



Risk of Knee Osteoarthritis in Runners

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Abstract

Introduction: It has been estimated that approximately 30 to 37 million Americans run for exercise. There is concern that this form of exercise may increase the risk for development of osteoarthritis in weight-bearing joints. It is felt that the constant loading of lower extremity joints that occurs during running could damage cartilage and underlying bone and predispose to osteoarthritis. As the number of runners, as well as number of Americans with osteoarthritis continues to grow, it is important to establish if there is a link between running and future development of osteoarthritis.

Method: A literature search was performed using PubMed and MEDLINE using the following keywords: knee, osteoarthritis, runners, running. Articles were reviewed and selected based on their relevance to this topic.

Results: Of the articles reviewed, one did show a positive relationship overall between running and development of radiological evidence of osteoarthritis. Another found a positive relationship in men under age 50, and postulated that this was due to higher running pace. Female runners may have an increased risk of osteophyte development (though presence of osteophytes alone does not meet the criteria for diagnosis of osteoarthritis). Most studies, however, concluded that running did not cause osteoarthritis.

Conclusion: There may be an increased risk for developing osteoarthritis for those who run at faster paces. For those who run at moderate paces, the risk does not appear to be increased. Studies have shown that runners have less physical disability in both lower and upper extremity functions. In addition, running has emotional benefits (stress relief, runner's high), cardiovascular benefits, increases bone density, and increases pain threshold. In the absence of joint abnormalities or underlying injuries, at moderate paces, running appears to be safe and even highly beneficial.

Introduction

It has been estimated that approximately 30 million [1] to 37 [2] million Americans run for exercise. The popularity of running likely stems from the low cost of participation, the ability to participate at any time

without the constraints of gym hours or having to wait for available equipment, and its cardiovascular benefits [3]. In the past, there have been concerns that this form of exercise may increase the risk for development of osteoarthritis (OA) in weight-bearing joints [4]. It was felt that the constant loading of lower extremity joints that occurs during running would damage cartilage and predispose to osteoarthritis. Preliminary studies on animals both supported [5] and refuted [6-8] this claim. Furthermore, in human beings, OA has been shown to be more prevalent in certain occupations including miners, pneumatic drillers, farmers, and seamstresses [9]. If the repetitive movements associated with these occupations predisposes workers to OA then it would seem likely that the repetitive movements associated with running could also predispose to OA. As the number of runners [2], as well as number of Americans with OA [10] continues to grow, it is important to establish if there is a link between running and future development of OA.

Pathophysiology of Osteoarthritis

A normal joint is composed of articular cartilage, subchondral bone, the joint capsule, synovial membrane and fluid, tendons, muscles and ligaments. Articular cartilage helps to reduce friction, absorb shocks, and to transmit weight loads to underlying bone. Due to its thin size articular cartilage is not able to fully protect the joint on its own [10, 11]. Synovial fluid helps to protect the joint in a similar way, but in addition, serves as a barrier against inflammatory cells and debris and prevents inflammatory mediators from binding to nociceptors. Also, muscle contractions help stabilize the joint and absorb excessive energy transmitted to the joint [10, 11].

The pathophysiology of OA is complex and involves all of the different joint components [10]. In the articular cartilage, OA usually begins with small tears called fibrillations, which progress to clefts and fissures until eventually the underlying bone is exposed. Chondrocytes, which make up a small portion of articular cartilage, begin to multiply; however the quality of the collagen and proteoglycans they release is abnormal. The matrix becomes less stiff and less able to protect the joint. At the same time, the subchondral bone begins remodeling. This new bone formation is stiffer and less able to absorb shocks, which leads to further destruction of articular cartilage. Subchondral sclerosis and osteophytes also develop with this bone remodeling. Loose fragments of

cartilage in the synovial fluid lead to inflammation in the synovial membrane. This stimulates synoviocytes to release inflammatory mediators, as well as cartilage degrading enzyme [10]. These pathologic changes in the synovial fluid result in "defective synovial fluid viscosity, elasticity, barrier exclusion and shielding", as well as exposure of synovial nociceptors [11]. With this increase in pain comes decreased use, muscle atrophy, and further loss of joint protection.

The Role of Joint Abnormalities

What does seem clear is that joint instability, malalignment, and prior injury may lead to OA with regular participation in exercise. McDermott and Freyne [12] studied 20 runners complaining of knee pain and found 6 with radiologic degenerative changes, 5 of which met criteria for OA. All six had genu varum and 4 had a past history of trauma. Degenerative changes were significantly associated with genu varum, previous severe injury and number of years spent running. Other studies have shown that individuals with ligamentous and meniscal injuries of the knee have increased risk for developing OA [13]. Even day-to-day activities can accelerate OA in joints that are "unstable, subluxed, dysplastic, incongruous, or malaligned" due to abnormal distribution of stress over the articular cartilage [13].

Methods

A literature search was performed using PubMed and MEDLINE using the following keywords: knee, osteoarthritis, runners, running. Articles were reviewed and selected based on their relevance to this topic.

Results

Studies Showing an Increased Risk of Knee Osteoarthritis in Runners

Kujala, et. al. [15] compared 117 male high-level athletes, including 28 long-distance runners, 31 soccer players, 29 weight lifters, and 29 shooters (the control in this study). Osteoarthritis was defined as having at least grade 2 arthritic changes (based on criteria used by Kellgren and Lawrence [16]) in either the TF joint or the PF joint on anteroposterior (AP) and lateral radiographs. The prevalence of OA was 3% in shooters, 29% in soccer players, 31% in weight lifters, and 14% in runners. The age-adjusted risk of knee OA was substantially elevated in runners as compared with shooters (OR 4.8) but not nearly as elevated as in soccer players (OR 12.3) or weight lifters (OR 12.9).

However, the authors felt that due to the small number of both runners and shooters with knee OA these results may not be valid.

A prospective study by Cheng, et. al. [17] at the Cooper Clinic in Dallas, TX, examined 16,961 men and women aged 20-87 (median 44) over a 25 year period and surveyed them on their current regular exercise patterns. To be included in the study, patients had to report the present of OA of the hip or knee that had previously been diagnosed by a physician. Responders were divided into 5 groups: sedentary (control), high activity (walked/jogged more than 20 miles per week), moderate activity (10-20 miles per week), low activity (up to 10 miles per week) and other (participated in some other form of physical activity). In women, there was no association between physical activity and OA. In men, only the highest level of physical activity was associated with OA, and this trend was only significant in men under 50 years of age. The authors felt this may have been related to immeasurable factors, such as the intensity of physical activities (jogging speed) in that age group.

Lilley et al. [18] compared the running gait of fifteen mature (40-60 years) and 15 young (18-25 years) females. Forty years of age was found to be the age at which structural changes begin to occur at the joints. The purpose was to investigate whether mature females demonstrated gait characteristics that may predispose them to knee conditions. Participants also took the Knee Osteoarthritis Observation Survey (KOOS) to evaluate the potential for knee osteoarthritis and injuries, with low scores indicative of more prominent knee symptoms. All participants had at least 12 months of running experience, and took part in three 1 hour sessions of running per week. Participants performed 10 running trials in the biomechanics laboratory in which both kinematic and ground reaction force data were collected. The study found that mature females produced significantly higher peak rearfoot eversion, knee internal rotation, external adductor moment and loading rate of ground reaction force compared to the young participants. These running gaits increase vulnerability of injury to the knee. Mature females showed considerable negative correlations between KOOS scores and peak eversion angle. These results support the idea that the running gait of mature females may predispose them to knee conditions. Results from the KOOS survey suggested few symptoms of osteoarthritis were present among the mature group, but it is possible that osteoarthritis may develop if they continue with the gait patterns.

Studies Showing No Increase in Risk of Knee Osteoarthritis in Runners

Twenty-seven competitive Danish runners who had qualified for county teams between the years 1950 and 1955 were compared with 27 controls matched for age, height, weight and physical workload in a study done by Konradsen, et. al. in 1990 [19]. Of note, initially 30 runners were selected, but three had stopped running by the date of the study (only one from OA). Subjects were evaluated by a pain questionnaire, clinical exam, including range of motion and joint alignment and radiographs of both the hips and knees (joint space and number of osteophytes). There was no difference between the two groups on any of these measures.

In a 2008 prospective observational study by Chakravarty et. al. [20], 45 long-distance runners were compared with 53 controls over a period of 18 years. The long-distance runners participated in vigorous exercise for approximately 300 minutes a week and all subjects were within an age range of 50-72 years. The subjects underwent serial knee radiographs which were examined for joint space narrowing, sclerosis and osteophytes. These findings were used to determine the Total Knee Score in order to assess the progression of radiographic OA. Total knee scores were inferior in the initial radiograph in runners compared to controls, but by the end of the study the scores were similar in both groups. Based on the results of the study it was concluded that despite having worse radiographic scores and more prevalent OA at the baseline, long distance runners did not have more severe OA or replaced knees than controls.

Sohn and Micheli [21] studied former college varsity long-distance runners and swimmers. Of the 504 runners, there was a 2% incidence of severe hip or knee pain, a 15.5% incidence of mild to moderate pain, and a 0.8% incidence of surgical procedures performed for relief of pain related to OA (all were total hip arthroplasties). In the 287 swimmers there was a 2.4% incidence of severe hip or knee pain, a 19.5% incidence of mild to moderate pain and a 2.1% incidence of surgical procedures performed. These differences were not significant, and, therefore, suggest that long-distance running does not increase the risk for development of OA when compared with generally low-impact sporting activities. Within the running group, runners reporting pain averaged a greater number of miles run per week than those who remained asymptomatic, but this difference was not statistically significant. There was no difference in number of years run. The average runner in this study ran 25.4 miles per week; therefore it is difficult to speculate whether heavy mileage has any effect on future risk of OA. It is also important to note that definition of OA in this study was not based on

radiologic findings, as in most studies.

In a 2010 study by A. Van Ginckel et al [22], nine females in a running program were compared to 10 sedentary controls with an average age of 20-40 years. These subjects were subjected to gadolinium enhanced magnetic resonance imaging of cartilage (dGEMRIC) in a 10 week program to estimate the change in glycosaminoglycan (GAG) content of knee cartilage. GAGs are key structural matrix compounds in regulating cartilage tissue compressive strength. Therefore, GAG content was used as a marker for cartilage quality. On examination, the novice runners showed a positive change in the dGEMRIC index when compared to the sedentary controls. The results suggest that a running routine may have a chondroprotective effect on the knee when compared to a sedentary lifestyle in asymptomatic subjects. Therefore, a moderate running routine may be valuable in OA prevention strategies.

In a 1986 study by Panush et. al. [23], 17 males who ran an average of 28 miles per week for an average of 12 years were compared with 18 sedentary males matched for age, height, and weight. Both groups had comparable medical histories and physical exam findings. Subjects underwent roentgenographic evaluation of the hips, knees and feet. There was found to be no significant difference between the groups with regard to osteophytes, cartilage thickness or grades of degenerative changes (by criteria derived by Ahlback in 1968). The study concluded that "reasonably long-duration, high-mileage running need not be associated with premature degenerative joint disease of the lower extremities."

In a similar cross-sectional study by Lane et. al. [24] forty-one long-distance runners from the 50-Plus Runners Association were compared with 41 community controls matched for age, sex, education, and occupation. Participants underwent extensive medical history questionnaires, rheumatologic examination and x-ray films of the hands, lateral lumbar spine, and knee joints. The films were then scored by two blinded readers for sclerosis, spur formation and joint space narrowing. Subjects were also evaluated for bone mineral density. Female runners showed more knee joint sclerosis and spur formation than the matched controls. This was not seen in males. Both male and female runners showed increased joint space width, but this difference was not statistically significant. In this study, it was felt that spur formation alone, without pain or joint space narrowing did not meet the definition of OA. It was, therefore, concluded that running did not increase risk for OA. Of note, female runners also had more sclerosis and spur formation in the spine, however,

bone mineral density was significantly higher. Male runners also had higher bone mineral density than male controls.

Lane et. al. continued to follow these participants and reported their data at 2 years [4], 5 years [25], and 9 years [26] of follow-up. At 2 years, 34 of the original 41 matched pair were available for assessment. Almost all subjects showed progression of roentgenographic scores of OA, which was statistically significant in the hand, and in knee spur progression in the running group. Females continued to have more spurs than matched controls. At 5 years, 73 of the original 98 subjects and 33 of the original 41 matched pairs remained. Overall, there was progression in all groups in terms of joint space narrowing, spur formation and sclerosis. The only statistically significant changes were in progression of osteophytes in controls and joint space narrowing in female runners. Overall, the progression was found to be comparable between the runners and non-runners. By 9 years, 28 runners and 27 non-runners remained. Of the 43 subjects who were not available for radiologic assessment 30% reported that they had moved out of state and 70% reported that they were not able to attend the scheduled appointments. Over the 9-year time period the running group decreased their overall running minutes and running miles per week by 43% and 30% respectively, but maintained their overall average weekly exercise minutes. Non-runners increased their total exercise minutes, mostly with brisk walking. Progression of osteophytes was 178% for runners and 142% for non-runners, progression of joint space narrowing was 22% for runners and 32% for non-runners and combined total knee score (joint space narrowing + osteophytes + subchondral sclerosis) was 64% for runners and 66% for non-runners. Again, no significant between-group differences were seen. Multivariate regression models were then performed to determine which risk factors were potentially associated with progression of radiographic knee OA. Independent variables tested included age, BMI, disability, sex, exercise minutes per week, running minutes per week, years run, pace per mile, and total knee radiographic score in 1984. In all subjects this was determined to be 1984 knee radiographic combined score, BMI and female sex. For runners, predictive factors also included faster pace per mile. Both groups exhibited similar loss of bone mineral density over the 9 years, however runners remained nearly 20% higher than non-runners. Hohmann et. al [27] studied six recreational and two semi-professional male runners who ran an average of 3000 km annually during the 5 years preceding the baseline MRI taken prior to the marathon. The

average age range of the subjects was 23-58 years. They underwent magnetic resonance imaging of the hip and knee before and after a marathon run. The MRI images were used to assess the pathological changes such as marrow edema, periosteal reaction, or joint effusions. MRI scans taken 24 to 48 hours after the marathon showed no definite difference compared directly to the pre-race scan. Marrow edema or periosteal stress reactions were not observed in any images, with the exception of a subject with the reconstructed anterior cruciate ligament. It was found that external impact loading does not create internal stresses on bone and cartilage that are comprehensible on MR images in long-distance running. This evidence indicates that the activity does not result in excessive joint loads. It was therefore concluded that long-distance running does not predispose participants to the development of premature osteoarthritis.

Discussion

Of the eleven articles outlined above, four articles showed an increased risk of OA of the knee in runners [14, 15, 17, 18]. However, in the second study, the authors stated that the number of both runners and controls with OA was too small to make accurate conclusions [15]. In the third study there was only a significant difference in men under age 50 [17]. Females and men over 50 years of age did not show an increased risk of developing OA. It was suggested that the increased risk in men under 50 was related to faster running pace. Luquesne hypothesized that "normal strength and pace of periarticular muscular contraction occurring in correct time for protecting the joint when impacts are transmitted to the lower limb might be impaired by... muscular fatigue [28]." Therefore, at faster paces, muscle may tire easily and be less capable of protecting the joint. In the fourth study, the running gait of mature females predisposes them to OA more so than the running gait of younger females [18].

Seven of the articles reviewed concluded that there is not an increased risk for OA of the knee in runners. One did not use radiological data to define OA, making it questionably useful for comparison with the other studies [21]. The study by Panush [23] had a small sample size of 17 runners and 18 nonrunners, but the authors felt "their considerations of power indicated that the conclusions were valid." Konradson [19] had larger sample sizes but such low rates of OA in both groups that the data may be misleading [28]. Chakravarty [20] had a large sample size that was

followed over 18 years in which he found that long distance runners did not have more severe OA or replaced knees than controls. Van Ginckel [22] found that a running routine may have a chondroprotective effect on the knee when compared to a sedentary lifestyle in asymptomatic subjects. Although Lane [26] reported no increase in risk of knee OA overall for runners, there was an increased risk of osteophyte formation in female runners. Faster pace per mile was also predictive of progression of knee OA.

Based on this review of the literature, there may be an increased risk for developing OA for those who run at faster paces or with the certain running gait of mature females. For those who run at moderate paces, the risk of OA does not appear to be increased. Female runners may have an increased risk of osteophyte development (though presence of osteophytes alone does not meet the criteria for diagnosis if OA). While one study did show that osteophytes are predictive of subsequent disability [29], further research should be done to determine how well radiographic abnormalities in runners predict future development of symptomatic OA. In a study comparing 498 long-distance runners with 365 matched controls, Lane, et. al. [30] found that runners had less physical disability in both lower and upper extremity functions and sought medical services less often. Other studies have shown similar results [31, 32]. From a clinical standpoint, disability is a much more important factor than radiographic findings. In addition to lower levels of disability, running has emotional effects (stress relief, runner's high), cardiovascular effects [3], increases bone density [26], and increases pain threshold [14]. In the absence of joint abnormalities or underlying injuries, at moderate paces, running appears to be safe and even highly beneficial.

Conclusion(s)

Those who run at faster paces or with the certain running gait of mature females may be at an increased risk for developing osteoarthritis. Those who run at moderate paces do not appear to be at increased risk. Runners have less physical disability in both lower and upper extremity functions, according to published studies. Also, running provides emotional benefits (stress relief, runner's high), cardiovascular benefits, increases bone density, and it increases pain threshold. In the absence of joint abnormalities or underlying injuries running, at moderate paces, appears to be safe and even highly beneficial.

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