INFLUENCE OF DIFFERENT HEIGHTS ON MECHANICS OF CHILDREN'S LANDING

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Much of the research related to landing had concentrated on the impact loads and the biomechanical implications of the impact and the resulting loads placed on lower extremity tissues of adults. This fact has caused a lack of research papers devoted to children. The purpose of this study was to analyze the kinematic and kinetic differences of children barefoot drop landing from three different heights (20, 40, 60 cm). Kinematic and kinetic data were acquired simultaneously, and then data were processed by inverse dynamics in order to acquire mechanical load data acting on the ankle, knee, and hip joints. The quantitative results of the present study might generate more knowledge about the motor performance and the importance of landing. This knowledge should be considered while teaching, coaching and training children.

KEY WORDS: kinematics, kinetics, barefoot, children, landing, inverse dynamics.

INTRODUCTION: Children's daily life involves lots of jumping and landing activities. Jumping and landing are part of many sporting activities, and recognized as a crucial part with respect to health problems. In a landing impact, the human body is exposed to large force and moment that always has potential to create injury. In the past, much of the research related to landing had concentrated on the impact loads and the biomechanical implications of the impact and the resulting loads placed on lower extremity tissues of adults. There has been a lack of research papers devoted to children. Generally, most of the athletes had been trained from their very young ages. Though a long-term training might improve their skills, the possibilities of injuries increased, relatively. 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. Such knowledge should to be considered while teaching, coaching and training children.

METHOD: Five male six-grade children performed 5 times drop landing being barefoot and keeping their hands on their hips, from three different heights (20, 40, 60 cm). The mean (±S.D.) height, mass and age were 149±5.6 cm, 40.8±4.5 kg, and 12.1±0.3 years, respectively. Kinematic and kinetic data were acquired simultaneously by using a Peak Performance high speed camera (120 Hz) and a Kistler (model 9287) force platform (1200 Hz). Joint angular position and velocity were calculated from the kinematic data. 180 degrees at the lower extremity joints corresponded to an erect, standing position with the trunk, thigh and shank in a straight line, and the foot at a right angle to the shank. Positive values were assigned for extension at the hip and knee and plantarflexion at the ankle. Then, data were processed by a computer program written in C language in order to acquire the normal forces, shear forces, net muscle joint moments, muscle joint powers and work done on the extensor muscles on the ankle, knee, and hip. The selected variables were tested by one-way repeated ANOVA (alpha = .05) and Scheffe method posterior comparisons.

RESULTS AND DISCUSSION: Kinematic and kinetic descriptors of drop landing are presented in Table 1, 2 and in Figure 1. The results indicated that there were significant increases in the lower extremity joints displacement and the greatest angular velocities (hip and knee joints), the total landing time, first peak vertical reaction force, impulse from contacting the force platform to the first peak vertical reaction force, second peak vertical reaction force, 50 ms impulse, total landing impulse, peak normal force (compress), and shear force in the three lower extremity joints as the landing height increased. Furthermore, there were significant decreases in hip and knee angles at landing. That meant that the subjects flexed more at knee and ankle joints in preparation for a greater landing height. Devita & Skelly (1992) reported similar results. Although there were no differences in the joint moments and powers, most of the trials (3/5) suggested that at landing, the subjects actively flexed hip, extended knee and ankle joints firstly, and then extended hip joint. Most of the energies were absorbed by the first 50 % of the landing time (see Figure 1).

Table 1. Mean values of kinematic quantities across all subjects.

Height [cm]	20	40	60
Angles of lower extremity joints at landing [degree]			
Hip	154.5(6.6)	150.0(7.5)	144.5(6.6)
Knee	161.2(3.4)	155.0(4.2) [1]	149.0(2.9) [1]
Ankle	144.8(6.1)	140.0(7.9)	136.1(5.4) [1]
Displacement of lower extremity parts in joints [deg]			
Hip	23.9(5.7)	41.0(16.3)	64.1(21.7) [1]
Knee	38.1(5.8)	55.6(12.4) [1]	61.3(8.4) [1]
Ankle	44.2(6.3)	47.3(5.3)	43.8(10.3)
Greatest angular velocities of lower extremity joints [rad/s]			
Hip	-4.58(1.25)	-6.82(1.27) [1]	-8.06(1.35) [1]
Knee	-6.71(0.73)	-9.05(1.93) [1]	-10.69(1.69) [1]
Ankle	-9.82(1.78)	-12.19(3.90)	-12.49(2.53)
Total landing time [ms]	168.4(15.8)	216.6(40.6) [1]	283.2(74.7) [1]

Mean, SD values are calculated from mean values over trials for each subject; standard deviations are in (). [1] Statistically significant ($p < .05$) difference between 20 cm and 40 cm, 20 cm and 60 cm.

Table 2. Mean values of kinetic quantities across all subjects.

Height [cm]	20	40	60
First peak vertical reaction force [BW]	0.7(0.3)	1.3(0.4) [1]	1.8(0.4) [1]
Impulse from contacting the force platform to the first peak vertical reaction force [N×m×s/kg]	2.3(1.2)	3.8(1.4)	5.3(1.6) [1]
Second peak vertical reaction force [BW]	2.7(0.4)	3.4(1.1)	5.5(1.6) [1]
50 ms impulse [N×m×s/kg]	24.1(9.4)	35.9(17.1)	52.0(22.2) [1]
Total landing impulse [N×m×s/kg]	132.7(36.1)	187.3(35.5) [1]	264.9(75.9) [1]
Peak normal force in the three lower extremity joints [N/kg]			
Hip	-6.5(3.1)	-8.2(3.2)	-13.0(2.7) [1]
Knee	-9.9(2.8)	-11.8(4.7)	-16.7(4.2) [1]
Ankle	-10.7(3.2)	-13.3(5.1)	-18.5(4.3) [1]
Peak shear force in the three lower extremity joints [N/kg]			
Hip	5.3(1.9)	7.0(3.3)	11.1(4.5) [1]
Knee	-6.1(1.9)	-8.1(3.2)	-11.3(3.7) [1]
Ankle	9.8(3.2)	12.3(5.6)	16.1(5.0) [1]

Mean, SD values are calculated from mean values over trials for each subject; standard deviations are in (). [1] Statistically significant ($p < .05$) difference between 20 cm and 40 cm, 20 cm and 60 cm.

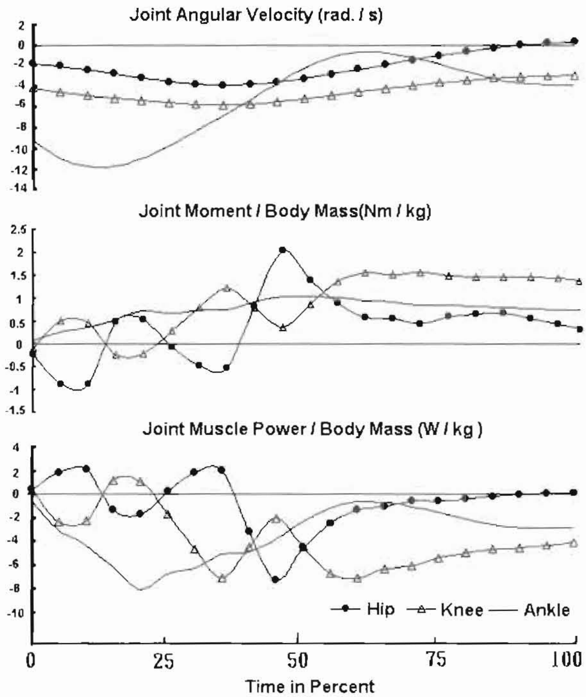

Figure 1. Mean joint angular velocities, net joint moments, and net joint muscle powers during landing phase (0 –100 %) of drop landings from 20 cm height.

CONCLUSION: During the barefoot landing, the improper landing skill may increase the possibility of injury. It is suggested that when teaching children how to land from a great height, the children should actively flex hip, extend knee and ankle joints firstly, and then extend hip joint to increase lower extremity joints displacement and landing time, which will reduce the impact force, and so potential of injury could be avoided.

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