Possible factors responsible for increased risk of tendon injuries during strength training in adult patients: systematic review

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Abstract

Background: Exercise is a fundamental aspect of physiotherapy, with an increasing number of studies focusing on tendon problems. This review aims to identify situations where physiotherapists should exercise caution and precision when prescribing resistance exercises.

Aims: This study aimed to analyze factors responsible for an increased risk of tendon injuries during resistance training in adult patients.

Material and methods: A search was conducted in June and July 2023 in PubMed/Medline, EMBASE, Science Direct, PEDro, and Cochrane databases. Clinical trials, meta-analyses, randomized controlled trials, reviews, and systematic reviews published within the last ten years were included if they considered strength and resistance training as risk factors for tendon injuries. Studies on in vitro tissues, post-surgery patients, or lacking training procedure descriptions were excluded.

Results: During the search conducted in June and July 2023, 538 articles were analyzed. 6 articles meet criteria, and 1 other were found valuable even thou were not meeting criteria fully.

Conclusions: There is a potential greater risk for tendon injuries in obese patients, particularly in the upper extremities; in female patients; when antibiotics such as fluoroquinolones, ofloxacin, and norfloxacin are administered with corticosteroids; and in individuals with noticeable strength deficits.

Key words

adult,
tendon injuries,
resistance training,
systematic review.

Introduction

Exercise is fundamental to physiotherapy and the International Federation of Orthopaedic Manipulative Physical Therapists (IFOMPT), in its 2004 definition, identified exercise as a key component of modern manual therapy management. In recent years there has been an increase in knowledge about exercise. We have a lot of data about the positive influence of endurance and strength training [1-3]. On the other hand, it is not always clear how fast we should progress and how much load we can safely progress. There is also an increasing number of studies on tendon injuries, tendinopathy, tendinitis, tendinosis and tendon rupture [4,5].

Physiotherapists, including manual therapists, prescribe exercises as a treatment modality on a daily basis. Do we really know when to be more aware of a possible increased risk of injury? Do we take risk factors into account in C/O, P/E and treatment? As we use exercise as a treatment, especially heavy exercise, we should from time to time check our knowledge with modern scientific literature. This review will try to answer and collect the most obvious situations when the physiotherapist should be more careful and precise when prescribing resistance exercises.

Aims

The aim of this study was to analyse possible factors responsible for an increased risk of tendon injury during strength training in adult patients.

Material and methods

Search strategy

The search was conducted in PubMed/Medline, EMBASE/Science Direct, PEDro and Cochrane databases in June and July 2023. Free text terms related to the topic were used.

PICO terms used to guide the search strategy: (1) Patient group: Adults with systematic exercise; (2) Intervention: Exercise, strength training, 1 time per week; (3) Comparison: Adults not doing strength training or doing other types of training; (4) outcome: Tendon injury.

Limitations used: Clinical trial, meta-analysis, randomised controlled trial, review, systematic review, articles older than 10 years.

Inclusion and exclusion criteria

Inclusion criteria: Strength, resistance training, risk factors for tendon injury, adult humans, possible comorbidities, systematic review, meta-analysis, randomised controlled trials, clinical trials, review, papers in English, publications not older than 10 years, abstract available.

Exclusion criteria: Non-adults, in vitro, postoperative treatment, publications older than 10 years, no training described.

Articles search

The following Boolean operations were used in searching for the articles:

PubMed/MEDLINE

"resistance training" OR "strength training" AND ("risk factors" OR "sports injuries") NOT disease AND "tendon" with 6 results, 3 articles were found meeting criteria.

To expand the PubMed search more possibilities were used:
drug AND "tendon injuries" with 66 results, 1 article was found meeting criteria.
"risk factors" AND "tendon injuries" with 55 results, 2 articles were found meeting criteria,

EMBASE/Science Direct

"resistance training" AND "risk factors" AND "tendon injury" with 18 results, no article matching criteria,
"strength training" AND "risk factors" AND "tendon injury" with 20 results, no article matching criteria,

Cochrane

"tendon injury" with 21 publications not one article meeting criteria

"risk factors of injury" with 154 publications not one article meeting criteria

PEDro

tendon injuries AND risk factors with 3 results not one meeting criteria.
risk factors AND tendinopathy with 4 results not one meeting criteria.
strength training AND tendon injuries with 5 results not one meeting criteria.
strength training AND tendinopathy with 19 results not one meeting criteria.
resistance training AND tendinopathy with 17 results not one meeting criteria.
"risk factors" AND "strength training" with 34 results and 1 article was found meeting criteria.
"risk factors" AND "resistance training" with 116 results added subdiscipline: orthopeadics – no records found.

Results of search

During the search conducted in June and July 2023, 538 articles were analysed. 6 articles met the criteria and 1 other was considered valuable, although it did not fully meet the criteria.

Databases searched: Pubmed, Science direct, Cochrane, PEDro. 538 articles were found and analysed. Studies excluded: n = 531 Non-adults, in vitro, postoperative treatment. Publications more than 10 years old. Included studies: n = 7 (Brukner 2015 [4], van der Horst et al. 2015 [6], Gual et al. 2016 [7], Lin et al. 2018 [8], Alves et al. 2019 [9], Macchi et al. 2020 [10], Sancese et al. 2023) [11].

When the time limit was set to 5 years, 3 studies were found to meet the criteria. When the time limit was extended to 10 years, after reading the abstracts of 538 articles, 7 publications met the criteria. Not all were clinical trials, but all described important factors influencing tendon pathophysiology and were included for their value in explaining the clinical problem discussed. The characteristics of the studies are summarised in **Table 1** below.

Results of the studies

Brukner 2015 [4] is an open access clinical analysis on the prevention and treatment of hamstring injuries. Different types of hamstring injuries are described. It is worth mentioning that recurrence rates are high and lack of strength seems to be an important factor. The author concluded that strengthening exercises should be performed with the hamstrings in a lengthened position to promote load adaptation. Various tests have been suggested as predictors of hamstring injury and the use of the Nordboard has been an interesting addition to the testing process. Prevention of these injuries is the ultimate goal and there is increasing evidence that Nordic hamstring exercises are effective in reducing the incidence.

Van der Horst N et al. 2015 [6], evaluated the preventive effect of the Nordic Hamstring Exercise (NHE) on hamstring injuries in amateur football players. The study was a randomised controlled trial. The author assumed that hamstring injuries are one of the most common muscular injuries in football. It is also important to note that there is a high recurrence rate for this type of injury. It seems that eccentric hamstring strength is an important factor in these cases. The NHE is designed to prevent this problem. Prior to this study, the effectiveness of the NHE in preventing hamstring injuries in amateur football had not been evaluated. Male amateur football players (age, mean +/- SD 24.5 +/- 3.8 years) from 40 teams were randomly assigned to an intervention group (n = 20 teams, 292 players) or a control group (n = 20 teams, 287 players). The intervention group was instructed to perform 25 sessions of NHE over a 13-week period. Both the intervention and control groups performed regular football training and were followed for the incidence and severity of hamstring injuries during the calendar year 2013. The primary outcome was injury inci-

dence. Secondary outcomes were injury severity and adherence to the intervention protocol. The authors recorded 38 hamstring injuries, affecting 36 of 579 players (6.2%). The risk of hamstring injury was reduced in the intervention group compared to the control group and was statistically significant ($p = 0.005$). There were no statistically significant differences in injury severity between the intervention and control groups. Adherence to the intervention protocol was 91%. The authors concluded that the NHE protocol added to regular amateur training significantly reduces the incidence of hamstring injuries, but does not reduce the severity of hamstring injuries.

Gual et al. 2016 [7] was a clinical trial where the authors evaluated the effects of in-season inertial resistance training with eccentric overload in an adult population at risk for patellar tendinopathy. The population studied was volleyball and basketball players, who were considered to be at risk for patellar tendinopathy. The authors investigated the influence of weekly resistance squat training. 38 women and 43 men were randomly assigned to either the intervention group (IG) or the control group (CG). Both groups maintained their off-season training routines for 24 weeks. The IG additionally performed 1 weekly session of eccentric overload by performing 4 sets of 8 repetitions of the squat using flywheel inertial resistance. Neither group suffered from patellar tendinopathy during the study period. It was interesting to note that adding a weekly session of eccentric overload squat training to a regular basketball and volleyball training programme improved lower limb muscle strength without inducing patellar tendon complaints.

Lin et al 2018 [8], in their narrative review, described common sports injuries including anterior cruciate ligament (ACL). They highlighted the not commonly recognised fact that there are gender differences in the epidemiology, risk factors and outcomes of these conditions. They postulated that an understanding of these factors may improve clinical management, reduce injury rates and facilitate return to play. It is important to note that female athletes are at greater risk of ACL injury in high school, college and professional sports. Additional risk factors appear to be increased lateral tibial slope, smaller ACL size, and suboptimal landing mechanics, which are more common in female athletes. Level of evidence: IV according to PubMed.

Alves et al. 2019 [9], performed a systematic and meta-analysis on the possible influence of fluoroquinolones on the increased risk of tendon injury. The authors performed a literature search to identify observational studies that reported results on the risk of Achilles tendon rupture (ATR), the risk of Achilles tendinitis (AT), or the risk of any tendon disorder (ATD). A meta-analysis was performed by pooling the odds ratios (ORs) with their 95% confidence intervals (CIs). Fifteen trials were included in the meta-analysis. Fluoroquinolone treatment was associated with an increased risk of ATR, AT, and an increased risk of ATD. The risk was statistically significant in patients aged ≥ 60 years. Analysis by type of fluoroquinolone was only possible for ATR, where ofloxacin and norfloxacin were found to increase the risk, but not ciprofloxacin and levofloxacin. The authors confirmed the risk of tendon injury associated with fluoroquinolones. Older age and concomitant use of corticosteroids appear to be additional risk factors for tendinopathy.

Macchi et al. 2020 [10] conducted a systematic review of clinical trials on the influence of obesity on the risk of tendinopathy, tendon rupture, tears and postoperative complications. The authors concluded that inflammation and mechanical stress play a role in the development of tendon problems and influence their healing. In obese people, high levels of pro-inflammatory cytokines and high mechanical stress promote chronic low-grade inflammation. A systematic review was conducted by searching the PubMed, Embase and Cochrane Library databases. We included studies with any level of evidence published between January 2000 and 10 July 2019 in peer-reviewed journals reporting clinical outcomes. 22 trials were finally included, with 49,914 participants (5984 with

obesity), of whom 31,100 (1884 with obesity) had upper extremity tendinopathy and 18,814 (4010 with obesity) had lower extremity tendinopathy. Obesity was defined as a body mass index (BMI) ≥ 30 kg/m according to World Health Organization (WHO) criteria. The authors found that obesity was associated with a higher risk of upper and lower extremity tendinopathy. It was also associated with a higher risk of upper extremity tendon rupture and tear, leading to tendon surgery in both men and women. Interestingly, no association was found between BMI and lower extremity rupture. Level of evidence: Level IV, prognostic study, according to PubMed.

Sancese et al. 2023 [11] conducted a clinical control trial comparing the effects of in-season sprint training versus Nordic Hamstring Exercise (NHE) training on risk factors for hamstring strain injury (HSI). The authors randomised eighteen male university football players to a sprint or NHE group. They completed baseline isokinetic strength and sprint mechanics assessments prior to their assigned intervention, which was delivered twice weekly for 4 weeks before post-testing. Significant increases in biomechanical parameters were found, but there was no significant effect on sprint power or sprint mechanics. The authors concluded that both training programmes may be effective in reducing the risk of HSI, but through different mechanisms.

A total of seven relevant studies were identified and categorised as shown in Table 1 (based on levels of evidence, Centre for Evidence Based Medicine, 2011).

Results of evidence

Brukner 2015 [4], an open access clinical analysis, a PEDro scale rating is not applicable. According to the design, the level of evidence was calculated as level 4.

Van der Horst N et al. 2015 [6] was rated 5/10 on the PEDro scale. Eligibility criteria: Yes; Random allocation: Yes; allocation concealment: No; Baseline comparability: Yes; Blind subjects: No; Blind therapists: No; Blind assessors: No; Adequate follow-up: No; Intention-to-treat analysis: Yes; Between-group comparisons: Yes; Point estimates and variability: Yes. Note: The eligibility criteria item does not contribute to the total score.

Gual et al. 2016 [7] in the PEDro scale was scored 4/10. Eligibility criteria: Yes; Random allocation: Yes; Concealed allocation: No; Baseline comparability: Yes; Blind subjects: No; Blind therapists: No; Blind assessors: No; Adequate follow-up: No; Intention-to-treat analysis: No; Between-group comparisons: Yes; Point estimates and variability: Yes. Note: The eligibility criteria item does not contribute to the total score.

Lin et al. 2018 [8], a narrative review, a PEDro scale assessment is not applicable. According to the design, the level of evidence was calculated as level 4.

Alves et al. 2019 [9], a systematic review and meta-analysis was performed by pooling odds ratios (ORs) with their 95% confidence intervals (CIs), a PEDro scale rating is not applicable. According to the design, the level of evidence was calculated as level 2.

Macchi et al. 2020 [10], systematic review, Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were applied and the risk of bias (ROBINS tool) of the studies was assessed as well as the methodological quality (Coleman score), still according to PubMed it is level of evidence IV, prognostic study.

Sancese et al. 2023 [11], clinical control study, this study is under evaluation in the PEDro database. The rating could be 4/10 on the PEDro scale. Eligibility criteria: Yes; Random allocation: Yes; allocation concealment: No; Baseline comparability: Yes; Blind subjects: No; Blind therapists: No; Blind assessors: No; Adequate follow-up: Yes; Intention-to-treat analysis: No; Between-group comparisons: Yes; Point estimates and variability: Yes. Note: The eligibility criteria item does not contribute to the total score.

Table 1. The characteristics of the relevant studies (based on Levels of Evidence, Centre for Evidence Based Medicine, 2011).

Authors	Study design	Population	Intervention investigated	Comparison intervention	Outcomes used	Study findings
Brukner 2015 [4]	Clinical analysis	Male, female athletes	Not applicable	Not applicable	Not applicable	Summary of current knowledge, no clear answer except that strength training may be beneficial in preventing hamstring injuries
van der Horst N et al. 2015 [6]	Randomized controlled trial	Amateur soccer players	25 sessions in a 13-weeks of Nordic Hamstring Exercise (NHE)	Regular soccer training	Hamstring injury incidence and severity	NHE protocol in regular amateur training significantly reduces the incidence of hamstring injuries, but does not reduce the severity of hamstring injuries
Gual et al. 2016 [7]	Clinical trial	Volleyball and basketball players	1 weekly session of eccentric overload by 4 sets of 8 repetitions of the squat using flywheel inertial resistance	Only scheduled in-season training	Victorian Institute of Sports Assessment patellar tendinopathy questionnaire (VISA-p), vertical countermovement jump, squat power (concentric and eccentric)	Adding a weekly session of eccentric overload squats to a regular basketball and volleyball training programme will increase lower limb strength without triggering. patellar tendon complaints
Lin et al. 2018 [8]	Narrative review	3 sports injuries with sufficient data to discuss differences in epidemiology, risk factors, management strategies and outcomes between the sexes	Female athletes injury rate	Male athletes injury rate	Risk factors assessment	Female athletes more commonly sustain injury

Alves et al. 2019 [9]	Systematic review and meta-analysis	Fifteen studies were included in the meta-analysis	Fluoroquinolones adverse effects on tendon	Patients not taking fluoroquinolones	Number of tendon problems (odd ratio, confidence interval 95%)	The risk of tendon injuries is associated with fluoroquinolones
Macchi 2020 [10]	Systematic review and meta-analysis	22 studies with 49,914 participants (5984 with obesity), whom had upper and lower extremity tendinopathy	Obesity as a risk factor for tendons problems	Patients without obesity and tendons problems	Risk of tendon problems, (odds ratio, confidence interval 95%)	Obesity was associated with a higher risk of tendinopathy, tendon tears and ruptures, and complications after tendon surgery than non-obesity
Sancese 2023 [11]	Clinical control trial	Male university football players	In-season sprint training	Nordic hamstring exercise	Hamstring eccentric peak torque, knee extension peak torque	No difference in training programmes. No significant effect on sprint performance or sprint mechanics

Discussion

The promotion of activity and exercise as medicine is growing. The WHO, in its updated recommendations on activity levels for healthy people, suggested a preferred amount of weekly activity. Importantly, for the first time in history, the WHO included the need for resistance training in this type of guideline [3]. The benefits of resistance training have been known for many years. Resistance training is an important part of physical fitness programmes. It improves quality of life and physical fitness in different age groups and populations [1,2,14,15].

There is evidence that resistance training strengthens tendons and ligaments. This is due to the adaptation and modification of collagen tissue as a result of exercise. Collagen fibres become denser and thicker, and the tendon itself becomes stiffer. Resistance training may play a role in the remodelling process and adaptations for injury prevention by increasing the endomysium content of collagen XIV, macrophages and tenascin-C in the myotendinous junction region [16]. An increase in tendon stiffness in response to resistance training has been observed in both animal and human studies [17-19]. Stiffness is an important mechanical parameter of the tendon. Stiffness is described as the force required to stretch a tendon per unit distance. If the tendon is stiffer than the muscle, it is able to generate force more quickly. With prolonged resistance training, tendons increase the amount of collagen fibrils, increase the diameter of collagen fibrils and increase fibril density [20-22]. On the other hand, we still do not know much about the risk

factors associated with the possibility of injury in resistance training. Perhaps the recent increase in concern about various types of tendon problems (tendinopathies) is related to the increased activity levels of people in gym-based strength training.

Physiotherapists, including manual therapists, prescribe exercises as a treatment modality on a daily basis. Do we really know when to be more aware of a possible increased risk of injury? Do we take risk factors into account during C/O, P/E and treatment? In my opinion, not always and this was the reason for preparing my review. As we use training with load and especially heavy loads as a treatment, we should check our knowledge with modern scientific literature from time to time. This review tries to answer and collect the most obvious situations when physiotherapists should be more careful and precise when prescribing resistance exercises. According to the literature review, it is not easy to identify potential risk factors for tendon and ligament injuries. The literature is not clear and there is a lack of knowledge. In general, we can try to identify internal and external factors. Some of them we can recognise and influence to a certain extent, but still the decision about the right load and load progression is crucial to prevent injuries. Too much load means injury, too little load means no benefit to our patients. The review tries to look for risk factors, but there is not much information on fitness/physiotherapy related injuries in the general population. Kemler et al. 2020 [23] conducted an online survey on fitness-related injuries. Interestingly, most injuries occurred during strength training. The shoulder and knee were the most commonly injured body parts and, importantly, 67% of all injuries were muscle, tendon and ligament injuries. Most injuries occurred during unsupervised gym-based fitness activities, with shoulders most commonly injured during strength training and knees most commonly injured during aerobic exercise, mainly treadmill training.

The evidence is scarce. Most articles describe the most typical tendon injuries. Brukner 2015 [4] prepared a clinical analysis on the topic of prevention and treatment of hamstring injuries. The author described the current knowledge about the prevalence of hamstring problems, the causes as well as the different types of hamstring injuries. Even though the article is 8 years old, it is still a valuable addition to help organise knowledge about risk factors for tendon problems in the lower extremity. What is emphasised is that not all hamstring injuries are the same, so healing is also different. The slow stretch type of injury and injuries involving the central tendon take longer to heal completely. Danielsson 2020 [5] add a description of a typical hamstring injury, usually caused by maximal hip flexion with knee extension. Recurrence rates are high and lack of strength may be an important factor [4,24]. It appears that strengthening exercises should be performed with the hamstrings in an extended position. Various tests have been suggested as predictors of hamstring injury and the use of the Nordboard, a patented device for assessing hamstring strength and imbalance, was an interesting addition that could increase the objectivity of the testing process [24]. These ideas were supported by the study by van der Horst 2015 [6], which investigated the preventive effect of NHE on hamstring injuries in amateur footballers. The authors stated that it appears that eccentric hamstring strength is an important factor that could reduce the risk of injury. The questions that remain unanswered are how much loading for whom, when and how we should progress loading. Some answers to these questions can be found in the study by Sancese 2023 [11]. The authors compared two types of training (one of which was NHE) on the potential risk of hamstring strain injury and found no difference in the final comparisons. It is possible that it is not the type of exercise that is important, but the achievement of the final goal, which should be an increase in strength.

It is important to consider other factors that we, as physiotherapists, might notice during C/O and P/E. Macchi 2020 [10] studied the influence of obesity on the risk of tendinopathy, tendon

rupture, tendon tear and postoperative complications. As the obesity epidemic is increasing in many countries of the world, this could be an important point. According to the Global Burden of Disease study of overweight and obesity, there are over 4 million people who colour each year as a result of obesity [25]. The number of obese people is increasing, and this applies to both adults and children. From 1975 to 2016, the proportion of obese people aged 5-19 years increased more than fourfold worldwide, from 4% to 18%. Today, more people are obese than underweight in every region except sub-Saharan Africa and Asia. Previously a problem only in high-income countries, obesity is now increasing in low- and middle-income countries, particularly in urban areas [25]. Obesity is associated with many health problems. It changes metabolism and also appears to affect the collagen tissue in our bodies. A common way of describing people's weight is the BMI, which is the weight of an adult in kilograms divided by their height in metres squared. According to WHO recommendations, if the BMI is over 25, we consider a person to be overweight. If it exceeds 30 then we call it obesity. Macchi 2020 [10] concluded that inflammation and mechanical demands may play a role in the development of tendon problems and influence their healing in obese individuals. When adipose tissue exceeds a certain percentage of body composition, much higher levels of pro-inflammatory cytokines and higher mechanical demands can be observed, promoting chronic low-grade inflammation [26]. The authors found that obesity was associated with a higher risk of upper and lower extremity tendinopathy and was also associated with a higher risk of upper extremity tendon tears and ruptures leading to tendon surgery in both men and women. Interestingly, no association was found between BMI and lower extremity rupture. This effect may be due to the increased stress on the lower extremity with increased body mass. Our additional conclusion may be that loading can increase tendon durability even in a non-optimal body environment, increased inflammation in the whole body, and could be an argument that loading obese patients with proper progression could be beneficial for them. Unfortunately, we do not know what exactly proper progression is in this case. We can only conclude that we should be slower with loading progression when training the upper extremities than the lower extremities.

Factors that cannot really be influenced, but perhaps should be taken into account during resistance training, were described in the article by Lin et al. 2018 [8]. The authors pointed out that gender differences are important risk factors for some injuries. They described not only tendon and ligament problems, but of interest for this review were anterior cruciate ligament (ACL) injuries. According to the authors, females (the authors focused mainly on female athletes) are at greater risk of developing ACL injuries due to internal factors such as anatomical constitution (increased lateral tibial slope, smaller ACL size), but also external factors such as suboptimal landing mechanics, which were found to be more common in female athletes than in male athletes. We should not conclude that similar characteristics apply to all female tendons, muscles and ligaments, but perhaps we should be slower to increase loading. In particular, dynamic loading, such as the increasingly popular plyometric training, should be carefully planned, taking into account not only the load progression but also the correct technique and quality of movement, even more so in women than in men.

What was really interesting was the fact that important factors influencing general body condition are drugs [27]. For some time it has been suspected that statins may contribute to tendon injuries. In their study Thompson 2016 [28], which was a population-based retrospective cohort evaluation, the authors concluded that statin use was not associated with tendon rupture. Alves 2019 [9] performed a systematic and meta-analysis on the possible influence of the group of antibiotics, fluoroquinolones, on the increased risk of tendon injury. The topic seemed important because in 2016 the US Food and Drug Adminis-

tration (FDA) and in 2018 also the European Medicines Agency (EMA) prepared warnings about possible side effects of quinolone and fluoroquinolone antibiotics administered by mouth, injection or inhalation. Importantly, the side effects can last up to a year, according to the EMA. The authors conducted a literature search to identify observational studies that reported results on the risk of tendon injuries. The risk was statistically significant in patients aged ≥ 60 years. Analysis by type of fluoroquinolone was only possible for Achilles tendon injuries, which showed that ofloxacin and norfloxacin were associated with an increased risk of injury, but not ciprofloxacin and levofloxacin. The authors confirmed the risk of tendon injury associated with fluoroquinolones. Older age and concomitant use of corticosteroids appear to be additional risk factors for tendinopathy. It is important to note that these antibiotics are not often given to patients. Their use is usually associated with more serious health conditions when other antibiotics do not work. A current example might be COVID-19 patients who have developed long COVID syndrome. In these cases, antibiotics are sometimes used to facilitate the healing process and to prevent bacterial infections, which are more common due to the reduced efficiency of the immune system [29]. Physiotherapists should be aware of these possibilities and, if possible, ask about antibiotic treatment in the last 1-2 years.

In conclusion, there are not many studies that describe risk factors in strength training. On the other hand, we do know quite a lot about what reduces tendon injuries and makes them stronger.

Study limitations

The main limitation of this study was the lack of peer review by another independent person of this paper. The quality of the articles reviewed was generally high, although the problem was that the topic itself was quite broad and the papers described were not able to fully answer the study question. This topic, although quite interesting, is not really well researched and will require more studies in the future.

Clinical implications

There are not many studies on the subject, but it seems that we should be more careful about the progression of exercise when planning treatment. Especially for obese patients, upper extremity training. Female patients should also be given more consideration. Older patients, over 60 years old, when treated with antibiotics such as fluoroquinolones, ofloxacin, norfloxacin also have a greater risk of tendon injury. Generally, for any patient if we notice lack of strength, compared to other side, age, sex we should also be careful.

Conclusions

It is not clear what factors increase the risk of tendon and ligament injuries. Lack of strength may be an important factor that we can influence with proper training. It is interesting that there may be many ways to train and make tendons stronger, but we need more research for different age groups. It is also not clear how to assess strength and what is optimal for a particular age, gender, sport or profession.

To make training safer, we should be more aware of obese patients, especially when training the upper extremities. As the obesity epidemic is increasing, this could be an important factor in changing our approach to treatment. Further detailed studies are needed on the topic of entry strength assessment and load progression.

Women have a higher risk of ACL injury than men, so dynamic jumping and loading exercises (e.g. plyometrics) should be performed with more attention to progression and correct technique. We would like to see more research on this topic, what the situation is with other typical tendon problems such as hamstrings or rotator cuffs in women and if there are differences between the sexes.

What is good to know, and we can check this in C/O, is that there are certain antibiotics that have a side effect of increasing tendon stiffness and increasing the risk of injury. These are the

fluoroquinolones, especially ofloxacin and norfloxacin. Patients who are given these drugs, who are over 60 and who are taking corticosteroids are at even greater risk of developing tendinopathy. It is important to note that these antibiotics are not often taken by patients. They are used for more serious conditions when other antibiotics do not work. A current example could be COVID-19 patients who have developed long COVID syndrome. In these cases, antibiotics are sometimes used to facilitate the healing process and to prevent bacterial infections, which are more common due to the reduced efficiency of the immune system. Physiotherapists should be aware of these possibilities and ask about antibiotic treatment in the last 1-2 years, as the side effects can last a long time.

Declarations

Ethical Considerations: Ethical considerations are not required for this manuscript due to its review nature. This paper is based on a review of existing literature and does not involve new research on human or animal subjects; therefore, ethical approval is not applicable in light of the COPE (Committee on Publication Ethics) guidelines.

Clinical Trials: This study was not registered as a clinical trial as it did not involve investigational products or interventions that would classify it under clinical trial regulations.

Conflict of Interest: The authors declare no conflict of interest. The study was conducted independently and without any influence from external organizations or entities.

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