KNEE POWER IN LOW BACK PAIN SUBJECTS DURING RUNNING

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The purpose of this study was to examine lower extremity shock absorption between runners with and without low back pain. We compared data from three groups based on low back pain status: current low back pain, resolved pain after a single bout of low back pain and runners who never had low back pain (CTRL). All subjects ran at least 20 km per week and ran on a force treadmill at 3.8 m•s^{-1} while kinematic and kinetic data were collected. Work was determined from joint power histories during the shock attenuation portion of the stance phase. Individuals with a history of low back pain exhibited less peak knee negative power and negative work suggesting that they exhibited decreased eccentric muscle activity during foot-ground impact. The results of this study suggest that decreased eccentric activity of the muscles crossing the knee joint is associated with individuals who have low back pain and, to a lesser extent, with those who have residual low back pain. We suggest that the decreased eccentric activity can result in the foot-ground impact shock wave moving through the lower extremity with little attenuation to the low back region.

KEY WORDS: low back pain, joint power, work.

INTRODUCTION:

Over 80% of Americans will experience low back pain at some point in their life and one in 10 recreational runners will incur low back pain within the first year of training (Jacobs & Berson,1986). A loss of shock attenuating capacity generally is thought to result from a breakdown and repair of the tissues surrounding the spine (Radin et al., 1973). It has been estimated that the low back accounts for approximately 10% of all injuries experienced by recreational runners (Taunton et al., 2003). Impacts and accelerations experienced during the impact phase (i.e., 1st 25% of support phase) tend to be more pronounced, and have been implicated in lower extremity running injuries (Voloshin, & Wosk, 1982). These findings suggest that impacts and the mechanisms of impact attenuation may be related to low back pain in runners.

In a prior study using the same subjects, it was determined that joint stiffness increased as a function of low back pain (Hamill et al., 2007). It was suggested that the increase in joint stiffness could be attributed to a lack of shock absorption at the knee. The purpose of this study was, therefore, to examine knee joint shock absorption using the knee power histories of individuals with low back pain and resolved low back pain and to compare these individuals with a healthy control group. It was hypothesized that knee power and negative work would be less in the low back pain group compared to the resolved low back pain and control groups.

METHOD:

Subjects: Three subject groups, each consisting of 11 participants, were recruited for this study. Subjects had to run at least 20 km/week with a heel-toe footfall pattern. The participants in the low back pain group (LBP) all had pain for at least four months after the onset of injury. Because we wanted to examine the effects of non-specific low back pain, subjects were excluded from the study if there was any medical diagnosis or medical evidence of a herniated or bulging disc, or any evidence of nerve involvement, such as numbness or tingling in the extremities. All LBP injuries were the result of participation in running-based activities. The individuals in the resolved low back pain group (RES) had recovered from a single bout of low back pain that lasted less than six weeks. The control group (CTRL) never had any occurrence of low back pain. All subjects signed an informed consent form that was approved by the institutional review board and completed a modified Physical Activity Readiness questionnaire.

Data Collection: Eight 240 Hz digital cameras were placed around a custom built 3-D force treadmill. The treadmill consisted of a rigid aluminum frame sitting on top of four multi-component force transducers. The forces were calculated by summing a particular channel from each of the four transducers, the locations of which were recorded along with the kinematic data. The cameras and the force transducers of the treadmill were all interfaced to the same microcomputer. Data sampling was accomplished at 240 Hz (kinematics) and 1200 Hz (kinetics).

Protocol: Clusters of retro-reflective markers on rigid plastic shells were placed on bilateral feet, shank, and thighs. Calibration markers were placed to identify joint center locations. Each subject was then given a familiarization period running on the treadmill lasting 5-10 minutes running at different speeds. Subsequently, the treadmill speed was set at 3.8 $m \cdot s^{-1}$. Subjects then ran for 30 s at the criterion speed during which kinematic and kinetic data were recorded during the final 20 s.

Data Analysis: The kinematic and kinetic data were filtered using a Butterworth filter at 10 Hz for the kinematic data and 30 Hz for the kinetic data. A Newton-Euler inverse dynamics procedure was used to calculate the three-dimensional lower extremity joint moments at the ankle and knee. Joint power was then determined as:

$$\mathrm{Power} = M_j * \omega_j$$

where M_j is the joint moment and ω_j is the joint angular velocity. While 3-D angles and moments were calculated, the primary motion was considered only in the sagittal plane. Thus, only sagittal plane power will be discussed in this paper. Peak power and negative work (i.e. area under the power-time history) were determined for five right and left footfalls for each subject. To further compare peak power of the right and left limbs of the each group, a symmetry index (SI) was used (Robinson et al., 1987). Higher numbers indicate greater asymmetry.

Data Analysis: Effect size (ES) was calculated to express differences relative to the pooled standard deviation. Cohen (1990) proposed that clinically significant differences are generally accepted when ES > 0.5.

RESULTS:

Knee power profiles for both the right and left limbs were consistent in shape and magnitude with Derrick et al. (1997) (Figure 1).

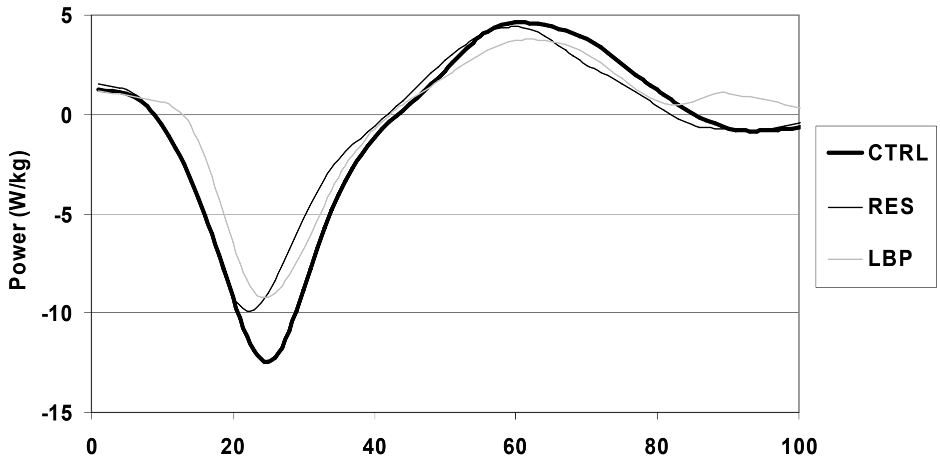

Figure 1: Mean power histories for the right of all subjects in each group.

The SI between the right and left limbs for the CTRL, RES and LBP groups was less than 6% for both parameters indicating symmetry between the right and left limbs. Thus, for the analyses, the average values of the right and left limbs were used.
For peak negative power values, between the LBP and RES groups, there was a percent difference of 14.33% and an ES = 0.60. The percent difference between the RES and CTRL groups was 17.5% with an ES = 0.77. Even greater differences were observed between the CTRL and LPB groups with a percent difference of 29.3% and an ES = 1.33.
Negative work values are presented in Figure 2. Between the LBP and RES groups, there was a percent difference of 3.3% and an ES = 0.22. The percent difference between the RES and CTRL groups was 18.8% with an ES = 1.11 while between the CTRL and LPB groups the percent difference was 22.9% and an ES = 1.48.

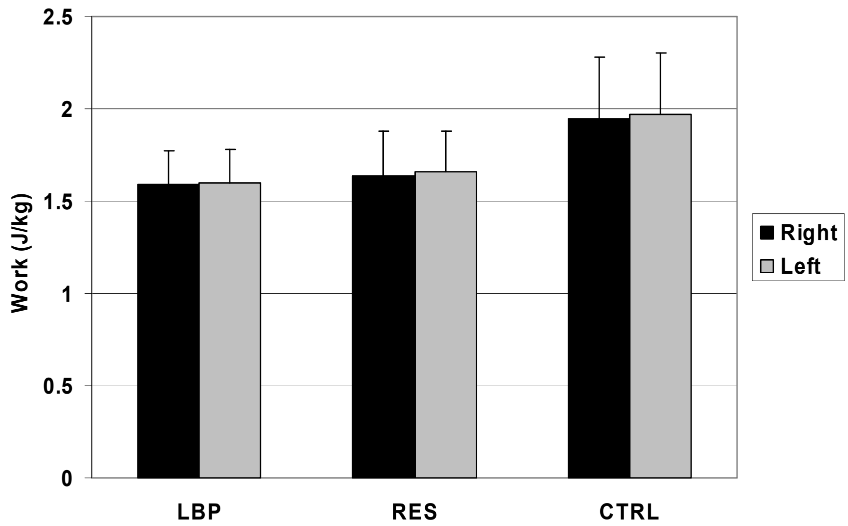

Figure 2: Mean (+SD) negative work values for right and left limbs of all groups.

DISCUSSION:
When a runner's foot makes contact with the ground, the resulting impulsive force causes a shock wave that travels along the lower extremity and through the trunk to the head. The shock wave is generally attenuated by soft tissue, the actions of muscle and the motion of the joints. This shock passes from the appendicular to the axial skeleton in the low back or lumbar/sacral region. When the shock is poorly attenuated, the lumbar/sacral area is considered to be particularly susceptible to injury resulting in low back pain. For heel-toe runners, the action of the knee joint is a primary shock attenuator in running while the motion of the ankle does not appear to influence shock attenuation (Derrick et al., 1998).
For the same subjects as those in this study, knee stiffness was shown to increase as the degree of low back pain increased while ankle stiffness remained constant (Hamill et al., 2007). We suggested that, with increased knee stiffness, there would be less shock attenuation in individuals with low back pain resulting in the impact shock caused by the foot-ground contact to radiate through the lower extremity to the low back (i.e. lumbar) area. Since we did not have a direct measure of shock attenuation, we can infer attenuation from the power history during the initial phase of the support period. The integral of negative power, negative work, during the stance phase of locomotion is associated with the net eccentric activity of the muscles that cross the joint. Eccentric work of muscles is considered to remove energy from the system with the result that the total energy in the system is reduced.
It could be assumed, therefore, that, if the degree of energy removed from the system increased, the degree of shock attenuation would also be increased. In this study, the low back pain individuals had reduced values of negative work (i.e. less change in energy)

compared to the control subjects. This was confirmed by the clinically significant values (i.e. ES > 0.5) for peak negative power and negative work done during the weight acceptance portion of the support phase. That is, the control or healthy subjects used this eccentric activity at the knee joint as a mechanism to reduce the foot-ground impact shock as it travelled through the lower extremity to the low back region.

CONCLUSION:

The results of this study suggest that decreased eccentric activity of the muscles crossing the knee joint is associated with individuals who have low back pain and, to a lesser extent, with those who have residual low back pain (i.e., have recovered from LBP and are running pain-free). We suggest that the decreased eccentric activity can result in the impact shock wave moving through the lower extremity with little attenuation to the low back region.

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