

UNIVERSITY STUDY REPORT ON



ATTENUATION OF IMPACT SHOCK DURING JOGGING: comparison between running shoes and Kangoo Jumps

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Abstract :

Impact force experienced during running has been recognised as a source of injury. Much less is known about these phenomena during Kangoo Jumps, a revolution in shoe design, which includes a spring attached to the sole of the shoe. The purpose of this study was to investigate the impact characteristics for Kangoo Jumps and to test the hypothesis that there is lower impact shock during Kangoo Jumps than in running. 11 athletes (6 males and 5 female's subjects) participated in the study. Each completed two different trials with low-mass accelerometers attached to the proximal tibia and to the lumbar spine (L5). Each performed three trials of vertical jumping and a trial of running for 20 seconds at a self-pace, wearing his or her normal training shoes and the Kangoo Jumps.

Our results showed that the Kangoo Jump condition exhibited a significant reduction of the acceleration force present during running. We observed an acceleration of 7g at the tibia and 2.5g at the lumbar spine with the training shoes; with the Kangoo Jumps, the acceleration impact force was only 3.5g at the tibia and 1.9g at the lumbar spine.

It is concluded that Kangoo Jumps running results in less impact shock to the body with each foot contact and may be a useful exercise modality for the rehabilitation in case of reducing impact shock during aerobic training.

Impact, Shock Attenuation, Accelerometers, Kangoo Jumps





Introduction

Walking and running are well known as exercises that can improve cardiovascular endurance, strengthen muscles and reduce body fat. Under normal circumstances of running or jumping, the elastic compliance of the internal structure of the foot such as the internal arch and tendons reduce impact forces and provide only about 40 to 60% energy return.

One aspect of running which has been well-documented is the impact shock transmitted through the body when the foot collides with the ground. This event occurs about 6.000 times in a race of 10 km. The shock wave is transmitted across the structures of the lower extremity and upward through the spine to the head. One positive aspect of the shock is to stimulate the bone mass density of the lower extremities. However repetitive landings and impacts have also been implicated in degenerative diseases for the knees and the hips.

In case of injuries, it seems to be important to restore the full ability to compete using different methods which diminish joint loading without diminishing the capacity to improve the cardiovascular endurance.

Recently, there has been a fitness shoe system developed, which is fun the Kangoo Jumps shoe, that would appear to attenuate the impact of high acceleration forces. The shoe is constructed in a similar fashion to that of an inline roller skate, with the exception of wheels. Under the shoe is an elliptical arch stretching from the toe to the heel of the shoe that is bisected with a removable band. At each step we observe a depression of the arch that works like a spring and returns to its previous form.

The purpose of this study was to examine impact shock and the attenuation characteristics during Kangoo Jumps running. To that end we have measured impact acceleration at the tibia and lumbar spine during Kangoo jumping and running and compared these results with data collected from the same subjects while running with normal training shoes.

Methods:

Eleven healthy subjects (mean +/- SD age 31 +/- 7 yr.; height 176 +/- 11 cm.; mass: 64.6 +/- 9 kg.), 6 males and 5 females volunteered to take part in the study. They were sport teachers in fitness centers and none reported any significant musculoskeletal disorder. All subjects were trained in Kangoo Jumps. They performed trials in each of 2 conditions: 2 jogging on a trail of 50 meters at self pace, wearing his or her normal training shoes and the Kangoo Jumps. The impact shock in each trial was quantified by measurement of the peak acceleration (PA) that occurred just after foot landing in each stance phase at the proximal tibia level and at the lumbar spine level by 3 piezoresistive accelerometers (IC Sensors 3021) oriented in orthogonal directions.

The time domain variables output for statistical analysis were PA_{tibia} and PA_{lumbar spine}. The main effect of condition for these dependent variables was tested using a within-subject, repeated-measures ANOVA.





Results:

Typical examples of tibial and spine accelerometer signals during the stance phase for both running with Kangoo and training shoes are shown in figure 1 and 2.

During running we observed a lower significant peak impact for Kangoo shoes ($P = 0.001$). Mean PA tibia value for the Kangoo running condition was 4 G, the mean spine value, 2.5 G whereas running with normal training shoes showed higher values of force acceleration; 7.8 G PA tibial and 2.3 PA spine.

The length of the step measured by the time in air is greater with Kangoo shoes: 143 cm with Kangoo Jumps, 123 with training shoes.

Tables 1, 2 and 3 present a summary of all variables and the results of statistical tests between conditions.

Table 1

Kangoo running						
	Total time (ms)	Time in air(ms)	Time on floor(ms)	length(cm)	PA tibial (G)	PA spine(G)
Mean value	421.8	592	186	144	4.0	2.3
SD	24.8	51.2	-7.8	11	0.4	0.3



Fig. 1 and 2: Exemplar time series of tibial and lumbar spine acceleration signals during stance phase of running (left panel) and Kangoo jumping (right panel). PA indicates peak acceleration just after foot contact.

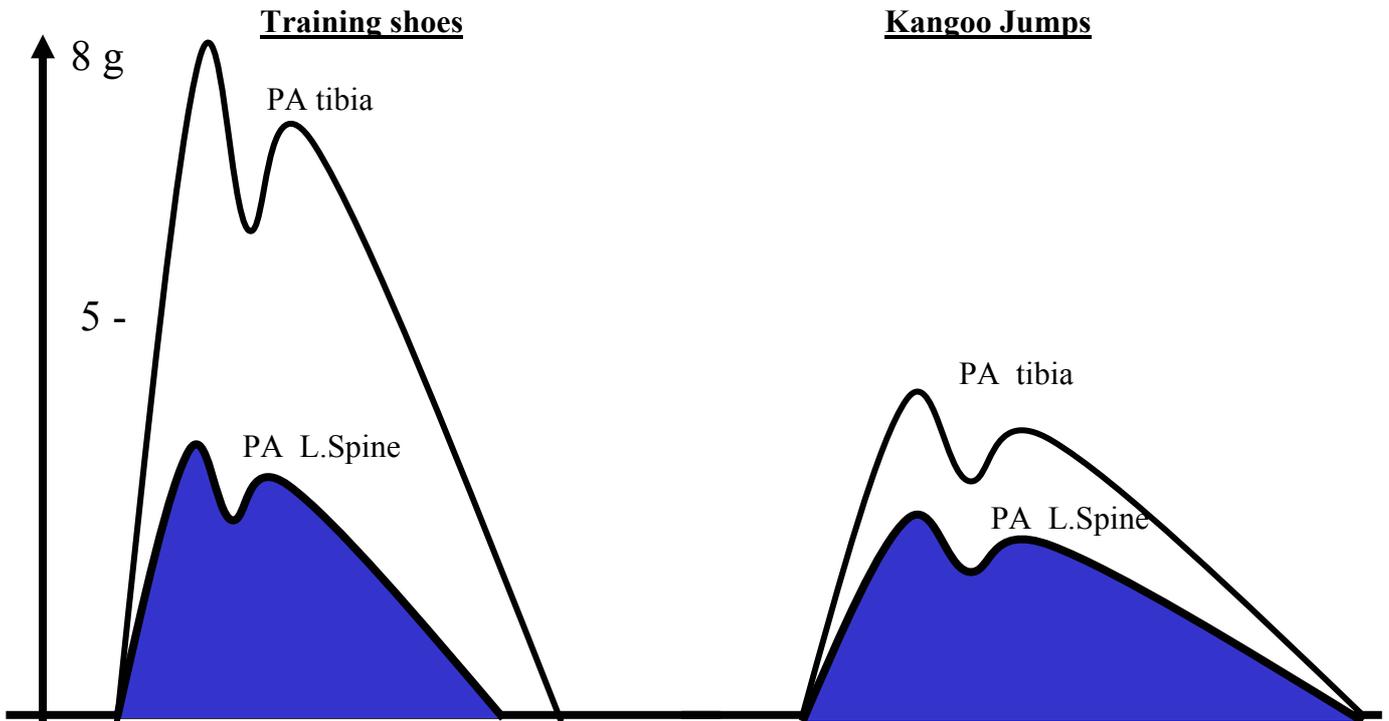


Table 2

Training shoes running						
	Total time (ms)	Time in air(ms)	Time on floor(ms)	Length(cm)	PA tibial (G)	PA spine(G)
Mean value	349.1	520	203	123	7.8	2.8
SD	7.3	57.2	-8.3	9.5	0.6	0.3

Table 3

Comparison training Vs Kangoo shoes						
	Total time (ms)	Time in air(ms)	Time on floor(ms)	length(cm)	PA tibial (G)	PA spine(G)
Mean value	-72.6	-72.5	16.8	-21	3.8	0.5
SD	20.6	49.9	-6.9	-9.5	1.9	0.4
P	<0.05	<0.05	<0.05	<0.05	<0.001	<0.001





Discussion:

The purpose of this study was to investigate the peak acceleration force characteristics when jogging in a pair of Kangoo Jumps compared to normal training shoes. The results clearly show that the Kangoo Jumps result in considerable less impact forces being transferred to the lower limbs compared to the normal training shoes. In particular, the impulse during first initial contact with the ground is reduced some 50%. Furthermore, the length of the step measured by the time in the air is greater with Kangoo shoes than with training shoes. This is a valuable contribution to attenuate the frequencies of impacts of the lower limb with the ground for the same intensity of the physical work.

The frequency analysis of tibial and lumbar spine acceleration showed that Kangoo Jumps running condition demonstrated less impact acceleration, with lower values than running with training shoes for peak and median frequency. The frequency range is associated with the collision of the foot to the ground and this frequency band may be implicated in musculoskeletal injuries. Some have suggested that removal of higher frequencies may reduce the likelihood of degenerative joint diseases. Kangoo Jumps may therefore prove to be an aerobic exercise workout that is less harmful to the joints in terms of repetitive impacts of the foot and ground.

The results of the frequency analysis for the running trials agree with other studies. The running condition with training shoes displayed peaks between 6 and 10 g at the tibia level as found in previous studies. With Kangoo Jumps, the peak acceleration is 50% lower. The attenuation of the force impact is significant.

These preliminary results showed promise for the use of Kangoo Jumps for low impact exercise such as recreational jogging or fitness. The uninjured person may be able to continue with a high volume ground based activity without the impact injury risk inherent in the sport activity. Further there may be application of these shoes in rehabilitating patients with lower limb injuries. The patients could perform activities similar to normal jogging, maintaining cardiovascular endurance but in a lower impact situation. Jogging with Kangoo Jumps may be a valuable intermediate step in the rehabilitation process.

Training for long distance races is another possible use for Kangoo Jumps. Top level athletes have to train more than 10 hours in the week. To reduce the risk of an overuse injury, many athletes perform aqua jogging, an other training method to increase the aerobic capacity. Kangoo Jumps shoes minimise the impacts with the ground and offer a good opportunity to train outdoor without the risk of injuries like stress fractures and tendinitis.

