Effect of Running on Cartilage Biomechanics

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Introduction:
Effects of running and other exercise on articular cartilage have traditionally been examined in animal models (1), but until recently little information has been available on human cartilage. Magnetic resonance imaging now permits to delineate human articular cartilage directly, and to analyze three-dimensional cartilage morphology (volume, surface areas, thickness) under in vivo conditions, if appropriate segmentation and image analysis methods are applied (2-4). The objective of this presentation is to review work on both short-term effects of running and other exercise on human articular cartilage (deformational behavior) as well as long-term effects of exercise on the cartilage (functional adaptation to mechanical loading) (5).

Methods:
Fat-suppressed or water excitation spoiled gradient echo sequences with a resolution of approximately 1.5 mm (slice thickness) and 0.31 mm in-plane resolution have been shown to delineate articular cartilage morphology accurately and with high precision (5-7). Manual or semi-automated segmentation approaches can be used to distinguish the cartilage from surrounding tissues in contiguous MR images (8). Based on these segmentations, the cartilage surfaces and volume can be reconstructed three-dimensionally, and measures of cartilage morphology (volume, thickness, and surface areas) can be extracted. Cartilage deformational behaviour can be assessed ex vivo using compression devices (9) or in vivo, by imaging the joint before and immediately after exercise (10). Whereas cartilage deformation appears to become less with aging (10), sex (9,10) and physical training status (11) do not appear to affect in vivo deformational behaviour. There now exists good evidence that cartilage undergoes some type of atrophy (thinning) under reduced loading conditions, such as postoperative immobilization (12) and paraplegia (13). However, increased loading (as encountered by top athletes) does not appear to be associated with increased average cartilage thickness (14,15). Findings in twins, however, suggest a strong genetic contribution to cartilage morphology (16).

Results:
Findings suggest that human cartilage deforms very little in vivo (< 10%) during physiological activities (17) and recovers from exercise-induced deformation within 90 min after loading (18). Whereas cartilage deformation appears to become less with aging (10), sex (9,10) and physical training status (11) do not appear to affect in vivo deformational behaviour. There now exists good evidence that cartilage undergoes some type of atrophy (thinning) under reduced loading conditions, such as postoperative immobilization (12) and paraplegia (13). However, increased loading (as encountered by top athletes) does not appear to be associated with increased average cartilage thickness (14,15). Findings in twins, however, suggest a strong genetic contribution to cartilage morphology (16).

Discussion:
The relatively small amount of deformation of cartilage under physiological loading conditions is explained by its ability to undergo hydrostatic pressurization. Potential reasons for its inability to adapt to mechanical stimuli include a lack of evolutionary pressure and a decoupling of mechanical competence and tissue mass.

References: