Incidence of Major Tendon Ruptures and Anterior Cruciate Ligament Tears in US Army Soldiers

LTC Daniel W. White,*† MD, Joseph C. Wenke,‡ PhD, MAJ Dan S. Mosely,§ MD, Sally B. Mountcastle,‖ PhD, and Carl J. Basamania,¶ MD
From the †Tripler Army Medical Center, Honolulu, Hawaii, ‡US Army Institute of Surgical Research, Fort Sam Houston, Texas, §DeWitt Army Hospital, Fort Belvoir, Virginia, ‖Keller Army Hospital, West Point, New York, and ¶Duke University Medical Center, Durham, North Carolina

Background: Although a rare event, the prevalence of major tendon rupture has increased in recent decades. Identification of risk factors is important for prevention purposes.

Hypothesis: Race is a risk factor for major tendon ruptures.

Study Design: Cohort study (prevalence); Level of evidence, 2.

Methods: All patients admitted for surgical management of a rupture of a major tendon at Womack Army Medical Center, Fort Bragg, North Carolina, in 1995 and 1996 were identified and evaluated for risk factors.

Results: The authors identified 52 major tendon ruptures: 29 Achilles, 12 patellar, 7 pectoralis major, and 4 quadriceps tendon ruptures. All patients were active-duty soldiers, and 1 was a female soldier. Forty-one tendon ruptures occurred among black soldiers, 8 occurred among white soldiers, and 3 occurred among Latino soldiers. The population at risk included 93 224 exposures during the 2-year period, of which 67.1% were white, 24.5% were black, and 8.4% were self-classified as other race. The rate ratio for tendon rupture, adjusted for gender and age, was 13.3 (95% confidence interval, 6.2-28.5) between blacks and whites and 2.9 (95% confidence interval, 0.8-10.9) between Latinos and whites.

Conclusion: The rate of major tendon rupture was 13 times greater for black men in this study population when compared with whites. Interventions among those at a higher risk for injury should be considered.

Keywords: pectoralis major tendon rupture; quadriceps tendon rupture; patellar tendon rupture; Achilles tendon rupture; race; mechanism of injury

Spontaneous major tendon ruptures (MTRs) are rare events. However, the prevalence of MTRs (pectoralis major tendon [PMT], quadriceps tendon [QT], patellar tendon [PT], and Achilles tendon [AT]) has increased in recent decades presumably because of increased recreational sports activity in our society.[15] Pectoralis MTRs are most frequently associated with weight training, specifically bench press, and strenuous athletic activities, most notably football, wrestling, and rugby.[4,23] Ruptures of the QT and PT are rare events. These injuries are commonly seen in elder patients and are frequently associated with chronic medical illness, use of glucocorticoid medications, or the use of fluoroquinolones. In younger patients, QT and PT ruptures are associated with participation in repetitive jumping and sprinting exercises. Quadriceps ruptures have specifically been reported to occur, often with simultaneous bilateral ruptures, with anabolic steroid use.[7,9,18,27] Achilles tendon ruptures have also been well described in the literature. Risk factors include an increase in physical activity, participation in repetitive jumping and sprinting sports, preceding histologic degeneration of the AT, chronic diseases treated with corticosteroids, use of fluoroquinolone antibiotics, male gender, and possibly blood group O.[12,13,15,16]

Despite the knowledge of these tendon injuries, there has not been an inclusive demographic study performed on ruptures of the major tendons to determine the effect of activity, race, age, or gender. The majority of the reports have been case studies or focused on one particular tendon and do not have the scope to determine if race is associated with the risk of rupture. It has been shown recently that

*Address correspondence to LTC Daniel W. White, MD, 1 Jarrett White Road, Tripler AMC, HI, 96859 (e-mail: daniel.w.white@us.army.mil).

The opinions or views expressed herein are those of the authors and should not be construed as official policy of the Department of the Army or the Department of Defense.

No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. 35, No. 8
DOI: 10.1177/0363546507301256

TABLE 1
Age and Race Distribution of the Population at Risk at Ft Bragg and Major Tendon Ruptures and ACL Tears at Womack Army Medical Center, January 1995 to December 1996

	White		Black[a]		Other		Total	
	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
Number of exposures[b] among population at risk at Ft Bragg over 2 years	62 559	67.1	22 856	24.5	7809	8.4	93 224	
ACL tears	246	75.7	58	17.8	20	6.5	325	
Major tendon rupture	8	15.4	41	78.8	3	5.8	52	
Population at risk age distribution, y								
24 and younger	26 674	28.7	6959	7.5	3015	3.2	36 648	39.4
25-34	25 646	27.5	10 644	11.4	3141	3.4	39 431	42.3
35 and older	10 239	10.9	5253	5.6	1653	1.8	17 145	18.3
Total	62 559	67.1	22 856	24.5	7809	8.4	93 224	
Major tendon rupture age distribution, y								
24 and younger	1	1.9	3	5.8	0	0	4	7.7
25-34	4	7.7	24	46.1	1	1.9	29	55.7
35 and older	3	5.8	14	26.9	2	3.9	19	36.6
Total	8	15.4	41	78.8	3	5.8	52	
ACL tear age distribution, y								
24 and younger	95	29.2	35	10.8	10	3.1	140	43.1
25-34	118	36.3	20	6.1	11	3.4	149	45.8
35 and older	33	10.2	3	0.9	0	0	36	11.1
Total	246	75.7	58	17.8	21	6.5	325	

[a]One black male sustained bilateral patellar tendon ruptures. There were 51 total injured people and 52 total injuries.
[b]One exposure was defined as 1 year that the service member was in the armed forces. Therefore, for example, a person who was at Ft Bragg during the entire study period contributed 2 exposure years.

black race and participation in basketball increase the risk of AT ruptures.[8] Male gender predominance in tendon ruptures has been shown to be between 4 and 7 times greater than for women in different studies.[14] However, these studies are limited only to AT injuries and do not include the other major tendons. The purpose of the present study is to review the prevalence of MTRs during a 2-year period in a military population to determine if race increases risk for sustaining an MTR and to determine which activity predominates during these injuries. Because it is not possible to quantify the population's exposure to high-risk behaviors, we have also reviewed the ACL reconstructions during the same period. Anterior cruciate ligament tears occur during participation in similar high-risk activities, and any difference identified between the populations might reveal risk factors for ACL tears or MTRs.

MATERIALS AND METHODS

We conducted a retrospective review of all orthopaedic records at Womack Army Medical Center, Fort Bragg, North Carolina (WAMC), between January 1995 and December 1996. The study population included all eligible active-duty military health care beneficiaries eligible for care at WAMC during this 2-year period. We identified all patients admitted for surgical management of a rupture of the PMT, QT, PT, or AT during this 2-year period. These records were abstracted, and the following covariates were identified: age, race, gender, activity at time of injury, mechanism of injury, history of smoking, steroid use, fluoroquinolone antibiotic use, preceding pain at the injury site, and prior MTR. Race was self-categorized as black, white, and other; age was categorized as 24 years and younger, 25 to 34 years, and 35 years and older.

To assess person time at risk, we queried the Defense Medical Epidemiology Database, which compiles International Classification of Diseases–9 Clinical Modification coding information for every patient encounter occurring in a military treatment facility, in addition to maintaining the total number of soldiers on active duty each year. Using the database, we determined the number of service members on active duty at Ft Bragg and at Pope Air Base during the study time period by race, gender, and age. Race was categorized as black, white, or other. Race was self-reported in the database. One exposure year was defined as 1 year that the service member was in the armed forces.

Because we had only service member years at risk and did not have the actual amount of hours spent in activity at risk by gender, race, and age within the study population, we decided to investigate the rate of ACL injury, which is a similarly devastating injury, to determine if there was a difference between ACL injury and race. This provides a comparison of injuries between injury types among active persons, as most ACL injuries occur during sports activities. We therefore identified all ACL injuries in the study population during the study period and abstracted the aforementioned covariates from medical

TABLE 2
Number of Injuries by Activity Type and Race Among All Muscle Tendon Ruptures (N = 52) at Womack Army Medical Center, January 1995 to December 1996

	White		Black		Other[a]		Total	
	No. of Injuries	% of Total	No. of Injuries	% of Total	No. of Injuries	% of Total	No. of Injuries	% of Total
Achilles tendon								
Basketball	5	71.4	16	76.2	1	50.0	22	75.9
Bench press	0		0		0		0	
Direct blow	0		0		0		0	
Fall	0		0		0		0	
Football	0		1	4.8	0		1	3.4
Other[b]	2	28.6	4	19	1	50.0	6	20.7
Total	7		21		2		29	
Patellar tendon								
Basketball	0		9	75.0	0		9	75.0
Bench press	0		0		0		0	
Direct blow	0		1	8.3	0		1	8.3
Fall	0		2	16.7	0		2	16.7
Football	0		0		0		0	
Other[b]	0		0		0		0	
Total	0		12		0		12	
Pectoralis major tendon								
Basketball	0		0		0		0	
Bench press	1	100.0	3	60.0	1	100.0	5	71.4
Direct blow	0		0		0		0	
Fall	0		0		0		0	
Football	0		0		0		0	
Other[b]	0		2	30.0	0		2	28.6
Total	1		5		1		7	
Quadriceps tendon								
Basketball	0		1	25.0	0		1	25.0
Bench press	0		0		0		0	
Direct blow	0		0		0		0	
Fall	0		0		0		0	
Football	0		1	25.0	0		1	25.0
Other[b]	0		2	50.0	0		2	50.0
Total	0		4		0		4	

[a]All injuries among "other" race occurred in Latino soldiers.
[b]"Other" includes hand-to-hand combat, push-ups, racquetball, running, softball, and being struck from behind.

records; however, the data available for ACL patients did not include smoking, medication, or steroid use history.

We conducted overall summary statistics for each injury type to determine the proportion of injuries by gender, activity at time of injury, age, and race. We used multivariate Poisson regression to estimate the rate of each type of MTR per 1000 person-years, controlling for gender and age, and for ligament injury, controlling for gender. We computed rate ratios and 95% confidence intervals (CIs) using whites as the referent category. Data were analyzed using SAS, version 8.1 (SAS Institute, Cary, NC, 1999).

RESULTS

Tendon Ruptures

We identified 52 MTRs and 325 ACL tears among 93 224 service member exposures during the study period (Table 1). All tendon ruptures and ACL tears at WAMC occurred among active-duty patients during this time period. Among the 52 injuries, there were 29 AT ruptures (56%), 12 PT ruptures (23%), 7 PMT ruptures (14%), and 4 QT ruptures (8%) (Table 2). One patient, a black male, sustained a bilateral PT rupture playing basketball.

Among the 51 patients, only 1 (2%) of the injuries occurred in a female patient. Forty-one of the injuries (79%) occurred among black soldiers, 8 (15%) occurred among white soldiers, and 3 (6%) occurred among Latino soldiers. Approximately 8% of the injuries occurred in subjects 24 years and younger, whereas 55% occurred in those 25 to 34 years, and 37% occurred in those 35 years and older. Among the 51 patients, 20% reported smoking, 100% denied the use of anabolic steroids or fluoroquinolone antibiotics, and 100% reported no prior pain at the site of injury. Eleven patients experienced prior tendon ruptures, and all of these patients were black; 9 sustained AT ruptures, 1 sustained a PT rupture, and 1 sustained a PMT rupture.

The majority (92%) of tendon ruptures occurred during participation in a sport or physical activity that involves plyometric movements (Table 2). The most common activity causing

muscle tendon rupture was basketball (62%) followed by bench pressing (10%) and running (6%). Thirty-two of the 47 lower extremity tendon ruptures occurred playing basketball, and only 4 were not sports related (fall or direct trauma). Bench press was responsible for 5 of the 7 PMT ruptures.

There were a total of 93 224 active-duty person-years of exposure during the study period: 24.5% among blacks, 67.1% among whites, and 8.4% among those with race classified as other. All of the injuries that occurred in the race classified as other occurred in Latino soldiers. The rate ratio for tendon rupture, adjusted for gender and age, was 13.3 (95% CI, 6.2-28.5) between blacks and whites and 2.9 (95% CI, 0.8-10.9) between Latinos and whites. When considering only those injuries that occurred during an activity other than playing basketball, the rate ratio, adjusted for gender and age, was 13.7 (95% CI, 3.8-45.4) between blacks and whites and 5.2 (95% CI, 0.9-31.2) between Latinos and whites.

Anterior Cruciate Ligament Injury

During this same period, 325 patients underwent ACL reconstruction at WAMC, of whom 289 (89%) were male and 246 (76%) were white. All ACL tears occurred while participating in a sports activity, and no patient had a history of MTR. A similar proportion of black men (88%) and black women (12%) injured their ACLs when compared with white men (89%) and white women (10%) or to Latino men (90%) and Latino women (10%). The percentage of all female soldiers who required ACL reconstruction (11%) was similar to the percentage of person-time at risk in the active-duty population during the time period (11%), although the percentage of white soldiers who required ACL reconstruction (89%) was higher than the percentage of person-time at risk among whites (64%) in the active-duty population during the time period. We found that 43.1% of the ACL injuries occurred in soldiers 24 years and younger, 45.9% occurred in soldiers 25 to 34 years of age, and 11.1% occurred in soldiers 35 years and older. The rate ratio, adjusted for gender, was 0.64 (95% CI, 0.48-0.85) between blacks and whites and 0.68 (95% CI, 0.44-1.1) between Latinos and whites.

DISCUSSION

Race is often a risk factor for disease in many areas of medicine. Particularly, there are race differences in kidney disease, hypertension, diabetes, breast cancer, and osteoporosis.[24] The notion of race as a risk factor in tendon ruptures is not novel, as Davis et al[8] reported that black race and participation in basketball were predominant risk factors for AT ruptures. In addition, white European American female basketball players in the Women's National Basketball Association (WNBA) were recently found to have an 11 times greater rate of ACL tears than did African American players.[30] In our select population, white race predominated among patients requiring ACL reconstruction. However, a greater number of black soldiers sustained MTRs (78.8%). In addition, blacks were at increased risk for MTRs (rate ratio, 13.7; 95% CI, 3.8-45.4) but at decreased risk for ACL rupture (rate ratio, 0.64; 95% CI, 0.48-0.85).

Tendons are relatively avascular dense connective tissue that consists of closely packed collagen fibers that form 70% of the dry weight of tendons. Tendons are generally able to withstand greater forces and are stronger than the muscles. Collagen is responsible for resisting the tensile forces applied to the tendon. With aging, collagen becomes stiffer, has reduced tensile strength, and develops an increase in the cross-linking of the tropocollagen molecules. These factors make aged tendons more likely to tear.[21] Jozsa et al[15] reported that the mean age of patients who rupture their AT and patients who rupture other tendons (proximal biceps, extensor pollicis longus, quadriceps, and others) was 35.2 and 50.7 years old, respectively. Comparison of the data in this study reveals similar findings. In this study, 92% of MTRs occurred in patients older than 25 years, whereas ACL reconstructions tended to be in younger patients (43%, <25 years old), a finding supported by Jozsa et al.[15]

Fort Bragg, North Carolina, is a major US Army installation with predominance of combat arms soldiers. Because female soldiers are excluded from combat arms occupations, the percentage of female soldiers in the overall population was only 11%. Many of these female soldiers are in airborne support units, which are physically demanding occupations. Despite the high physical demands, the percentage of female soldiers who required ACL reconstruction (11%) was similar to the percentage of female soldiers in the overall population. In high school and college sports, female athletes have experienced increased ACL injuries compared with their male counterparts (4 times and twice as many ACL injuries in basketball and soccer, respectively).[3,29] In the WNBA, white athletes were noted to have an 11 times greater rate of ACL tears than did black athletes.[30] In our population, 7 black female soldiers sustained ACL tears, whereas 26 white female soldiers experienced ACL tears. The race incidence (2.2% injury in 5.1% of the population) in black women was less than the white women (8% injury in 5.9% of the population), but this does not approach the 11 times greater risk experienced in the WNBA. It has previously been reported that tendon ruptures predominate in men.[14,22,25] The prevalence of female gender in the tendon rupture population was strikingly different, with only 1 female soldier experiencing an MTR. This woman was a 42-year-old smoker who sustained a PT rupture as a result of a fall. Despite the rigorous physical standards and daily physical activity of this US military population, the prevalence of female soldiers with ACL tears was not higher, and the prevalence of MTRs was significantly lower. Currently, there is much interest in determining why the female ACL tear rate is increased. Information from ongoing studies may reveal insight into why there is a distinct difference in MTR prevalence as well. Currently, the cause of this difference is not known.

Tendons actively participate in the transmission of force generated by muscles to achieve motion. Specifically, the tendons of locomotion (quadriceps, patellar, and Achilles) are elastic; the stored energy in the tendon is used to facilitate movement.[28] High forces created by eccentric muscle activation are usually responsible for tendon failure.

Activities that maximize eccentric loading, such as repetitive jumping and sprinting exercises for the lower extremities (bench press for the pectoralis), potentiate the risk for tendon rupture.[21] Specifically, those activities in which the eccentric load is maximized and then followed by a forceful concentric contraction (plyometric activities) place the highest tensile forces across the tendon. Participation in sports activity accounted for the majority of the ruptures in our study, with basketball participation accounting for most of the lower extremity injuries. In this study, all ACL tears occurred as a result of sports participation, with race incidence proportion ratios that were similar to the overall population (rate ratio was 0.64 [95% CI, 0.48-0.85] between blacks and whites) yet significantly different than the race incidence ratio of the MTR population (rate ratio was 13.7 [95% CI, 3.8-45.4] between blacks and whites). Furthermore, although basketball accounted for 62% of the tendon ruptures, of the patients who sustained a tendon rupture as a result of an activity other than basketball, 75% (15/20) were black soldiers despite only composing 24% of the entire population. These findings suggest that risk factors for tendon ruptures include black race and potentially plyometric activities. It is not possible to quantify the race ratio of exposure to high-risk activities, but because all ACL tears occurred during sports participation, this may serve as a proxy for activity. Because ACL tears did not predominate in black soldiers, we assume that black soldiers are not the only soldiers exposed to high-risk activities.

There is another unique military feature of this population that warrants discussion. Many of these soldiers are on airborne status and regularly participate in parachute exercises. The parachute landing fall is a dynamic fall involving eccentric muscle contraction of the lower extremity locomotion muscle groups designed to minimize injury during the landing. None of the tendon ruptures in this population occurred as a result of this activity. The theory is that the eccentric contraction without maximal contractile force applied, as is seen in repetitive jumping or sprinting with plyometric activity, is not a significant enough load to result in tendon ruptures. Similarly, none of the ACL tears in this population occurred as a result of parachuting. Anterior cruciate ligament tears have occurred as a result of military parachute exercises, but these injuries typically occur as a result of getting the leg tangled in the static line that is attached to the aircraft. This frequently results in knee dislocations, is the predominant mechanism of knee ligament injuries in parachuting, and is distinctly different from the eccentric muscle contraction of the dynamic parachute landing fall.

There are many potential causes for the observations in this tendon rupture population. These can be separated into intrinsic and extrinsic factors. Intrinsic factors include the rate and magnitude of force applied across the tendon and the health of the tendon. The extrinsic factors include high-risk activity exposure, training errors, and environmental factors.

The rate and magnitude of force applied across the tendon depend on the forces generated by the adjoining muscle. There are 2 types of muscle fibers, type I (slow twitch) and type II (fast twitch). Many studies have evaluated the potential of a genetic-related difference in the predominant muscle fiber type. Type II (fast-twitch) muscle fibers, specifically Type IIb (fast-twitch glycolytic) fibers, have a larger diameter and generate a more rapid contractile force. A larger muscle fiber that generates higher rates of force across the tendon to the insertion would potentially put the tendon at higher risk for rupture.

There is no clear consensus on whether a racial difference in skeletal muscle fiber type exists. Ama et al[2] evaluated 23 sedentary black Africans and 23 sedentary white Canadians. The whites had a significantly higher percentage of type I fibers and a lower percentage of type II fibers, but the differences were only slightly greater than the sampling error, and the authors acknowledged that the results should be viewed with caution. Coetzer et al[5] studied 5 white and 6 black South African distance runners, finding a trend toward a higher percentage of type II fibers in black runners but did not achieve statistical significance. Duey et al[10] studied 14 US black and 14 US white sedentary college students and found no significant differences between the 2 racial groups for type I, IIa, or IIb fibers. Malina[19] reviewed 8 studies from 1938 to 1976, evaluating the vertical jump and sprint performance of American black and white children. Seven of the 8 studies revealed better performances in the black children, suggesting a higher percentage of type II fibers. Finally, Ama et al[1] studied maximal knee extension in black and white Americans. They noted that the black subjects demonstrated greater fatigue at 90 seconds, lending support for a higher percentage of type II fibers. In conclusion, current knowledge does not support the theory that a racially-based difference in fiber type exists and cannot explain the racial incidence ratio of MTRs in our population.

Another intrinsic difference could be anthropometric variation. Longer lever arms could result in increased forces across the tendon. It has been suggested[20] that blacks have longer upper and lower extremities relative to height. These morphologic differences could result in higher tensile loads across the tendon, but this was not investigated in this study.

It has previously been shown that blood type O may be associated with tendon ruptures. Unfortunately, in our population, we were unable to determine the blood type of the overall population, the ACL tear population, or the MTR population. Without these data, we cannot comment on the relationship between blood type and MTRs. In a report on a 10-year demographic database with 3.1 million blood donors, Garratty et al[11] reported that the highest percentage of blood type O was found in Latino (56.5%), North American Indian (54.6%), and black (50.2%) donors. Our data reveal an increased racial incidence ratio of MTRs in black soldiers. The increased prevalence of blood type O among blacks may be an explanation for the predominance of blacks experiencing MTRs. However, the study also reveals that a high percentage of blood type O is found in Latinos, and this population did not experience an increased incidence of tendon ruptures. Future prospective

studies of tendon ruptures should consider including analysis of blood type to determine if this is an associated risk factor.

The use of fluoroquinolone antibiotics has been previously reported as a risk factor for MTRs.[17,31] Basic science research suggests that the fluorinated quinolone compounds alter the expression of collagenases and matrix metalloproteinases theorized to cause the tendinopathy and ruptures previously cited.[6] In our population, the use of fluoroquinolone antibiotics was not found in any of our 51 tendon rupture patients. Therefore, no conclusion regarding this risk factor can be made in this study.

The status of tendon health is the final intrinsic factor. It is well accepted that AT ruptures occur at the watershed area, where there is decreased vascularity.[16] It is also well established that decreased activity and age are responsible for collagen degradation, decreased tensile strength, and decreased concentration of metabolic enzymes in the fibroblasts.[21] There is a well-established race-related incidence of hypertension, cardiovascular disease, and peripheral vascular disease with an increased risk in black males.[26] Potentially, this vascular phenomenon, which worsens with age, may be present in other soft tissues, including the major tendons in blacks. If a race-related vascular phenomenon were present in tendons, and compounded the known aging effects in tendons, this could help explain the increased racial incidence ratio of MTRs in this population. Unfortunately, blood pressure data were not available for the overall population, ACL tear population, or the MTR population; therefore, no conclusions regarding this theory could be made from these data. There is a paucity of literature on this topic, so at this time no conclusions can be reasonably made regarding this theory.

The predominant extrinsic factor is the exposure to high-risk activities. It has been well described that an eccentric load placed on a maximally stressed pectoralis muscle causes rupture of the inferior fibers.[32] This same mechanism has also been described in AT ruptures.[15] In our study population, we found this to be true with most of our MTRs. In our study, 93% of the patients experiencing a MTR described sports participation that involved an eccentric load on the affected muscle group at the time of injury. However, there is a paucity of studies that quantify the exposure to high-risk activities. Davis et al[8] noted that basketball was a risk factor for AT ruptures, but they could not quantify the exposure. Similarly, we note that sports participation, especially basketball, was associated with MTRs, but we lack exposure time for these activities. Therefore, we cannot stratify the risk in relation to the activity. One might surmise that race is a proxy for activity in this MTR population. However, the disparity in the race-related incidence rate of MTRs and ACL tears in this study is strikingly different. In addition, Trojian and Colins[30] showed that when they controlled for activity exposure in the WNBA, there was a difference in ACL tear risk in different races, with the white European American players having more than 6 times greater tear rate than did the other ethnic groups combined and 11 times greater than did African American players.

There is a host of other information that relates to the extrinsic factors that we do not have. Generally speaking, older individuals tend to sustain more chronic overuse injuries. In addition, the status of the sporting venue is another variable. Fields or playing courts that have poor ergonomic design with little shock absorption increase the risk of injury. Finally, the quality of the equipment worn (shoes and protective equipment) may alter the injury rate. If there is a race difference in the prevalence of participation in the sporting events, this might be compounded by the environmental and equipment features that increase the risk of injury.

In conclusion, in our population, black race, age, male gender, and sports participation were all significant risk factors for tendon rupture. Although there are many theories as to the cause of the race predominance of tendon ruptures in this population, there are insufficient data to come to sound conclusions. Furthermore, it is unclear why the stated theories for the findings result in an increased incidence of MTRs but not ACL tears. The distinction between the age, sex, and race differences between ACL tears and MTRs in this population is poorly understood.

Future studies are surely warranted. Potential studies include quantifying the activity exposure and obtaining biopsies in the affected tendon and adjoining muscles. The goal would be to identify any modifiable risk factors that could be used to reduce the incidence of tendon ruptures and possibly improve treatment.

REFERENCES

1. Ama PF, Lagasse P, Bouchard C, Simoneau JA. Anaerobic performances in black and white subjects. *Med Sci Sports Exerc*. 1990;22:508-511.
2. Ama PF, Simoneau JA, Boulay MR, Serresse O, Theriault G, Bouchard C. Skeletal muscle characteristics in sedentary black and Caucasian males. *J Appl Physiol*. 1986;61:1758-1761.
3. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer: NCAA data and review of literature. *Am J Sports Med*. 1995;23:694-701.
4. Bak K, Cameron EA, Henderson IJ. Rupture of the pectoralis major: a meta-analysis of 112 cases. *Knee Surg Sports Traumatol Arthrosc*. 2000;8:113-119.
5. Coetzer P, Noakes TD, Sanders B, et al. Superior fatigue resistance of elite black South African distance runners. *J Appl Physiol*. 1993;75:1822-1827.
6. Corps AN, Harrall RL, Curry VA, Hazleman BL, Riley GP. Contrasting effects of fluoroquinolone antibiotics on the expression of the collagenases, matrix metalloproteinases (MMP)-1 and -13, in human tendon-derived cells. *Rheumatology.* 2005;44:1514-1517.
7. David HG, Green JT, Grant AJ, Wilson CA. Simultaneous bilateral quadriceps rupture: a complication of anabolic steroid abuse. *J Bone Joint Surg Br*. 1995;77:159-160.
8. Davis JJ, Mason KT, Clark DA. Achilles tendon ruptures stratified by age, race and cause of injury among active duty U.S. military members. *Mil Med*. 1999;164:872-873.
9. De Franco P, Varghese J, Brown WW, Bastani B. Secondary hyperparathyroidism, and not beta 2-microglobulin amyloid, as a cause of spontaneous tendon rupture in patients on chronic hemodialysis. *Am J Kidney Dis*. 1994;24:951-955.
10. Duey WJ, Bassett DR, Torok DJ, et al. Skeletal muscle fibre type and capillary density in college-aged blacks and whites. *Ann Hum Biol*. 1997;24:323-331.

11. Garratty G, Glynn SA, McEntire R. ABO and Rh(D) phenotype frequencies of different racial/ethnic groups in the United States. *Transfusion.* 2004;44:703-706.
12. Habusta SF. Bilateral simultaneous rupture of the Achilles tendon: a rare traumatic injury. *Clin Orthop Relat Res*. 1995;320:231-234.
13. Haines JF. Bilateral rupture of the Achilles tendon in patients on steroid therapy. *Ann Rheum Dis*. 1983;42:652-654.
14. Jarvinen M. Epidemiology of tendon injuries in sports. *Clin Sports Med.* 1992;11:493-504.
15. Jozsa L, Kvist M, Balint BJ, et al. The role of recreational sport activity in Achilles tendon rupture: a clinical, pathoanatomical, and sociological study of 292 cases. *Am J Sports Med*. 1989;17:338-343.
16. Kannus P, Jozsa L. Histopathological changes preceding spontaneous rupture of a tendon controlled study of 891 patients. *J Bone Joint Surg Am*. 1991;73:1507-1525.
17. Kowatari K, Nakashima K, Ono A, Yoshihara M, Amano M, Toh S. Levofloxacin-induced bilateral Achilles tendon rupture: a case report and review of the literature. *J Orthop Sci.* 2004;9:186-190.
18. Liow RY, Tavares S. Bilateral rupture of the quadriceps tendon associated with anabolic steroids. *Br J Sports Med*. 1995;29:77-79.
19. Malina RM. Racial/ethnic variation in the motor development and performance of American children. *Can J Sport Sci*. 1988;13:136-143.
20. Malina RM, Hamill PVV, Lemeshow S. Body dimensions and proportions, white and Negro children 6-11 years: United States. *Vital Health Stat 11*. 1974;143:1-66.
21. O'Brien M. Functional anatomy and physiology of tendons. *Clin Sports Med*. 1992;11:505-520.
22. O'Shea K, Kenny P, Donovan J, Condon F, McElwain JP. Outcomes following quadriceps tendon ruptures. *Injury.* 2002;33:257-260.
23. Peliton J, Carr DR, Sekiya JK, Unger D. Pectoralis major muscle injuries: evaluation and management. *J Am Acad Orthop Surg*. 2005; 13:59-68.
24. Pleis JR, Coles R. Summary health statistics for U.S. adults: National Health Interview Survey, 1999. *Vital Health Stat 10*. 2003;212:1-137.
25. Puranik GS, Faraj A. Outcome of quadriceps tendon repair. *Acta Orthop Belg.* 2006;72:176-178.
26. Rao S, Austin H, Davidoff MN, Zafari AM. Endothelial nitric oxide synthase intron 4 polymorphism is a marker for coronary artery disease in African-American and Caucasian men. *Ethn Dis*. 2005;15:191-197.
27. Siwek CW, Rao JP. Ruptures of the extensor mechanism of the knee joint. *J Bone Joint Surg Am*. 1981;63:932-937.
28. Teitz CC, Garrett WE Jr, Miniaci A, Lee MH, Mann RA. Tendon problems in athletic individuals. *Instr Course Lect*. 1997;46:569-582.
29. Teitz CC, Hu SS, Arendt EA. The female athlete: evaluation and treatment of sports-related problems. *J Am Acad Orthop Surg*. 1997;5:87-96.
30. Trojian TH, Colins S. The anterior cruciate ligament tear rate varies by race in professional women's basketball. *Am J Sports Med*. 2006;34:895-898.
31. van der Linden PD, van Puijenbroek EP, Feenstra J, et al. Tendon disorders attributed to fluoroquinolones: a study on 42 spontaneous reports in the period 1988 to 1998. *Arthritis Rheum.* 2001;45:235-239.
32. Wolf SW, Wickiewicz TL, Cavanaugh JT. Ruptures of the pectoralis major muscle: an anatomic and clinical analysis. *Am J Sports Med*. 1992;20:694-701.