# *Run while you're young*: Age dependent differences in cartilage T2 response to running in trained marathoners

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**Introduction:** Although exercise is recognized as a risk factor in development of osteoarthritis (OA), this relationship is poorly understood. Experimental studies in large animal models have shown that low intensity exercise increases maturation of the type II collagen matrix, and has a protective effect on cartilage damage resulting from subsequent high impact loading exercise (1). In humans, high impact loading exercise such as running increases risk for developing OA (2). Because it is impossible to reproduce the biomechanics of human joints with animal models, there is benefit in developing non-invasive markers of cartilage response to exercise that could be applied to human studies. Prior *in vivo* MRI studies have demonstrated changes in patellar cartilage thickness (3), and T2 values (4) in response to knee flexion exercise. The purpose of this study is to determine feasibility of measuring T2 changes in knee cartilage with running, and to identify differences in trained athletes as a function of age.

**Methods:** Quantitative T2 maps of 9 trained marathon runners, 3 females, 6 males, were obtained at baseline and within 10 minutes after running 30 minutes. Subjects consisted of a young cohort age 24 to 40 years (n=4) that trained 20 miles/week, and an older cohort age 47 to 53 years (n=5) that averaged 24 miles/week. T2 maps were obtained using a Bruker 3T MR spectrometer, a 24 cm gradient insert, and 15 cm linear Litz coil (Doty Scientific). Sagittal T2 maps of the femoral tibial joint were calculated from a 6 section, 12 echo sequence with TR/TE = 1500/9-106 ms, 4 mm section thickness, 384 x 384 matrix and a 12.75 cm field of view (FOV). A leg holder interfaced to the gradient/coil set allowed rapid and reproducible positioning of subjects for the pre and post exercise scans. Cartilage T2 maps and profiles were generated using automated subroutines in CCHIPs/IDL software. Pre and post exercise T2 profiles of weight bearing femoral and tibial cartilage were normalized for thickness to allow comparison. The pre exercise T2 profile was subtracted from the post exercise T2 profile to determine regional difference in T2 following exercise. For each cohort, the difference T2 profile was pooled to calculate mean change in T2 as a function of normalized distance (Δ *T2 profile*).

**Results:** Changes in cartilage T2 profiles were observed for all marathoners after running. As shown in **Figure 1**, young marathoners increased T2 of the deepest 50% of cartilage, while T2 of the superficial 50% decreased linearly toward the articular surface. For older marathoners a significant decrease in cartilage T2 occurred over the entire thickness of weight-bearing femoral cartilage, greatest at a normalized distance of 0.65. In tibial cartilage a decrease in T2 occurred in the outer 70% of cartilage, which was greater than that observed in young marathoners.

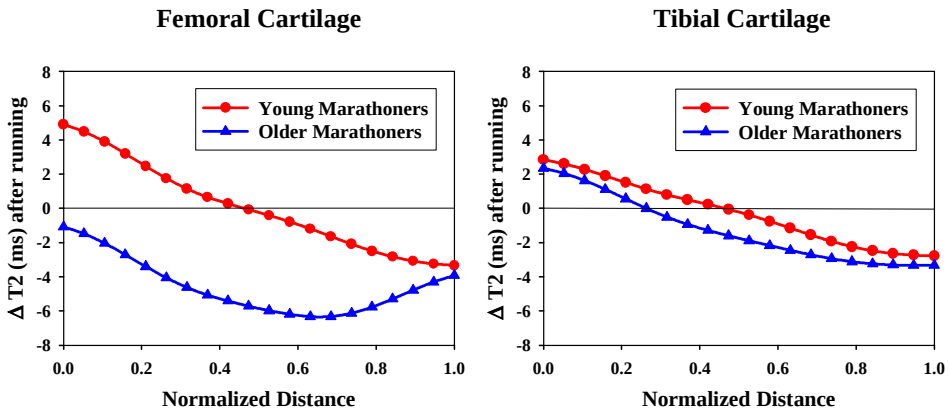


**Figure 1:** Δ *T2 profiles*: The mean change in T2 of articular cartilage after 30 minutes of running is presented as a function of normalized distance from bone. For young marathon runners (●) longer T2 values are observed in deeper layers of cartilage, while T2 shortening occurs near the articular surface. This pattern is substantially different in femoral cartilage of older marathoners (▲) where T2 shortening occurs over the entire thickness of cartilage.

**Discussion:** It has been hypothesized that compressive loading of cartilage decreases T2 through changes in orientation of collagen fibers, and redistribution of water (5-7). For young marathoners, increasing T2 of the deep 50% of cartilage, and decreasing T2 of the superficial 50% is consistent with observations of Grunder *et al*, in static loading experiments on excised porcine osteochondral plugs (7). In correlation with polarized light microscopy they attributed increased signal intensity of the deeper radial zone to loss of collagen fiber anisotropy under load, and the superficial decrease in intensity to an increase in tangential orientation of superficial fibers (7). However, T2 shortening of deeper cartilage we observed in older cartilage cannot be attributed to loss of anisotropy, which should increase T2 of weight-bearing femoral cartilage. High impact cyclical loading that occurs with running produces non-uniform compressive strain in cartilage, reaching ~50% in superficial cartilage, and decreasing to ~5% in the middle radial zone (8). As a result fluid flux in healthy cartilage is confined to superficial cartilage, and may contribute to a decrease in T2 observed in this region. We hypothesize for older marathoners, greater permeability resulting from pre-clinical damage of the solid matrix, allows fluid exudation in deeper layers of cartilage, decreasing water content as reflected by the decrease in T2. This implies greater compressive strain develops in deeper layers of cartilage of older runners that could lead to fatigue fractures of the collagen matrix, and progressive cartilage damage.

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