

Which risk factors are involved in a distal biceps tendon injury? A systematic review

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Abstract

Distal biceps tendon rupture is a rare injury predominately occurring in middle-aged men. This study aimed to collect relevant risk factors associated with distal biceps tendon rupture from the published literature. This systematic review aimed to collect and tabulate the risk factors for distal biceps tendon rupture. Studies published in English were searched concerning risk factors for distal biceps tendon ruptures until July 2022; cohort studies, case series and randomized controlled trials were subjected to analysis. Case studies, cadaveric studies and reviews in any form were excluded. The studies were quantitatively and qualitatively reviewed. One hundred twenty-one articles presenting risk factors for distal biceps tendon ruptures were identified, recruiting a total of 7,484–7,576 patients. The average age of the individuals was 46.8 years, with 96.7% being males and 94.7% having affinity for sports activities. In 56.7% of the cases, the dominant arm was involved, and in 54.6%, the right arm was affected. The use of tobacco was found in 20.8% of cases and of anabolic steroids in 2.5% of cases. On average, 55.8% of distal biceps tendon rupture patients had a physical occupation and the most common mechanism of the injury was related to heavy weight lifting observed in 53.2% of subjects. The most common and outstanding reported risk factors for distal biceps tendon ruptures were age, sex and sports activity, i.e., middle-aged males being still physically active and practicing sports. Steroid usage does not seem to increase significantly the risk of the distal biceps tendon rupture.

Key words: risk factor, tendon, rupture, distal biceps

Cite as

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Introduction

The biceps brachii muscle originates as a 2-headed muscle, with the long head originating from the supraglenoid tubercle and the short head from the coracoid process. The muscle inserts on the radial tuberosity as 1 tendon. The fibers of the long head insert more proximally than the fibers of the short head, leading to greater function in supination of the long head and greater function in flexion of the short head.¹ A rupture of the distal biceps tendon usually leads to immediate weakness in supination and flexion. Additionally, a popping sound can be heard, followed by ecchymosis and edema. In most cases, retraction of the muscle is visible as a reverse Popeye sign.

Distal biceps tendon ruptures are uncommon injuries, with an incidence of 1.2 in the past and up to 6 per 100,000 nowadays.^{2,3} This is likely explained by improved diagnostic procedures and consistent documentation of records nationwide.

Different methods have been implemented to diagnose and treat distal biceps tendon ruptures. Usually, clinical evaluation is sufficient, such as the hook test or the biceps squeeze test, yet in cases of doubt, ultrasonography (USG) or magnetic resonance imaging (MRI) can support the diagnosis.^{4,5} Acute ruptures are characterized by a better prognosis, as chronic cases tend to have increased complication rates. The anatomical reinsertion should be targeted to recover most of the strength in flexion and supination. In older patients, conservative treatment is a viable alternative. The single- and the double-incision approaches have been described in the literature as equally viable methods with slight differences in complication rates.^{6–9} The most common and major complications are lateral antebrachial cutaneous nerve (LABCN) injury, posterior interosseous nerve (PIN) injury, pain, and heterotrophic ossification.¹⁰ A graft can be used for tendon reconstruction in cases of chronic rupture or insufficient tendon quality.^{6,9} Overall, literature has shown that surgery on the ruptured distal biceps tendon can lead to a very satisfactory outcome with a slight loss in supination and flexion strength.^{11–13}

Yet, data collection about risk factors for distal biceps tendon injuries in the current literature is limited to a few reviews without quantification of the cases.

Objectives

In the published literature, risk factors for distal biceps tendon injuries have been presented, but not quantified as a systematic review. This systematic review aimed to determine the risk factors associated with distal biceps tendon ruptures, as well as to collect the data and articles currently available in the literature.

Material and methods

This systematic review was designed according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement from 2020. A registration and review protocol was not prepared.

Literature search

The databases of Scopus, Embase and MEDLINE were searched on July 15, 2022, for risk factors associated with distal biceps tendon ruptures. A starting date for the search was not defined. The terms applied for bibliographic search in these databases were “distal”, “biceps”, “rupture”, and “tear”, with the following Boolean line: (distal) AND (biceps) AND ((rupture) OR (tear)). Filters were set according to the inclusion and exclusion criteria mentioned below. The search was performed by the principal investigator and reviewed by 2 co-investigators independently. The abstracts were then screened to identify articles involving the distal biceps tendon. The full-text articles were then reviewed by the authors independently. The data was collected independently and then compared between the investigators. Differences in data collection were discussed, and the articles were rescreened. Inclusion and exclusion criteria were set before data collection. The inclusion criteria included articles published in English, retrospective/prospective cohort studies, case series, and randomized controlled trials. Exclusion criteria included reviews in any form, cadaveric studies, case reports, and patients with tendinopathy or tendinitis without rupture.

The data were extracted and tabulated into age, sex, dominant arm, lateralization of injury, tobacco smoking, alcohol consumption, steroid usage, occupation, body mass index (BMI), drug usage (fluoroquinolones and statins), radial tuberosity, sports, comorbidities, and mechanism of injury.

Search results

The initial search of all before mentioned databases combined yielded 1,237 results, of which 596 were from Scopus, 132 from MEDLINE and 509 from Embase. After screening for duplicates, 649 articles were excluded. After screening the abstracts according to the exclusion criteria, 114 additional articles were excluded. Four hundred seventy-four articles were left for full-text article review, and of these, 119 articles met the inclusion standards, and 2 additional articles were identified by reviewing the references of these articles, resulting in a total of 121 for the systematic review (Fig. 1,2).

Analysis of articles

The articles that did not report an absolute number of participants in the subgroups but instead reported a percentage of participants were calculated to the absolute number by rounding the number to the next full digit.

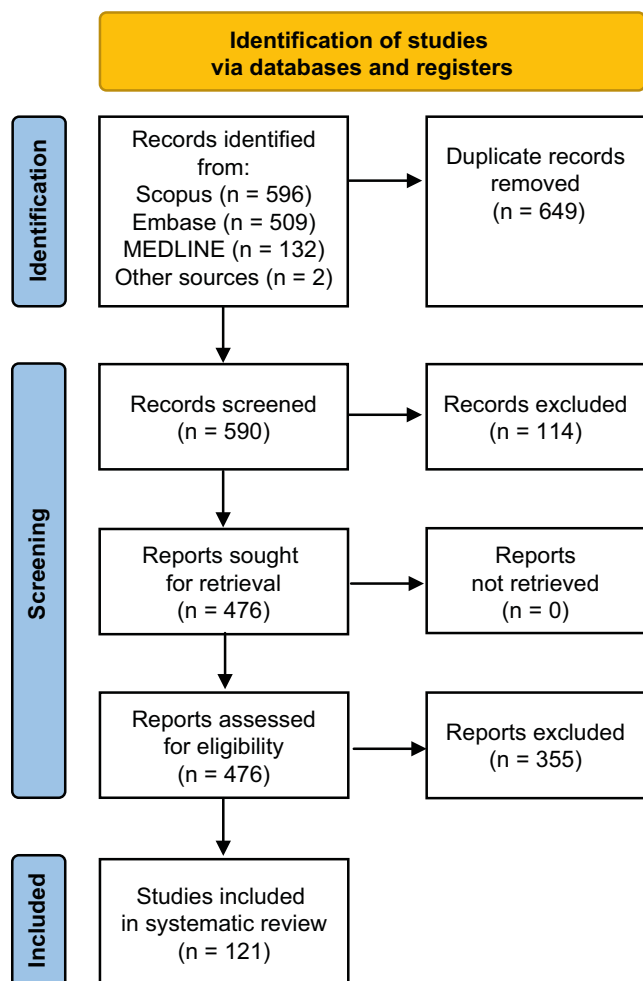


Fig. 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flowchart for a systematic review of risk factors for the distal biceps tendon rupture

Age

In 1 study, the age was not given as an average but instead in brackets. We assumed the middle value for each bracket and calculated the average value according to the provided data.

Occupation

This subgroup was divided into physical, mixed and non-physical groups. According to this classification, we assigned the occupation to their intensity in physical work. When an article categorized their cohort as physical and non-physical, the mixed category was counted as 0. Additionally, when an article partially did not report the occupation of participants, the amount of unknown occupations was deducted from the total number.

BMI

Some articles only reported height and weight either of each patient or as an average, so that was used to calculate the BMI.

Mechanism of injury

Martial arts, boxing and wrestling were considered to be fighting. Sports that did not belong to a fighting discipline, like football, baseball and rugby, were classified as sports. Weightlifting and bodybuilding were considered as lifting a heavy object as the mechanism. Additionally, when 2 mechanisms were mentioned for 1 number, this number was divided by 2, and each mechanism got half of the original number accredited.

Results

We analyzed the characteristics of 7,484–7,576 patients. The range is due to 1 article reporting a different/inconsistent number of patient information for different baseline characteristics.

Age

Of the 121 articles, 118 (97.5%) mentioned the age of the patients. In cases of bilateral ruptures, the age of the initial

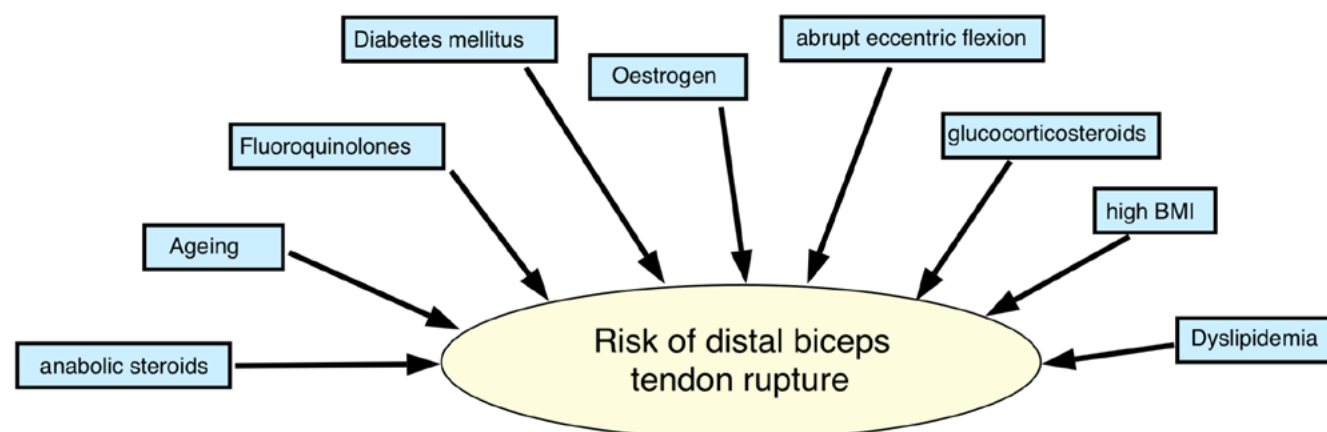


Fig. 2. Risk factors for distal biceps tendon ruptures

rupture was used in the average. The age of 7,408 patients at the time of the distal biceps tendon rupture was reported with an average age of 46.8 years. Furthermore, 7 articles reported the ages of female participants. The average age for 54 female patients was reported to be 60.1 years.

Sex

In total, 117 (96.7%) articles reported sex of the individuals. Of 7,355 participants, 7,112 were male (96.7%) and 243 (3.3%) were female.

Dominance and laterality

Information regarding injury to the dominant upper extremity was present in 88 articles (72.7%), while the laterality of the injury was addressed in 42 articles (34.7%). Of 3,798 patients analyzed in the 88 articles reporting dominance, 2,153 patients (56.7%) injured their dominant upper extremity and 1,645 patients (43.3%) injured their non-dominant upper extremity. From the point of laterality, 877 patients (54.6%) out of 1,606 injured their right upper extremity, while 729 patients (45.4%) injured their left side.

Tobacco smoking, steroids and alcohol

Overall, 33 (27.3%) articles included data on 3,573 patients, of which 743 (20.8%) were categorized as smokers. Regarding steroid use, 18 (14.9%) articles reported on 1,104 patients, in which 31 (2.8%) study participants were administered steroids, 28 (2.5%) patients admitted abusing anabolic steroids and 3 patients were used therapeutic glucocorticosteroids (lateral epicondylitis, sciatica and herniated disc). Only 3 (2.5%) articles reported alcohol consumption. Of 37 patients in the 1st study, 3 (8.1%) drank alcohol occasionally, 24 (64.9%) drank alcohol regularly and 10 (27%) abused alcohol. The 2nd study included 8 participants, of which no addiction to alcohol could be associated. The 3rd study reported 45 patients, of which 15 (33.3%) declared drinking alcohol regularly.

Occupation

In total, 29 (24%) articles reported either occupation of the patients or physical activity in their occupation. Of the 981 patients, 547 (55.8%) declared having a physical occupation, 122 (12.4%) a mixed occupation and 312 (31.8%) a non-physical occupation.

BMI

Body mass index was the subject in 10 (8.3%) articles during the time of rupture of the distal biceps tendon. The average BMI of 372 patients was 29.6, which is considered on the border between overweight to obese. Two articles categorized the BMI of their patients. Thus, 1 article

concluded that 58 (15.5%) patients were obese in their cohort of 373 patients, and another article concluded that 6 (8.7%) had normal weight, 17 (24.6%) were overweight and 46 (66.7%) were obese in a cohort of 69 patients.

Statins and fluoroquinolones

Two articles included information about statin usage, and 2 articles included fluoroquinolones. In the aspect of statins, 1 study gave a quantitative measurement with 32 out of 104 (30.8%) patients reported using statins. The other study with 10 participants mentioned the usage of statins, yet the quantitative number is unclear. For fluoroquinolones, 36 patients were evaluated, of which 1 (2.8%) was administered levofloxacin at the time of injury.

Radial tuberosity

Hilgersom et al. concluded that radial tuberosity volume and height are significant risk factors for distal biceps tendon ruptures. In his cohort of ruptured tendons, 9 participants had a mean radial tuberosity size of 705 mm³ compared to 541 mm³ in the control group of 18 study participants. The mean radial tuberosity height in the rupture group was 4.6 mm, while in the control group it was 3.7 mm.¹⁴ On the other hand, Kodde et al. concluded that radial tuberosity size did not correlate with distal biceps tendon ruptures in a cohort size of 22 patients in the rupture group and 22 in the control group.¹⁵

Sports

Of the 11 (9.1%) articles that reported on activity in sports, 177 (94.7%) of 187 were active sportsmen. Six of the 11 articles included data about the type of sports with 76 participants. The most common sports among those were weight lifting (n = 16), fitness (n = 15), boxing (n = 10), cycling (n = 7), martial arts (n = 5), and rugby (n = 5). Other types of sports reported were running (n = 3), soccer (n = 2), swimming (n = 2), triathlon (n = 2), tennis (n = 1), skiing (n = 1), rowing (n = 1), kabaddi (n = 1), bodybuilding (n = 1), wrestling (n = 1), climbing (n = 1), baseball (n = 1), volleyball (n = 1), golf (n = 1), and bow hunting (n = 1).

Comorbidities

In total, 10 (8.3%) articles included information about comorbidities. Two of those only mentioned the coexistence of systemic comorbidities but did not specify the comorbidities themselves. Of 139 patients, 35 (25.2%) had comorbidities. Four articles provided data about diabetes as a comorbidity; upon evaluating 364 patients, 17 (4.7%) were diagnosed with diabetes. Another study by Kelly et al. identified a 2.7% rate of diabetes in their cohort for patients below the age of 65 and a 19.8% rate for patients above the age of 65.² Hypercholesterolemia was a subject

Table 1. Summary of risk factors with references

Risk factors	Result	Reference
Age	46.8 years	3, 9, 11, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128
Age of women	60.1 years	3, 15, 23, 32, 65, 95, 103
Sex	96.7% men, 3.3% women	2, 3, 9, 11, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130
Dominance	56.7% dominant arm, 43.3% non-dominant arm	3, 9, 16, 17, 18, 19, 23, 26, 27, 28, 29, 30, 31, 32, 33, 34, 36, 37, 40, 41, 42, 43, 44, 46, 47, 48, 49, 52, 53, 54, 56, 59, 61, 62, 63, 64, 65, 66, 67, 68, 71, 72, 74, 75, 76, 77, 78, 81, 82, 83, 84, 85, 86, 87, 89, 90, 91, 92, 94, 95, 96, 97, 98, 101, 102, 103, 104, 106, 107, 108, 110, 111, 112, 113, 114, 116, 117, 118, 119, 121, 122, 123, 124, 125, 127, 128, 129, 130
Laterality	54.6% right arm, 45.4% left arm	3, 11, 14, 15, 17, 20, 21, 23, 24, 30, 31, 34, 43, 45, 49, 52, 53, 54, 55, 57, 61, 69, 70, 72, 74, 78, 82, 84, 86, 89, 92, 93, 101, 107, 108, 114, 119, 120, 124, 125, 127
Smoking	20.8%	2, 3, 9, 11, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 32, 34, 35, 36, 39, 41, 42, 43, 77, 102, 118, 128, 129, 130
Steroid	2.8%	3, 9, 15, 28, 32, 33, 34, 35, 37, 38, 39, 42, 61, 71, 102, 117, 129, 130
Occupation	55.8% physical, 12.4% mixed, 31.8% non-physical	2, 3, 21, 23, 31, 32, 33, 34, 35, 36, 43, 48, 65, 66, 67, 70, 71, 72, 75, 86, 95, 99, 100, 113, 116, 119, 120, 126, 130
BMI	29.6 kg/m ²	2, 14, 16, 23, 25, 34, 35, 36, 50, 68, 106, 119
Statin	30.8%	30, 35
Fluoroquinolone	2.8%	15, 35
Sports	94.7%	16, 21, 31, 33, 35, 37, 38, 39, 102, 113, 129
Alcohol	–	20, 32, 119
Radial tuberosity	–	14, 128
Comorbidities	–	2, 3, 17, 18, 21, 23, 24, 36, 37, 43
Mechanism of injury	–	3, 9, 11, 15, 17, 21, 28, 31, 34, 36, 42, 44, 47, 48, 59, 63, 67, 70, 86, 91, 94, 95, 96, 99, 101, 102, 106, 111, 113, 115, 116, 117, 119, 120, 123, 124, 125, 127

BMI – body mass index.

of 2 articles with 246 patients, of which 5 were diagnosed with hypercholesterolemia. Further comorbidities were addressed in 2 studies involving 241 patients. Hypertension (12), asthma (9) and diabetes (5) were the most common ones. Ischemic heart disease (3), tendinitis (3), hypercholesterolemia (2), inflammatory joint disease (1), and renal dysfunction (1) were also reported.

Mechanism of injury

Of the 121 articles, 39 (33.1%) articles reported about the mechanisms of injury, of which 5 qualitatively described the mechanism of injury. All 5 articles described an eccentric, excessive and sudden load in an acute setting as the most common. In the other 34 articles, the mechanism of injury for 43 patients out of 1,645 was unknown. The most common way of rupturing the distal biceps described was lifting a heavy object with 852 (53.2%) ruptures, followed by sporting activities with 196 (12.2%) ruptures. Also, quite common mechanisms of rupture were falling with 93 (5.8%) ruptures and forceful elbow extension-catching a falling object with

81 ruptures (5.1%). Less common were fighting and assault with 46 ruptures (2.9%), insidious ruptures with 34 ruptures (2.1%), pulling movements with 29 ruptures (1.8%), blunt impact with 10 ruptures (0.6%), and other causes in 243 ruptures (15.2%, Table 1).^{3–130}

Discussion

This systematic review summarizes the knowledge about current risk factors for distal biceps tendon ruptures. The average male age associated with the incidence of rupture was 46.8 years, while in female patients, the average age of rupture was more advanced at 60.1 years. We suspect that decreased loads posed on the arm due to everyday activities, along with increased tendon degeneration with aging, precipitates conditions in which a minimal load on the arm is sufficient to cause the distal biceps tendon to rupture. Likewise, the sex distribution indicates that men as more associated with ruptures. Dunphy et al. and Ford et al. reported a similar incidence of rupture

in male and female participants with 98.5% and 97.6%, respectively.^{9,23}

Additionally, we wanted to point out the risk factor of arm dominance in the literature. In most of the literature, the dominant side is affected by the rupture,^{131–135} yet in this systematic review, the dominant arm was involved in only 56.7% of the reported cases.

In this systematic review, it was observed that the majority of participants (94.7%) engaged in sports activities, either as professionals or as a leisure pursuit. The meaningfulness of BMI becomes less accurate when muscle mass is highly increased, such as in sportsmen. In these cases, BMI value would indicate higher than normal body mass, yet in some healthy states, the increase of BMI is due to muscle and not fatty tissue. Therefore, BMI alone is an inaccurate risk factor as the body composition of muscle and other structures is disregarded. Due to the high rate of study participants involved in sports activities, we believe that muscle mass is the major contributor to the increased BMI. Additionally, most of the patients reported at least a partially physical occupation (68.2%), leading to the possibility that muscle mass might be increased in those subjects.

The literature ascribes distal biceps tendon ruptures to middle-aged men, usually with an active lifestyle.^{2,136–138} This systematic review confirms the general knowledge, and reports the rupture incidence in men at 96.7%, at the mean age of 46.8 years, with 94.7% of individuals being involved in an active lifestyle and 68.2% having a physical or mixed physical occupation.

Regarding tobacco smoking, Kelly et al. reported findings that are not in line with our study. They used a national database and reported that 4.3% of the injured population were tobacco users, while in our review, 20.8% can be considered smokers. Regarding the point of diabetes mellitus, Kelly et al. reported that below the age of 65 years, diabetes rates were estimated to be 2.7%, and above the age of 65 to be 19.8% for the injured population.² The 4.7% diabetes incidence in our findings can be explained by the lack of age stratifications, i.e., participants aged above 65 years were included in the analysis and increased the rate of diabetes.

The study by Pope et al.¹³⁹ indicates that approx. 3–4 million individuals aged 13–50 years in the USA are using anabolic steroids, representing 8.4% of the 155 million individuals aged 15–50 years in the USA, according to the United Nations population count.¹⁴⁰ Therefore, the rate of anabolic steroid usage would be approx. 1.9–2.6% in the above-mentioned age groups. In our systematic review, the rate of patients who used anabolic steroids was at the upper range of normality (2.5%), according to the calculations presented above. On the other hand, the usage of anabolic steroids has a bad reputation, is connected to health risks and is often concealed by patients.

We think that risk factor analysis in distal biceps tendon ruptures is veiled due to the lower usage of arms compared to legs in daily life. Tendons of the legs are used every day

to carry the whole bodyweight, while muscles of the arm are only used when carrying objects. Therefore, tendons of the lower limb are much more prone to rupture due to systemic degenerative changes of the tendons than those of the upper limb.

Pathomechanisms of relevant risk factors

Aging has a tremendous effect on all tendons in the human body. On the cellular level, the active tenoblasts transform into inactive tenocytes with a general, age-dependent decrease in the number of tendon cells. Additionally, the overall metabolic activity of tenoblasts decreases drastically with age, leading to a reduced potential to repair and heal the tendon. Furthermore, metabolic anaerobic over aerobic pathways are favored due to overall reduced metabolism.

In the extracellular matrix (ECM), qualitative and quantitative changes can be seen. Collagen content reduces slightly, proteoglycans and glycoproteins decrease more intensively, as well as elastic components. Furthermore, water and mucopolysaccharide content of the tendon is also decreased, leading to increased stiffness of the tendon and a reduced gliding ability. Overall, a reduced tendon diameter and volume can be seen. Additionally, the vascular bed of the tendon is reduced, which results in reduced oxygen and nutrition transport to the tendon. Accumulation of lipids and calcium deposits can also be observed, which disrupts the tendon matrix and weakens the tensile strength. All of these mentioned factors lead to decreased tensile strength and increased risk of tendon rupture.¹⁴¹

Tobacco smoking has a similar effect as aging. It affects the healing ability by reducing the vascular supply of oxygen and nutrients, as nicotine is a potent vasoconstrictor.^{142,143}

It is hypothesized that sex is a risk factor in tendon ruptures, mainly due to hormonal differences. Estrogens are said to be tendon-protective.^{144–146} The mechanism of tendon protection by estrogens can be ascribed to inhibition in lysyl oxidase, the enzyme that forms cross-links between fibers in ligaments and tendons. The enzyme inhibition results in reduced cross linkage, producing more elastic tendons, and thus decreasing the impact of an abrupt muscle contraction.^{146,147} On the other hand, testosterone, by modulating androgen receptors, causes the muscle to increase its mass via protein synthesis.¹⁴⁸ Therefore, the combination of a deficit of female hormones and increased muscle mass and strength in men leads to an increased risk of tendon injury.

A similar mechanism of action can be ascribed to anabolic steroids since they are analogs of testosterone. Under anabolic steroids, a significant increase in muscle mass and strength can be observed, leading to increased tension on the tendon and a higher risk of rupture. Additionally, studies have shown that anabolic steroids also lead to dysplastic changes in the tendon and, therefore, decreased tensile strength.^{149,150}

The BMI, usually used as a rough indicator of body fat in non-athletic people, is shown to be a risk factor for tendon ruptures. The visceral fat-releasing inflammatory cytokines, including tumor necrosis factor alpha (TNF- α), interleukin 6 (IL-6) and interleukin 1 beta (IL-1 β), which are implicated in pathophysiological structural changes in the tendon and can increase the risk of ruptures.^{151,152}

Literature has shown that glucocorticosteroids alter the mechanical tendon properties by activating the glucocorticoid receptor, which influences gene expression and transcription. A reduction in collagen fiber diameter, in cross-linkage and of collagen content can be observed, which results in decreased tensile strength. Additionally, in vitro studies showed dysfunction of tenocytes, such as decreased proliferation, reduced collagen formation and increased reactive oxygen species (ROS) formation. Glucocorticosteroids also increase visceral fat deposition, which causes an increase in inflammatory cytokines as described above.^{150,151,153}

Dyslipidemia is an underestimated risk factor for tendon ruptures, as specifically cholesterol accumulates in the tendon and disrupts its integrity.^{151,154} Hypercholesterolemia can be associated with weakened tendons. Statins are used to treat elevated levels of cholesterol by inhibiting 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase, yet studies have also shown that statins themselves are a risk factor for tendon ruptures. The precise mechanism of action on a molecular level is still unclear. It is hypothesized that matrix metalloproteinase (MMP) activity is increased, which mediates the catabolic state in tendons without a change in total levels of collagen, leading to a decrease in extracellular collagen strength and an increased risk of tendon rupture.^{151,153,155}

Studies have shown that fluoroquinolones increase the risk of tendon ruptures. However, the mechanism of action can only be hypothesized. It is ascribed to direct toxicity as the rupture usually occurs hours after a single dose administration.¹⁵⁶ One of the hypotheses is that fluoroquinolones stimulate the production and accumulation of ROS and thus induce apoptosis. Another hypothesis points out the activation of MMPs and induction of prostaglandin E2, IL and cyclooxygenase 2 (COX-2) production, similar to the state observed in dyslipidemia and visceral fat accumulation.^{153,157,158}

Another tendon rupture risk factor is diabetes mellitus, more commonly type 2 (T2D). It was shown that non-enzymatic cross-links can be formed through the Maillard reaction between sugars and amino acids called advanced glycation end-products (AGEs).¹⁵⁷ This results in the formation of stiffer tendons and a higher risk of ruptures, as an abrupt muscle contraction leads to abrupt transmission of the force to the tendon.^{146,151,158} Additionally, high glucose levels modulate gene expression, such as the decreased levels of adenosine monophosphate (AMP)-activated protein kinase, leading to a decreased production

of adenosine triphosphate (ATP), and therefore decreased metabolic rate of tenocytes.^{159,160} In cases involving T2D, its onset is slow compared to type 1 diabetes, and therefore high glucose levels exist unrecognized for years. Furthermore, T2D is often associated with obesity, which itself is a risk factor for tendon rupture, as described above. The negative effects of glucocorticosteroids on tendons include hyperglycemia, which adds to the overall risk of steroids.

In the literature, the mechanism of rupture of the distal biceps tendon is usually described as an eccentric contraction.^{161,162} This is due to biomechanical forces in different elbow positions. When the elbow is 90°-angulated in the standing position, the point of insertion at the radial tuberosity is a few centimeters anterior to the elbow joint. A lever system is created, and as soon as the arm is extended, the distance between tendon insertion and the elbow joint is reduced. This reduction in distance leads to an increase in force produced on the tendon, although the same force is being applied to the distal arm. This increase in forces leads to rupture in the weakest part of the tendon, especially when it develops abruptly or with decreased tensile strength.¹⁶³ Another biomechanical risk factor involved in the tendon rupture has been ascribed to a reduced proximal radioulnar space near the point of insertion. It has been suggested that the polymorphic traits of the radial tuberosity could lead to a decrease in the radioulnar space. The linear distance between the radius and ulnar is reduced by 45% when pronated, leaving less than 1 mm for the distal biceps tendon to slide through.¹⁶⁴ In cases where the radial tuberosity is more pronounced, less space is available, and impingement of the tendon is possible, causing friction, inflammation and degeneration of the tendon.¹⁴

Limitations


This systematic review does have its limitations. The included studies showed a wide basis of heterogeneity, which made it impossible to perform a meta-analysis. Additionally, the included studies had different interests in their outcomes, which made the collection of studies heterogenic. As already seen in the results section, many studies provided incomplete data, and precise information was limited. It is well known that fluoroquinolones are a risk factor for tendon ruptures,⁷ yet only 2 studies reported information about these drugs. There is also probable reporting bias as temporary local inflammation in the area might be neglected in reporting, contrary to chronic diseases like asthma or hypertension. Therefore, hypertension and asthma might be overrepresented in this systematic review, similar to anabolic steroids, which might be purposely not reported by patients. Another limitation is that studies with level III or IV evidence were most often analyzed, and each of the included studies had their own limitations, e.g., small cohort size and incomplete data.


Conclusions


The most common and outstanding reported risk factors for distal biceps tendon ruptures were older age, male sex and sports activity. The average patient with a distal biceps tendon injury (slightly higher in the dominant arm) is a man aged 46.8 years with an active lifestyle and professional or sport activity. Steroid usage does not seem to significantly increase the risk of the distal biceps tendon rupture.

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