KEY WORDS: biomechanics, children, stiffness, landing, inverse dynamics

INTRODUCTION: Children daily life involves lots of jumping and landing activities. Jumping and landing are part of many sport activities, and recognized as a crucial part with respect to occurring health problems. During a landing impact, the human body is exposed to large force and moment that always has potential to create injury. From many papers, we can conclude that there are various possibilities to influence external and internal forces during ground contact (e.g. muscle tuning), and humans do adjust their leg stiffness to accommodate changes in stride frequency or surface stiffness, while hopping in places or running forward, and the stiffness indeed influence athletic performance in various sport activities. In the past, much of the research related to leg stiffness had concentrated on adults, lacking of research papers devoted to children, while most of the athletes had been trained from their very young ages. So the quantitative results of the present study might generate more knowledge about the motor performance and the importance of landing as an integral part of many sporting activities to be considered while teaching, coaching and training children.

METHODS: Ten male six-grade children performed 6 times drop landing on two different surfaces with barefoot and keeping their hands on their hips from 40 cm height. One surface was the force platform, it was harder, and the other was a gym mat, it was softer. Their stiffness were 3500 kN/m (HS) and 142 kN/m (LS), respectively. The mean (±S.D.) height, mass and age were 155.3 ± 8.2 cm, 48.0 ± 10.5 kg, and 11.9 ± 0.3 years, respectively. Kinematic and kinetic data were acquired simultaneously by using a Redlake high speed camera (250 Hz) and a Kistler (model 9287) force platform (1000 Hz). Then data were processed by a computer program written in C language in order to acquire the net forces and net muscle joint moments of the ankle, knee, and hip. The definition and calculation of leg stiffness and three lower extremity joints' stiffness were as described in detail in Farley et al (1998). The mechanism of leg stiffness adjustment for children landing on surfaces of different stiffness was checked using Pearson product-moment correlation between leg stiffness and hip, knee and ankle joint stiffness (alpha = .05).

RESULTS AND DISCUSSION: The results of this study were presented in Table 1, 2 and in Figure 1, 2. Table 1 and Figure 1 indicated that there was significant increase in leg stiffness, as the stiffness of landing surface decreased. Averagely, leg stiffness increased about 26 %. Farley et al. (1998), Ferris et al. (1999) reported similar result. Also, knee joint stiffness was significant increase, as the stiffness of landing surface decreased. It increased 19 % or so. But there was significant decrease in ankle joint stiffness, as the stiffness of landing surface decreased. It decreased 23 %. Farley et al. (1998) reported different result. They found that there was significant increase in ankle joint stiffness, as the stiffness of landing surface decreased. And hip and knee joint stiffness remained the same. Table 2 showed that knee joint stiffness might be the major mechanism of leg stiffness adjustment for children landing on surfaces of different stiffness in this study. This was different from the result of Farley et al. (1998). Farley et al. (1998) reported ankle joint stiffness was the major mechanism of leg stiffness adjustment, while hopping in places. It might due to the different types of these two activities. The peak reaction forces were same (see Figure 2).

Table 1 Mean values of leg stiffness and three lower extremity joints' stiffness during landing on surfaces of different stiffness.

N=10	HS	LS	
leg stiffness (kNm^{-1})	10.9 (3.7)	14.0 (6.2)	*
hip joint stiffness ($Nmdeg^{-1}$)	4.0 (2.6)	3.8 (2.1)	
knee joint stiffness ($Nmdeg^{-1}$)	1.5 (0.5)	1.9 (0.6)	*
ankle joint stiffness ($Nmdeg^{-1}$)	2.1 (0.7)	1.7 (0.7)	*

*$p<.05$

Mean, SD values are calculated from mean values over trials for each subject; standard deviations are in (). *Statistically significant ($p< .05$) difference between HS and LS.

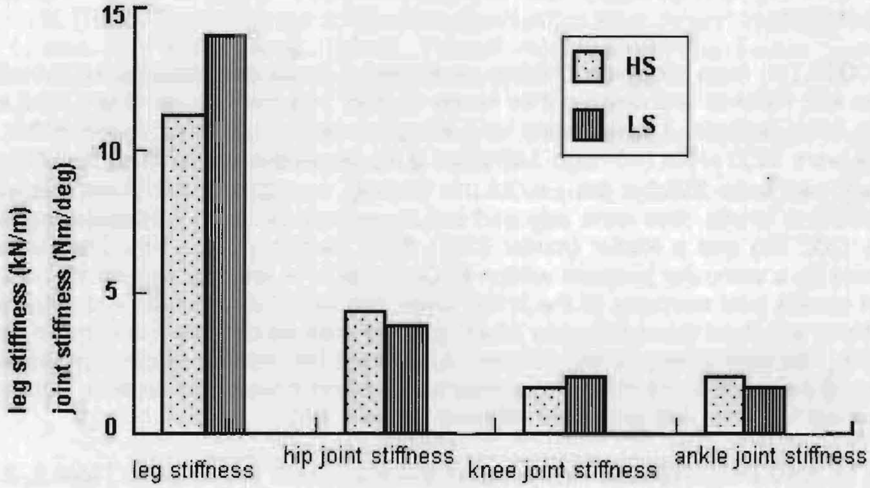

Figure 1 Mean value of leg stiffness and three lower extremity joints' stiffness during landing on surfaces of different stiffness.

Table 2 Pearson product-moment correlation between leg stiffness and hip, knee and ankle joint stiffness.

N=10	HS	LS	
Hip	0.73*	0.73*	*
Knee	0.94*	0.93*	*
Ankle	0.43	0.55	

*P<.05

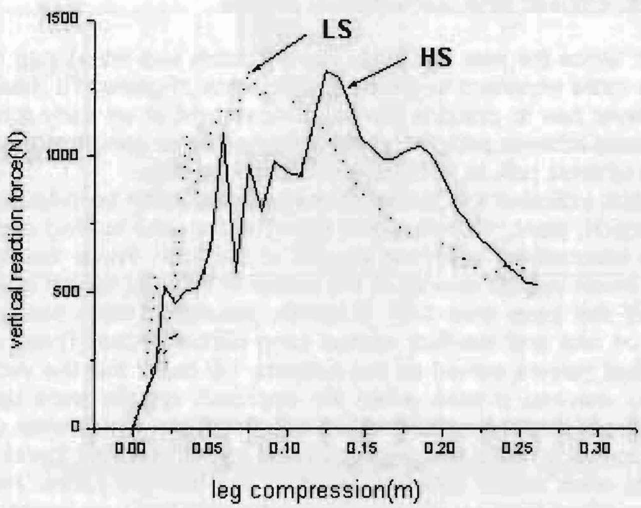

Figure 2 Curve of leg compression vs vertical reaction force of represented subject.

CONCLUSION:

1.The leg stiffness was affected by the stiffness of landing surface. More lower is the stiffness of landing surface, more higher is leg stiffness.

2 The mechanism of leg stiffness adjustment for children landing on surfaces of different stiffness in this study was knee joint stiffness.

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