Worldwide Incidence and Surgical Costs of Tendon Injuries: A Systematic Review and Meta-Analysis

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SUMMARY
Purpose. Tendon injuries represent a broad and economically expensive problem in clinical reality, however, there is no systematic review or meta-analysis in the literature that delves into this topic. The aim of this work is to investigate the incidence and clinical costs of tendon rupture on a global, continental and national scale.
Methods. PubMed, Google Scholar, PICO (Politecnico di Torino's bibliographic search engine) were the online databases interrogated for research purposes, while the Minister of Health was the institution contacted to obtain data regarding hospitalization rates. FHM (Federal Health Monitoring) (1) and HES (Hospital Episode Statistics) (2) were the national databases interrogated respectively for German and England data. We looked for the most recent and specific data possible, so papers too outdated or too general were excluded.
Results. The total number of tendon ruptures in the world ranges from 80 to 90 cases per 100,000 inhabitants, *i.e.*, 6 to 7 million per year. There is a linear relationship between the incidence of cases and the population, whilst it seems to be no correlation between surgical costs and inhabitants, as it likely depends on the populousness and economical power of a country.
Conclusions. This research may serve physicians and healthcare policymakers to make more informed decisions. It will also provide valuable information to industries and researchers involved in tendon repair solutions, to better understand the extent of the phenomenon worldwide.

KEY WORDS
Tendon rupture; tendon injury; epidemiology; incidence rate; surgery cost.

INTRODUCTION
This paper reports a methodical review and meta-analysis of the information available in the international scientific literature regarding the incidence and cost of tendon rupture. The final aim is to provide an estimate of the incidence of tendon ruptures according to the population size of a given country. The collected incidence data will be analyzed to estimate an approximative trend linking the number of tendon ruptures and the population of a specific country or any other geographical region of the world. In addition, a forest plot to show the incidence rate for the Achilles tendons injury was made.

This will serve physicians and healthcare policymakers to make more informed decisions. Tendons are a fundamental element of the connection between the bone and the muscle (3); they transform the force of muscle contraction into movement. Therefore, their injury causes a significant loss of function, disability and pain.

The mechanism of tendon damage can be mechanical or degenerative and lead to tendinopathy or tendon rupture (4). Tears or lacerations can be caused by a single episode of stress exceeding the tendon level of intolerance (*e.g.*, due to a high impact event) or by mechanical direct trauma (*e.g.*, knife injury). Tendinitis or tendinosis can occur after repetitive submaximal loading (overuse sports injury (5)) or for intrinsic tissue degeneration with or without predisposing systemic diseases (*e.g.*, age, functional overload syndromes, amyloidosis). On the other hand, different factors can be associated with chronic tendon damage, such as:

- the presence of local factors (*e.g.,* an intratendinous foreign body, rheumatoid tendinitis, tuberculous tendinitis, actinomycotic focus, granulomatous tendinitis, non-specific tendinitis, gout affection, xanthoma or a tendon tumor (6));
- the side effects of some pathologies (*e.g.,* chronic systemic diseases, ankylosing spondylitis, autoimmune diseases, collagen abnormalities, renal insufficiency (4, 6, 7));
- the adverse effects of some drug treatments (*e.g.,* aromatase inhibitors, antibiotics such as fluoroquinolone, glucocorticoids after long-term regimens, statins and renin-angiotensin II agents) (7);
- metabolic disorders (such as diabetes mellitus, hypercholesterolemia, thyroid disorders, and impair tendons health) (8-10);
- constitutional factors (*e.g.,* obesity (11)), genetic factors (6) and blood group (ABO) (6, 12).

However, the data reported in literature have shown no uniform consensus between the proportions of ABO blood groups and Achilles tendon rupture (13).

To enhance tendon repair, different treatments can be chosen. First of all, treatment can be surgical (suture (14, 15), augmentation and reconstruction (16), implant of devices as the TenoFix™ (17, 18), Achillon™ (4, 19), nitinol devices (20, 21), OrthoCoupler™ (6), PONTiS™ (22)) or conservative (*e.g.,* immobilization with splint, physiotherapy sessions in particular TECAR, infiltrations with platelet gel, Hyaluronic acid (23), and other non-surgical options (4)). The Laboratory of Bio-inspired Nanomechanics at Politecnico di Torino study the field of tendon injury and its relative repair method evaluating new innovative technical repair, this paper is to give an evaluation of the impact of tendon injuries and their relative cost on the healthcare system, providing information on the importance of this issue, this aim drives the current research.

METHODS

Search strategy

Our research was mainly conducted through the online databases PubMed, Google Scholar and PICO to find reviews and articles dealing with the incidence and treatment cost of tendon ruptures. The following keywords "tendon rupture", "tendon damage", "tendon injury", "epidemiology", "incidence", and "cost" were used in separate searches and in conjunction using the Boolean operators "AND" and "OR". The number of tendon repair surgical operations performed in Italy during the period 2016-2018 was provided by the Italian Ministry of Health upon request by the authors, while NHS (National Health System) of England supplied the data regarding national hospitalization rates through the HES database. FHM database was interrogated for German data concerning tendon ruptures. Additional information were obtained by the Italian Ministry of Health, National Health System of England, and Federal Health Monitoring for German. These three last sources follow the same standard code to identify the diagnosis of the disease (ICD code). This study has been conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Study inclusion and exclusion criteria

We started by including all of the articles without limitation of the year of publication or language to include as much information as possible about as many countries as possible. Based on the title and the abstract, the selected articles were reduced to n = 130 for full-text evaluation. Whenever more than one document related to the same geographical area was available, we considered only the most recent data. In the end, on a total of 25 papers, 10 were excluded from our analysis, mainly because the data were deemed as obsolete. **Table I** reports the reviewed papers included and excluded for the meta-analysis of the tendon injury incidence and the sources included for the meta-analysis of the related treatments costs.

Study quality assessment

To reduce the possibility of introducing errors or not correct information all the authors assessed each included article. In general, the inclusion/exclusion criteria allowed to reduce the general risk of bias; thus, this meta-analysis can be considered acceptable overall.

All the authors reviewed each article for risk of bias considering the following information such as 1) direct or indirect data, 2) approximations used, 3) included population, and 4) precision in study methods as parameters to evaluate the quality of papers.

For the tendon ruptures section, only articles of Erickson (31) and De Jong (32) were evaluated with a medium risk of bias because they are indirect data. For the tendon repair cost, the article of Sahin (45), Kolstov (46), and Clark (34) were evaluated with a medium risk of bias because indirect data were reported. All the other articles were evaluated with a low risk of bias. A further methodological quality

Table I. Sources of the data, papers included and excluded for the incidence and cost analyses.

	Included papers (incidence analysis)
Reference	**Country surveyed (time period)**
Clayton, R. A. *et al.* (2008) (24)	Orthopaedic Trauma Unit, Royal Infirmary, Edinburgh, U.K. (1996 - 2000)
Lantto, I. *et al.* (2015) (25)	Finland, Achilles tendon rupture (1979-2011)
Gwynne-Jones, D. P. *et al.* (2011) (26)	New Zealand, Achilles tendon rupture (1999 - 2008)
Reito, A. *et al.* (2019) (27)	Finland, quadriceps tendon ruptures (1997 - 2014)
Huttunen, T. T. *et al.* (2014) (28)	Sweden, acute Achilles Tendon ruptures (2001- 2012)
Ganestam, A. *et al.* (2016) (29)	Denmark, acute Achilles tendon ruptures (1994 - 2013)
Sheth, U. *et al.* (2017) (30)	Ontario, Canada, acute Achilles Tendon ruptures (2003 - 2013)
Erickson, B. J. *et al.* (2014) (31)	U.S.A., Achilles tendon rupture (2005-2011)
De Jong, J. P. *et al.* (2014) (32)	Olmsted county, U.S.A., acute tendon injuries in the hand and wrist (2001-2010)
	Excluded papers (incidence analysis)
Reference	**Reason for the exclusion**
Maffulli, N. *et al.* (1999) (33)	More recent data were available for the U.K.
Clark, S. T. *et al.* (2020) (34)	We were not able to isolate the tendon data from the ligament's
Manninen, M. *et al.* (2017) (35)	More recent data were available for Finland
Leppilahti, J. *et al.* (1996) (36)	More recent data were available for Finland
Pajala, A. *et al.* (2002) (37)	More recent and general data were available for Finland
Möller, A. *et al* (1996) (38)	More recent and general data were available for Sweden
Houshian, S. *et al.* (1998) (39)	More recent data were available for Denmark
Suchak, A. A. *et al.* (2005) (40)	More recent data were available for Canada
Dy, C. J. *et al.* (2012) (41)	More general and recent data were available for the U.S.A.
Lemme, N. J. *et al.* (2018) (42)	The data we derived were outliers with respect to the others
	Included papers (cost analysis)
Reference	**Data**
Westin, O. *et al* (2018) (43)	Surgical cost for tendon repair in Sweden (2009-2010)
Nyyssönen, T. *et al* (2000) (44)	Surgical cost for tendon repair in Finland (1986-1996)
Şahin, F. *et al.* (2013) (45)	Surgical cost for tendon repair in Turkey (2009-2011)
Koltsov, J. C. *et al.* (2020) (46)	Surgical cost for tendon repair in the State of New York (2010-2014)
Goel, D. P. *et al.* (2009) (47)	Surgical cost for tendon repair in Canada (2002-2005)
Clark, S. T. *et al.* (2020) (34)	Surgical cost for tendon repair in New Zealand (2010-2016)

assessment analysis may be performed employing Coleman Methodology Scores (CMS) (48).
To assess the study quality, we reported the obtained results as a plot of the number of cases *vs* the population size. We found that the best interpolation curve is a simple linear regression. This was confirmed by further testing other higher-order polynomial approximations on the data. The issue will be better addressed in the Result section. The average error (expressed as a percentage) has been reported and plotted as well. We also expected an increase in tendon injuries over the time, due to general population growth and some changes in lifestyle (such as more sedentariness); this was used to further assess our study quality.

Data extraction strategy

The following data were extracted: 1) incidence rate; 2) type of tendon; 3) country in which the study was conducted; 4) study duration or year and 5) total number of participants.

As for the England, Italy and Germany data provided from local databases, we employed the 4-digit ICD standard code to isolate only tendon rupture cases among the other ones. Additional information about the information provided by national databases is presented in **appendix 1A, B**. The raw data regarding other countries were extracted from the papers mentioned in **table II**.

Data synthesis, elaboration and presentation

The raw data were elaborated to be compared and to establish potential relations between the number of tendon ruptures in a country and other factors (*e.g.,* the population of the country). **Table II** reports the raw data and our elaboration on them. To do so, some hypotheses have been followed:

1. We referred to 2019 as our target year. If data retrieved from the original sources referred to a previous year, we corrected them accordingly: if they referred to a multiyear period and showed an increase in the incidence during this time, we supposed the incidence to continue its growth linearly until 2019, if no increase was met, it was made an average between these years.
2. If the available data were referred to as "tendon repairs", this number was considered to be 60% of the total number of tendon ruptures, according to the practice suggested by Huttunen *et al*. (2014) (28). We used the numbers reported by the original sources whenever explicitly stated as "injuries", "ruptures", or similar terms.
3. If not sufficient, data were present for all typologies of tendons, the number of AT (Achilles tendon) ruptures has been estimated to be - of the total ruptures (as suggested by Clayton *et al*. (2008) (24)).
4. We considered two possible options to approximate the total number of tendon ruptures relative to a larger geographical area (such as a continent) departing from smaller portions of it (*i.e.*, single countries), specifically:
   a. by summing up the number of tendon ruptures calculated for the constituent surveyed countries/continents and summing up their respective populations as well to find a general percentage of incidence;
   b. by averaging the available incidence percentages of the constituent countries, not considering the remaining unsurveyed nations.
5. If more data about a specific country were found, they were employed to compare the obtained results and verify their coherence.

In this way, we obtained an estimated number of tendon ruptures not only for the countries whose data were found, but also for Europe, North America, Oceania and, lastly, for the whole world. The raw data about Achilles tendons rupture were elaborated in a separate excel file, also data from the national health institute were added.

Table II. Raw data and elaboration.

Raw data	Elaboration and Notes	Estimated Incidence (referred to 2019)	Estimated n of ruptures (referred to 2019)
Average number of tendon repairs from 2016 to 2018: 26,066 in Italy.	The number of tendon repairs has been considered to be the 60% of the total tendon ruptures.	Average number of tendon ruptures per year: 43,443.	43,443 tendon ruptures in Italy.
Total incidence of different tendon injuries in Germany (1), based on 4 characters ICD code: 58,963. More details on the selected codes are shown in **appendix 1A**.	Total tendon injuries number has been used to estimate an incidence per 100,000 inhabitants, using the current population in 2019.	General incidence per year: 71.02/100,000.	58,963 tendon ruptures in Germany.
Total incidence of different tendon injuries in England (2), based on 4 characters ICD code: 53,534. More details on the selected codes are shown in **appendix 1B**. Note: reference period of this data is 2018-2019, so we considered this number as an average between these two years.	Total tendon injuries number has been used to estimate an incidence per 100,000 inhabitants, using the current population at 2019.	General incidence per year: 91.38/100,000.	53,534 tendon ruptures in England.

Raw data	Elaboration and Notes	Estimated Incidence (referred to 2019)	Estimated n of ruptures (referred to 2019)
The incidence per 100,000 person-years of AT rupture increased from 2.1 in 1979 to 21.5 in 2011 in Oulu, Finland (25). The incidence per 100,000 person-years of quadriceps tendon rupture increased from 0.55 to 2.82 from 1997 to 2014 in Finland (27).	In both cases, the linearity hypothesis was followed, leading to an estimated incidence for 2019. The result obtained for Oulu has then been projected on the national scale.	Incidence per 100,000 person-years of AT rupture: 26.35; Incidence per 100,000 person-years of quadriceps tendon rupture: 3.49; Number of AT ruptures in Finland: 1,454; Number of quadriceps tendon ruptures in Finland: 193.	4,555 tendon ruptures in Finland.
The sex-specific incidence per 100,000 person-years of AT ruptures was 47.0 in men and 12.0 in women in 2001 and 55.2 in men and 14.7 in women in 2012 in Sweden (28).	The sex-specific incidences and samples have been summed up to find the non-sex specific incidence of AT rupture in 2001 and 2011. Then, the linearity hypothesis was followed.	Incidence per 100,000 person-years of AT rupture in 2019: 38.42; Number of AT ruptures: 3 930.	11,790 tendon ruptures in Sweden.
The incidence per 100,000 person-years of AT rupture increased from 26.95 in 1994 to 31.17 in 2013 in Denmark (29).	The linearity hypothesis was followed, leading to an estimated incidence for 2019.	Incidence per 100,000 person-years of AT rupture: 32.50; Number of Achilles tendon ruptures: 1887.	5,661 tendon ruptures in Denmark.
The incidence per 100,000 person-years of AT rupture increased from 18.0 in 2003 to 29.3 in 2013 in Canada (30).	The linearity hypothesis was followed, leading to an estimated incidence for 2019.	Incidence per 100,000 person-years of AT rupture: 36.08; Number of AT ruptures: 12 657.	37,971 tendon ruptures in Canada.
The incidence per 100,000 person-years of Achilles tendon rupture was 24 between 1999 and 2008 in New Zealand (26).	The incidence was hypothesized to stay constant until 2019.	Number of AT ruptures: 1 184.	3,552 tendon ruptures in New Zealand.
The incidence per 10,000 person-years of AT rupture increased from 0.67 in 2005 to 1.08 in 2011 in the USA (31). The incidence per 100,000 person years of hand and wrist tendon rupture was 33.2 in the period 2001-2010 in the USA (32).	We hypothesized the incidence of hand and wrist tendon rupture to stay constant until 2019. As for the AT ruptures, the linearity hypothesis was pursued, leading to an estimated incidence for 2019. The studies of Erickson *et al.* (2014) (26) and De Jong, *et al.* (2014) (27) are not well in accordance with the assumed prevalence of AT ruptures over hand and wrist tendons (19). This may be due to the study of De Jong *et al.* (2014) (27) being based solely on a small geographical area (Olmsted County, Minnesota, USA)	Number of AT ruptures: 66 781. Number of hand and wrist tendon ruptures: 108,896.	309,239 tendon ruptures in the USA.

RESULTS

Study characteristics

The search of published literature conducted via several databases yielded numerous articles that included the keywords used in the first search phase (tendon rupture, tendon damage, tendon injury, epidemiology, incidence, cost) combined together. After the title and abstract of each study were examined and the articles, which reported the same information, were excluded. In conclusion, 15 articles were used in this analysis of the number of total ruptures and the costs. The exact procedure is portrayed in **figure 1**.

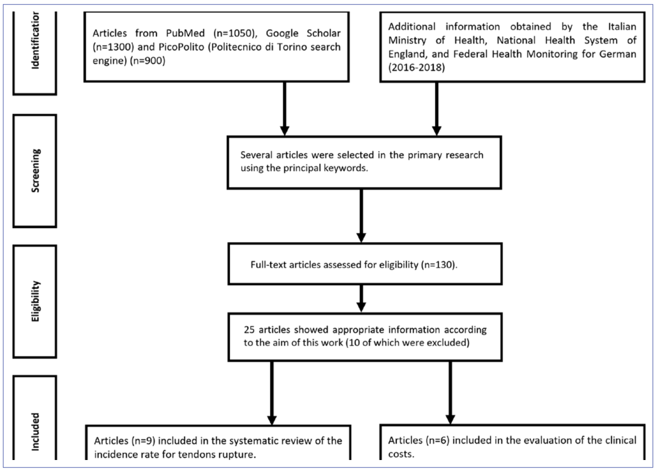

Figure 1. The PRISMA flow diagram of the studies that were initially identified, with all the steps leading to the final inclusion of 15 studies in this systematic review.

Quantitative synthesis/Meta-Analysis

Incidence of AT ruptures

The incidence of AT ruptures is the one more discussed in the scientific literature and for which more data were found. This is reported in the forest plot in **figure 2**.

Incidence in Europe

The obtained results for the European countries are shown in **table III** together with the results obtained for Europe following the two strategies defined in the Methods section (*i.e.*, method "**a**" and method "**b**", respectively employed in rows "**a**" and "**b**").

Other Continents and worldwide incidence

Regarding the rest of the world, only data about Canada, New Zealand, and the U.S.A. have been found. The New Zealander data has been employed to approximate the incidence rate in Oceania, assumed as equal to that of New Zealand. The incidence rate in North America was found following the first of the previously reported strategies (method "**a**"; we summed up the U.S.A. and Canada's cases and populations to find an average incidence). Thus, to be coherent, it has been considered the European data obtained in the same way. The results are shown in **table IV**. Also, to find a general incidence to apply to the world case and then calculate the total tendon ruptures in the world, the same two strategies applied for Europe have been pursued. In **table IV**, world rows "**Ia**" and "**Ib**" and the calculations and approximations have been performed taking into account the aggregated data for Europe, North America and Oceania, while in rows "**IIa**" and "**IIb**" Italy, United Kingdom, Finland, Sweden, Denmark, the State of New York, Canada and New Zealand's data have been considered.

Incidence according to the population

To analyze the obtained results, the number of tendon ruptures for the reported countries has been plotted against their respective populations (**figure 3A**). The interpolation curve has been found to follow the equation:

$n(p) = 6.0072 \times p \times 10\text{-}4 + 3461$

It has been verified that, if the data were interpolated with a third-degree polynomial line, the coefficients of the second- and third-degree terms were multiplied respectively by 10^{-12} and 10^{-21}. Thus, one can safely assume the interpolation curve to be a single-degree polynomial, which means that the relation between the number of tendon ruptures in a geographical region and its population can be approximated to be linear.

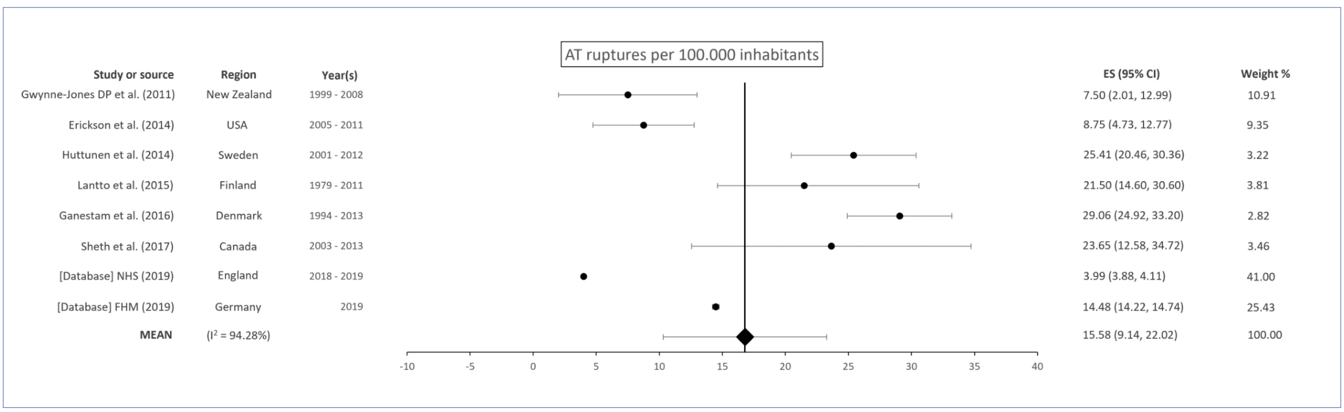

Figure 2. Forest plot of the incidence rate of the AT rupture in different countries.

Table III. Approximated tendon rupture numbers and incidences for the reported European countries and calculations for the total European incidence.

Surveyed countries				
	Total tendon ruptures (rounded)	Population	Incidence per 100,000 (calculated)	Incidence per 100,000 (rounded)
Italy	44,000	60,360,000	72.90	73
England	51,000	56,287,000	90.61	91
Finland	5,000	5,518,000	90.61	91
Sweden	12,000	10,230,000	117.30	117
Denmark	6,000	5,806,000	103.34	103
Germany	59,000	83,019,000	71.07	71

Europe							
	Total population of the surveyed countries (aggregate)	Total analysed cases	Average Incidence	European population	European population	Total tendon ruptures per year	Total tendon ruptures /year (rounded)
a	221,220,000	177,000	80	513,719,000	411,000	411,000	0.41 mil
b	n.d.	n.d.	91	513,719,000	467,000	467,000	0.47 mil

Table IV. Approximated tendon rupture numbers and incidences for the reported non-European countries and calculations for the world zones and the worldwide incidence.

Surveyed countries				
	Total tendon ruptures (rounded)	Population	Incidence per 100,000 (calculated)	Incidence per 100,000 (rounded)
Canada	38,000	38,005,000	99.99	100
New Zealand	4,000	4,979,000	80.34	80
USA	309, 000	328,240,000	94.14	94
World zones				
Europe	411,000	513,719,000	80.00	80
North America (USA and Canada)	347,000	366,245,000	94.75	95
Oceania	18,000	24,990,000	72.03	72

Worldwide incidence						
	Total population of the surveyed countries (aggregated)	Total analysed cases	Average Incidence per 100,000	Population	Total tendon ruptures per year	Total tendon ruptures per year (rounded)
Ia	904,954,000	776,000	86	7,786,799 000	6,697,000	6.70 mil
Ib	n.d.	n.d.	82	7,786,799,000	6,385,000	6.39 mil
IIa	592,444,000	528,000	89	7,786,799,000	6,930,000	6.93 mil
IIb	n.d.	n.d.	91	7,786,799,000	7,086,000	7.09 mil

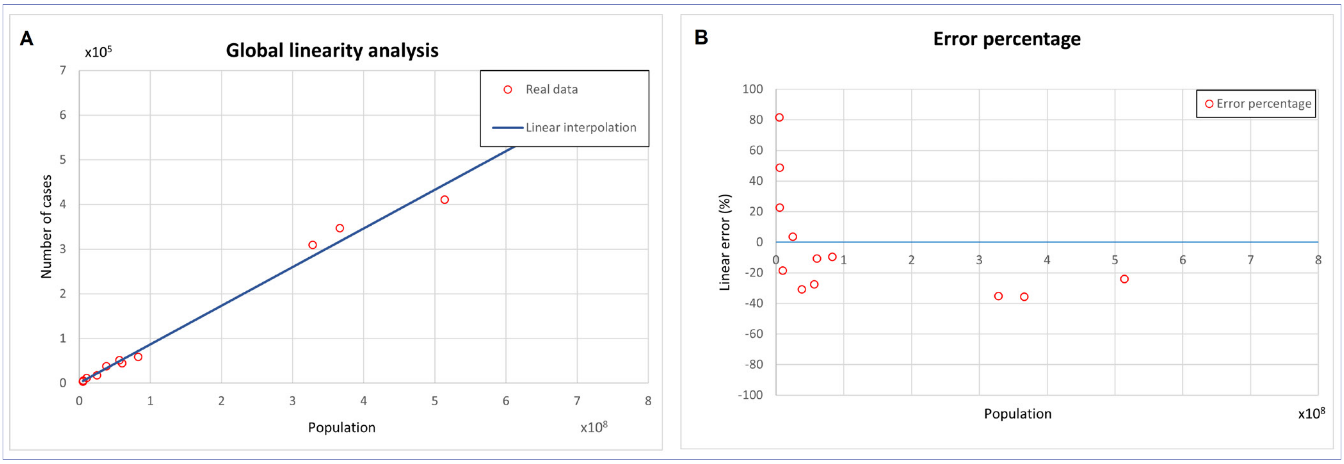

Figure 3. (A) Population size *vs* number of cases. Red dots: data estimated from the literature. Solid blue line: linear interpolation; **(B)** Error diagram.

In conclusion, the total number of tendon ruptures in the world appears to range between 80 to 90 cases per 100,000 inhabitants, *i.e.*, 6 to 7 million people per year.

Incidence according to age and gender

Tendon properties change as time passes and the subject ages. Therefore, one can define an incidence of tendon rupture according to the age of the patient. In particular, the age group percentage of the injured with respect to the total number of injuries has been obtained by averaging the data received from the Italian Ministry of Health (2016-2018). The injury percentages by age group resulted to be 8% (5-13 years); 6% (14-24 years); 15% (25-44 years); 23% (45-64 years); 19% (65-74 years) and 28% (over 75 years). It has also been estimated from these data that the mean age of patients who suffered a tendon rupture is 53 years.

As for the gender incidence, it has been decided to choose three countries and suppose their data to be representative of their world zone. In particular, has been found data relative to Finland (27), representative of Europe, the United States (42), representative of North America, and New Zealand (34), representative of Oceania. In particular, we obtained a percentage of incidence of 10.3 for females against a percentage of incidence of 89.7 for males in Europe; a female percentage of incidence of 22.9 against 77.1 for males in North America and a female incidence of 44 against 56 for males in Oceania. This data can be compared to the study conducted by Ho *et al.* (2017) (49), who reported a percentage of incidence of 19 for women and 81 for men.

Cost analysis

As for the cost analysis, the elaborated data are shown in **table V**. It must be noted that the reported number of tendon ruptures are those that had been previously found except for the State of New York; in this case, to calculate the number of tendon ruptures, the incidence found for the U.S.A has been applied to the New Yorker population (19.45 mil in 2019).

In **table V**, for Sweden, Finland, the State of New York and Canada, the costs are referred to the AT repair, while, for Turkey, the cost is referred to hand tendon repair and, for New Zealand, the cost is referred to both tendon and ligament repair. The data have been analyzed all together, regardless of the district of surgery, because they have all been considered generally referred to as surgical tendon repair and, thus, comparable in the broader terms. The presented data for Europe, North America and Oceania have been obtained by analyzing the collected information. Firstly, the average surgical cost in Europe was estimated by weighting the available data in Sweden, Finland and Turkey for their population and also applied to Italy. Similarly, the average and total surgical costs in North America have been calculated in the same way using the data from the State of New York and Canada. Then, the surgical cost in New Zealand has been approximated to be that of the whole of Oceania to obtain the total surgical cost in this continent. In the end, the average and total surgical cost for tendon repair in the world have been estimated using Europe, North America and Oceania's data shown in the World (**I**) row and using Sweden, Finland, Turkey, State of New York, Canada and Oceania's data shown in **table V** in the World (**II**) row. The total surgical tendon repair cost in the world is therefore estimated to be approximately 30 billion euros. To conclude, it was found from a survey conducted by the authors among 51 expert orthopedics and hand surgeons that in Italy the hand tendon repair cost is approximate-

Table V. Cost of tendon repair.

	Surgical cost (€)	Total tendon ruptures	Surgical treatments	Total surgical cost (€)	Total surgical cost per year (€) (rounded)
Surveyed countries					
Sweden	7,332 (38)	12,000	7,200	52,790,400	52.80 mil
Finland	1,259 (39)	5,000	3,000	3,777 000	3.78 mil
Turkey	1,772 (40)	66,000*	39,600	70,171,200	70.17 mil
State of New York	12,764 (41)	18,000	10,800	137,851,200	137.85 mil
Canada	16,705 (42)	38,000	22,800	380,874,000	380.87 mil
New Zealand	822 (29)	4,000	2,400	1,972,800	1.97 mil
World zones					
Europe	3,454	411,000	246,600	851,756,400	8.52 mil
North America	14,734	347,000	208,200	3,067,618,800	3.07 bil
Oceania	822	18,000	10,800	8,877,600	8.88 mil
World					
I	6,337	6,697,000	4,018,200	25,463,333,400	25.46 bil
II	6,776	7,008,000	4,204,800	28,491,724,800	28.49 bil

Reported data: elaboration and results for the reported countries, the world zones and the world.

ly €800 (considering the operating theatre costs, consumables and hospitalization). Therefore, applying the estimated average European cost for tendon repair of €3,454 would be a large overestimation, whereby the average cost is more similar to those in Finland or Turkey, ranging between €1,000 and €2,000.

DISCUSSION

Meta-analysis is a well-designed statistical method integrating the common outcome data from other studies to settle global conclusions or evaluations about a specific issue. To the best of our knowledge, this is the first comprehensive meta-analysis aiming at defining the tendon incidence rate and the relative costs. Due to a significant lack of reported data in the scientific literature, hypotheses and approximations had to be made. These were reported in the method section. As for the Italian case, the total number of tendon ruptures per year has been estimated considering the data provided by the Ministry of Health. In particular, the provided data concerned the total number of tendon repairs in Italy in 2016 (26,549 tendon ruptures), 2017 (25,598 tendon ruptures) and 2018 (26,050 tendon ruptures). We chose to average those numbers to estimate the number of tendon ruptures in Italy per year and we obtained the number of 26,066 tendon ruptures per year in Italy.

Furthermore, considering the assumptions and the approximations made, it can be said that the two methods employed to evaluate the number of tendon ruptures on a wider scale (Europe in this case) lead to similar results and can therefore be safely considered equivalent for the aim of this study. The total number of tendon ruptures in the world appears to range between 82 to 91 cases per 100,000 inhabitants, *i.e.*, 6 to 7 million people per year.

By conducting an error study on the linear interpolation (**figure 3B**), we found a higher error rate in countries with a smaller population than in more populous ones: it would be logical to think this is produced by injury causes' multiplicity and by the fact that every probability approaches the real value of cases as the population increases. Furthermore, the obtained curve does not pass through the axes' origin, which means that for a population of 0 people there would be non-0 cases of tendon ruptures, which is impossible.

Secondly, the model does not take into consideration many factors such as lifestyle, industrialization, economic power, etc. that could affect the number of tendon ruptures in a Country and could change the graph into a non-linear and more complex one. Therefore, the obtained result is only an approximation linking the number of tendon ruptures to the population of a Country. It is reasonable to believe that the number of tendon ruptures depends on more factors than the population only. On the other hand, all of the factors could not have been taken into consideration in this work but, if they were, it is reasonable to believe that the prediction model for the number of tendon ruptures would have been much more complex and probably non-linear. Overall, considering the error diagram in **figure 3B**, the model can still be considered a valid approximation of the relation "population *vs* tendon ruptures" in a geographical area, as shown in **figure 3A**.

Male incidence is generally higher than female one, although tendon ruptures among women have grown over years. This last phenomenon could be explained through the increasing participation of women in physical activity: the proportion of female participants in sports injury surveys has increased during the past few decades.

As reported by Bonilla *et al*. (2019) (50) sex hormones could play a significant role in the gap between male and female incidence of tendon rupture. The presence or absence of estrogen, whose receptors are expressed by tenocytes, affects proteoglycan expression, tendon metabolism, tendon healing, tenocyte viability, tendon laxity and also adaptive response to exercise in females or increases collagen expression.

For what concerns the cost analysis, the authors convey that the cost is likely to depend on the population and the level of economic development of the country.

CONCLUSIONS

This meta-analysis aimed to evaluate the tendon incidence rate and its relative costs of surgery worldwide. For this purpose, the Italian Ministry of Health, the National Health System of England, and Federal Health Monitoring for German were consulted in addition to the information reported in the literature (fifteen articles).

To evaluate the number of tendon ruptures on a wider scale two approximations based on literature were made. The two approximations show similar results in terms of average incidence per 100,000 inhabitants and total tendon ruptures per year.

Only a few articles reported the surgical cost analysis of the tendon repair surgery. The two types of approximations made by the authors show a similar result for the worldwide cost.

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DATA AVAILABILITY

All the data used in this research are available at the referenced sources.

CONTRIBUTIONS

FB, MRR, OGR: conceptualization, supervision. MC: conceptualization, methodology, validation, supervision, investigation, writing – review & editing. VB: supervision, writing – original draft. CS: funding acquisition, resources, supervision, investigation, project administration.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. The Information System of Federal Health Monitoring, Gesundheitsberichterstattung des Bundesavailable at Gesundheit Statistik Gesundheitsberichterstattung des Bundes. Available at: gbe-bund.de. Last access date: 06/22/2022.
2. Hospital Episode Statistics from NHS Digital, available at Hospital Episode Statistics (HES) - NHS Digital. Available at: https://digital.nhs.uk/. Last access date: 06/22/2022.
3. Wolfe SW, Pederson WC, Kozin SH, Cohen MS (eds). Green's Operative Hand Surgery. Elsevier Health Sciences, 2016.
4. Bistolfi A, Zanovello J, Lioce E, et al. Achilles Tendon Injuries: Comparison of Different Conservative and Surgical Treatment and Rehabilitation. J Nov Physiother Rehabil. 2017;1:039-053. doi: 10.29328/journal.jnpr.1001006.
5. Wertz J, Galli M, Borchers JR. Achilles Tendon Rupture: Risk Assessment for Aerial and Ground Athletes. Sports Health. 2013;5(5):407–9. doi: 10.1177/1941738112472165.
6. Kannus P, Natri A. Etiology and pathophysiology of tendon ruptures in sports. Scand J Med Sci Sport. 1997;7(2):107-12. doi: 10.1111/j.1600-0838.1997.tb00126.x.
7. Nyyssönen T, Lantto I, Lüthje P, Selander T, Kröger H. Drug treatments associated with Achilles tendon rupture. A case-control study involving 1118 Achilles tendon ruptures.

Scand J Med Sci Sport. 2018;28(12):2625-9. doi: 10.1111/sms.13281.
8. Oliva F, Marsilio E, Asparago G, et al. Achilles Tendon Rupture and Dysmetabolic Diseases: A Multicentric, Epidemiologic Study. J Clin Med. 2022;11(13):3698. doi: 10.3390/jcm11133698.
9. Oliva F, Piccirilli E, Berardi AC, Tarantino U, Maffulli N. Influence of Thyroid Hormones on Tendon Homeostasis. Adv Exp Med Biol. 2016;920:133-8. doi: 10.1007/978-3-319-33943-6_12.
10. Oliva F, Osti L, Padulo J, Maffulli N. Epidemiology of the rotator cuff tears: a new incidence related to thyroid disease. Muscles Ligaments Tendons J. 2014;4(3):309-14. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/pmid/25489548/.
11. Maffulli N. Rupture of the Achilles tendon. J Bone Joint Surg Am. 1999;81(7):1019-36. doi: 10.2106/00004623-199907000-00017.
12. Maffulli N, Wong J, Almekinders LC. Types and epidemiology of tendinopathy. Clin Sports Med. 2003;22(4):675-92. doi: 10.1016/S0278-5919(03)00004-8.
13. Maffulli N, Reaper JA, Waterston SW, Ahya T. ABO blood groups and achilles tendon rupture in the Grampian Region of Scotland. Clin J Sport Med. 2000;10(4):269-71. doi: 10.1097/00042752-200010000-00008.
14. Rawson S, Cartmell S, Wong J. Suture techniques for tendon repair; a comparative review. Muscles Ligaments Tendons J. 2013;3(3):220-8. doi: 10.11138/mltj/2013.3.3.220.
15. Singh R, Rymer B, Theobald P, Thomas PBM. A review of current concepts in flexor tendon repair: Physiology, biomechanics, surgical technique and rehabilitation. Orthop Rev (Pavia). 2015;7(4):101-5. doi: 10.4081/or.2015.6125.
16. Malagelada F, Clark C, Dega R. Management of chronic Achilles tendon ruptures—A review. Foot. 2016;28:54-60. doi: 10.1016/j.foot.2016.05.001.
17. Kubat W, Hsu J, Azharian A, Rekant M. The use of Teno Fix tendon repair device in a patient with multiple flexor tendon ruptures. J Hand Microsurg. 2016;02(01):28-30. doi: 10.1007/s12593-010-0004-9.
18. Brian W Su, Solomons M, Barrow A, et al. Device for zone-II flexor tendon repair. A multicenter, randomized, blinded, clinical trial. J bone Jt surgery. 2005;87(5):923-35. doi: 10.2106/JBJS.C.01483.
19. Assal M. Minimal invasive Achilles tendon suture system. Available at: http://fischermedical.dk/wp-content/uploads/Achillon.pdf. Last access date: 22/07/2022.
20. Reese SP, Kubiak EN. A Nitinol based flexor tendon fixation device: Gapping and tensile strength measurements in cadaver flexor tendon. J Biomech Eng. 2014;136(1):014501. doi: 10.1115/1.4025779.
21. Hirpara KM, Sullivan PJ, O'Sullivan ME. A new barbed device for repair of flexor tendons. J Bone Jt Surg - Ser B. 2010;92(8):1165-70. doi: 10.1302/0301-620X.92B8.23029.
22. Pontis. Pontis, Surgical Technique. Available at: https://pontisorthopaedics.com/. Last access date: 22/07/2022.
23. Oliva F, Marsilio E, Asparago G, Frizziero A, Berardi AC, Maffulli N. The Impact of Hyaluronic Acid on Tendon Physiology and Its Clinical Application in Tendinopathies. Cells. 2021;10(11):3081. doi: 10.3390/cells10113081.
24. Clayton RAE, Court-Brown CM. The epidemiology of musculoskeletal tendinous and ligamentous injuries. Injury. 2008;39(12):1338-44. doi: 10.1016/j.injury.2008.06.021.
25. Lantto I, Heikkinen J, Flinkkilä T, Ohtonen P, Leppilahti J. Epidemiology of Achilles tendon ruptures: Increasing incidence over a 33-year period. Scand J Med Sci Sport. 2015;25(1):e133-8. doi: 10.1111/sms.12253.
26. Gwynne-Jones DP, Sims M, Handcock D. Epidemiology and outcomes of acute achilles tendon rupture with operative or nonoperative treatment using an identical functional bracing protocol. Foot Ankle Int. 2011;32(4):337-43. doi: 10.3113/FAI.2011.0337.
27. Reito A, Paloneva J, Mattila VM, Launonen AP. The increasing incidence of surgically treated quadriceps tendon ruptures. Knee Surgery, Sport Traumatol Arthrosc. 2019;27(11):3644-9. doi: 10.1007/s00167-019-05453-y.
28. Huttunen TT, Kannus P, Rolf C, Felländer-Tsai L, Mattila VM. Acute achilles tendon ruptures: Incidence of injury and surgery in Sweden between 2001 and 2012. Am J Sports Med. 2014;42(10):2419-23. doi: 10.1177/0363546514540599.
29. Ganestam A, Kallemose T, Troelsen A, Barfod KW. Increasing incidence of acute Achilles tendon rupture and a noticeable decline in surgical treatment from 1994 to 2013. A nationwide registry study of 33,160 patients. Knee Surg Sport Traumatol Arthrosc. 2016;24(12):3730–7. doi: 10.1007/s00167-015-3544-5.
30. Sheth U, Wasserstein D, Jenkinson R, Moineddin R, Kreder H, Jaglal SB. The epidemiology and trends in management of acute Achilles tendon ruptures in Ontario, Canada a population-based study of 27 607 patients. Bone Jt J. 2017;99-B(1):78-86. doi: 10.1302/0301-620X.99B1.BJJ-2016-0434.R1.
31. Erickson BJ, Cvetanovich GL, Nwachukwu BU, et al. Trends in the management of achilles tendon ruptures in the united states medicare population, 2005-2011. Orthop J Sport Med. 2014;2(9):2325967114549948. doi: 10.1177/2325967114549948.
32. de Jong JP, Nguyen JT, Sonnema AJM, Nguyen EC, Amadio PC, Moran SL. The incidence of acute traumatic tendon injuries in the hand and wrist: A 10-year population-based study. Clin Orthop Surg. 2014;6(2):196-202. doi: 10.4055/cios.2014.6.2.196.
33. Maffulli N, Waterston SW, Squair J, Reaper J, Douglas AS. Changing incidence of Achilles tendon rupture in Scotland: a 15-year study. Clin J Sport Med. 1999;9(3):157-60. doi: 10.1097/00042752-199907000-00007.
34. Clark ST, Zhu M, Gamble GD, et al. Epidemiology of tendon and ligament injuries in Aotearoa/New Zealand between 2010 and 2016. Inj Epidemiol. 2020;7(1):5. doi: 10.1186/s40621-020-0231-x.
35. Manninen M, Karjalainen T, Määttä J, Flinkkilä T. Epidemiology of Flexor Tendon Injuries of the Hand in a Northern Finnish Population. Scand J Surg. 2017;106(3):278-82. doi: 10.1177/1457496916665544.
36. Leppilahti J, Puranen J, Orava S. Incidence of Achilles tendon rupture. Acta Orthop Scand. 1996;67(3):277-9. doi: 10.3109/17453679608994688.
37. Pajala A, Kangas J, Ohtonen P, Leppilahti J. Rerupture and deep infection following treatment of total Achilles tendon rupture.

J Bone Jt Surg. 2002;84(11):2016-21. doi: 10.2106/00004623-200211000-00017.
38. Moller A, Astrom M, Westlin. Increasing incidence of Achilles tendon rupture. Acta Orthop Scand. 1996.;67(5):479-81. doi: 10.3109/17453679608996672.
39. Houshian S, Tscherning T, Riegels-Nielsen P. The epidemiology of achilles tendon rupture in a Danish county. Injury. 1998;29(9):651-4. doi: 10.1016/s0020-1383(98)00147-8.
40. Suchak AA, Bostick G, Reid D, Blitz S, Jomha N. The incidence of Achilles tendon ruptures in Edmonton, Canada. Foot Ankle Int. 2005;26(11):932-6. doi: 10.1177/107110070502601106.
41. Dy CJ, Daluiski A, Do HT, Hernandez-Soria A, Marx R, Lyman S. The epidemiology of reoperation after flexor tendon repair. J Hand Surg Am. 2012;37(5):919-24. doi: 10.1016/j.jhsa.2012.02.003.
42. Lemme NJ, Li NY, DeFroda SF, Kleiner J, Owens BD. Epidemiology of Achilles Tendon Ruptures in the United States: Athletic and Nonathletic Injuries From 2012 to 2016. Orthop J Sport Med. 2018;6(11):2325967118808238. doi: 10.1177/2325967118808238.
43. Westin O, Svensson M, Nilsson Helander K, et al. Cost-effectiveness analysis of surgical versus non-surgical management of acute Achilles tendon ruptures. Knee Surg Sport Traumatol Arthrosc. 2018;26(10):3074-82. doi: 10.1007/s00167-018-4953-z.
44. Nyyssönen T, Lüthje P. Achilles tendon ruptures in South-East Finland between 1986-1996, with special reference to epidemiology, complications of surgery and hospital costs. 2000;89(1):53-7. Available at: https://pubmed.ncbi.nlm.nih.gov/10791646/.
45. Şahin F, Akca H, Akkaya N, Zincir ÖD, Işik A. Cost analysis and related factors in patients with traumatic hand injury. J Hand Surg Eur Vol. 2013;38(6):673-9. doi: 10.1177/1753193412469012.
46. Koltsov JCB, Gribbin C, Ellis SJ, Nwachukwu BU. Cost-effectiveness of Operative Versus Non-operative Management of Acute Achilles Tendon Ruptures. HSS J. 2020;16(1):39-45. doi: 10.1007/s11420-019-09684-0.
47. Goel DP, Chan D, Watson K, Mohtadi N. Safety and hospital costs of Achilles tendon surgery: The serendipitous impact of a randomized clinical trial. Can J Surg. 2009;52(6):467-72. Available at: https://www.canjsurg.ca/lookup/pmidlookup?view=long&pmid=20011182.
48. Coleman BD, Khan KM, Maffulli N, Cook JL, Wark JD. Studies of surgical outcome after patellar tendinopathy: clinical significance of methodological deficiencies and guidelines for future studies. Victorian Institute of Sport Tendon Study Group. Scand J Med Sci Sports. 2000;10(1):2-11. doi: 10.1034/j.1600-0838.2000.010001002.x.
49. Ho G, Tantigate D, Kirschenbaum J, Greisberg JK, Vosseller JT. Increasing age in Achilles rupture patients over time. Injury. 2017;48(7):1701-9. doi: 10.1016/j.injury.2017.04.007.
50. Bonilla KA, Pardes AM, Freedman BR, Soslowsky LJ. Supraspinatus Tendons Have Different Mechanical Properties Across Sex. J Biomech Eng. 2019;141(1):0110021-0110028. doi: 10.1115/1.4041321.

SUPPLEMENTS

Appendix 1. (A) ICD 4-digit codes Germany; **(B)** ICD 4-digit codes England.

(A)

M66.2	Spontaneous rupture of extensor tendons	1.402
M66.3	Spontaneous rupture of flexor tendons	1.703
M66.4	Spontaneous rupture of other tendons	626
M66.5	Spontaneous rupture of unspecified tendon	216
M76.5	Patellar tendinitis	320
M76.8	Other enthesopathies of lower limb, excluding foot	464
M76.9	Enthesopathy of lower limb, unspecified	26
M77.0	Medial epicondylitis	224
M77.1	Lateral epicondylitis	1.212
M77.5	Other enthesopathy of foot	759
M77.8	Other enthesopathies, not elsewhere classified	1.002
M77.9	Enthensopathy, unspecified	408
S09.1	Injury of muscle and tendon of head	77
S16.X	Injury of muscle and tendon at neck level	112
S29.0	Injury of muscle and tendon at thorax level	83
S39.0	Injury of muscle and tendon of abdomen, lower back and pelvis	933
S46.X	Injury of muscle and tendon at shoulder and upper arm level	12.951
S56.X	Injury of muscle and tendon at forearm level	1.412
S66.X	Injury of muscle and tendon at wrist and hand level	10.198
S76.X	Injury of muscle and tendon at hip and thingh level	9.459
S86.X	Injury of muscle and tendon at lower leg level	14.092
S96.X	Injury of muscle and tendon at ankle and foot level	1.043
T06.4	Injuries of muscles and tendons involving multiple body regions	0
T09.5	Injury of unspecified muscle and tendon of trunk	12
T11.5	Injury of unspecified muscle and tendon of upper limb, level unspecified	1
T13.5	Injury of unspecified muscle and tendon of lower limb, level unspecified	9
T14.6	Injury of muscles and tendons of unspecified body region	214
T92.5	Sequelae of injury of muscle and tendon of upper limb	0
T93.5	Sequelae of injury of muscle and tendon of lower limb	3

(B)

M66.2	Spontaneous rupture of extensor tendons	677
M66.3	Spontaneous rupture of flexor tendons	801
M66.4	Spontaneous rupture of other tendons	726
M66.5	Spontaneous rupture of unspecified tendon	312
M76.5	Patellar tendinitis	447
M76.8	Other enthesopathies of lower limb, excluding foot	605
M76.9	Enthesopathy of lower limb, unspecified	36
M77.0	Medial epicondylitis	934
M77.1	Lateral epicondylitis	3.033

M77.5	Other enthesopathy of foot	539
M77.8	Other enthesopathies, not elsewhere classified	105
M77.9	Enthensopathy, unspecified	1.519
S09.1	Injury of muscle and tendon of head	223
S16.X	Injury of muscle and tendon at neck level	352
S29.0	Injury of muscle and tendon at thorax level	394
S39.0	Injury of muscle and tendon of abdomen, lower back and pelvis	1.228
S46.0	Injury of muscle(s) and tendon(s) of the rotator cuff of shoulder	2.141
S46.1	Injury of muscle and tendon of long head of biceps	313
S46.2	Injury of muscle and tendon of other parts of biceps	2.031
S46.3	Injury of muscle and tendon of triceps	429
S46.7	Injury of multiple muscles and tendons at shoulder and upper arm level	91
S46.8	Injury of other muscles and tendons at shoulder and upper arm level	421
S46.9	Injury of unspecified muscle and tendon at shoulder and upper arm level	310
S56.0	Injury of flexor muscle and tendon of thumb at forearm level	71
S56.1	Injury of long flexor muscle and tendon of other finger(s) at forearm level	984
S56.2	Injury of other flexor muscle and tendon at forearm level	935
S56.3	Injury of extensor or abductor muscles and tendons of thumb at forearm level	472
S56.4	Injury of extensor muscle and tendon of other finger(s) at forearm level	1.161
S56.5	Injury of other extensor muscle and tendon at forearm level	524
S56.7	Injury of multiple muscles and tendons at forearm level	263
S56.8	Injury of other and unspecified muscles and tendons at forearm level	508
S66.0	Injury of long flexor muscle and tendon of thumb at wrist and hand level	1.072
S66.1	Injury of flexor muscle and tendon of other finger at wrist and hand level	4.523
S66.2	Injury of extensor muscle and tendon of thumb at wrist and hand level	2.077
S66.3	Injury of extensor muscle and tendon of other finger at wrist and hand level	5.726
S66.4	Injury of intrinsic muscle and tendon of thumb at wrist and hand level	257
S66.5	Injury of intrinsic muscle and tendon of other finger at wrist and hand level	129
S66.6	Injury of multiple flexor muscles and tendons at wrist and hand level	1.162
S66.7	Injury of multiple extensor muscles and tendons at wrist and hand level	678
S66.8	Injury of other muscles and tendons at wrist and hand level	1.314
S66.9	Injury of unspecified muscle and tendon at wrist and hand level	347
S76.0	Injury of muscle and tendon of hip	598
S76.1	Injury of quadriceps muscle and tendon	3.253
S76.2	Injury of adductor muscle and tendon of thigh	168
S76.3	Injury of muscle and tendon of the posterior muscle group at thigh level	314
S76.4	Injury of other and unspecified muscles and tendons at thigh level	429
S76.7	Injury of multiple muscles and tendons at hip and thigh level	91
S86.0	Injury of Achilles tendon	2.240
S86.1	Injury of other muscle(s) and tendon(s) of posterior muscle group at lower leg level	405
S86.2	Injury of muscle(s) and tendon(s) of anterior muscle group at lower leg level	265
S86.3	Injury of muscle(s) and tendon(s) of peroneal muscle group at lower leg level	151
S86.7	Injury of multiple muscles and tendons at lower leg level	127
S86.8	Injury of other muscles and tendons at lower leg level	890

S86.9	Injury of unspecified muscle and tendon at lower leg level	446
S96.0	Injury of muscle and tendon of long flexor muscle of toe at ankle and foot level	122
S96.1	Injury of muscle and tendon of long extensor muscle of toe at ankle and foot level	458
S96.2	Injury of intrinsic muscle and tendon at ankle and foot level	14
S96.7	Injury of multiple muscles and tendons at ankle and foot level	59
S96.8	Injury of other muscles and tendons at ankle and foot level	282
S96.9	Injury of unspecified muscle and tendon at ankle and foot level	149
T06.4	Injuries of muscles and tendons involving multiple body regions	107
T09.5	Injury of unspecified muscle and tendon of trunk	72
T11.5	Injury of unspecified muscle and tendon of upper limb, level unspecified	40
T13.5	Injury of unspecified muscle and tendon of lower limb, level unspecified	36
T14.6	Injury of muscles and tendons of unspecified body region	108
T92.5	Sequelae of injury of muscle and tendon of upper limb	514
T93.5	Sequelae of injury of muscle and tendon of lower limb	228