Epidemiology of imaging-detected tendon abnormalities in athletes participating in the Rio de Janeiro 2016 Summer Olympics

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ABSTRACT

Background Tendon abnormalities are prevalent among both elite and non-elite athletes. Cross-sectional imaging modalities are used to confirm and evaluate the severity of such lesions.

Aim To describe the demographics, prevalence, anatomical location and characteristics of tendon abnormalities in athletes who participated in the Rio de Janeiro 2016 Summer Olympic Games.

Methods We recorded all sports injuries reported by the National Olympic Committee (NOC) medical teams and the Organizing Committee medical staff during the Rio 2016 Summer Olympics. Diagnostic imaging was performed through the official IOC clinic within the Olympic Village, using digital ultrasound machines and 3T and 1.5T MR scanners. Image interpretation was performed centrally by board-certified musculoskeletal radiologists with expertise in sports injuries.

Results In total, 11 274 athletes (5089 women (45%), 6185 men (55%)) from 207 NOCs were included. NOC and Rio de Janeiro 2016 medical staff reported 1101 injuries. Central review of radiological images revealed 156 tendon abnormalities in 109 athletes (51.2% male, mean age: 26.8, range 18–39). The supraspinatus tendon was the most commonly involved tendon (31 cases, 19.9%), followed by the Achilles tendon (20 cases, 12.8%) and patellar and infraspinatus tendons (12 cases, 7.7%). Tendon abnormalities were most commonly seen in track and field athletes (54 abnormalities, 34.6%).

Conclusion 156 tendon abnormalities were reported, most commonly in track and field athletes, and involving mainly the shoulder tendons, as well as Achilles and patellar tendons.

INTRODUCTION

The 2016 Rio de Janeiro Summer Olympic games involved 11 237 elite athletes from 206 countries as well as a Refugee Olympic Team. The high use of imaging modalities by elite athletes confirms the importance of imaging in providing medical services during the games.[1] Protection of athletes' health is a clearly articulated mission of the IOC.[2] Medical surveillance during the games plays an important role in prevention and management of sports-related injuries in Olympian athletes. IOC has instituted injury and illness surveillance systems to detect risk factors and determine mechanisms.[3–7]

In addition, descriptive epidemiology of injuries in such a selective cohort is the first step in the identification of high-risk sports including their most common injuries, with the goal of providing tools to prevent sports injuries.[8] Identification of the most frequent injuries in different disciplines and their respective prevalence may allow appropriate allocation of diagnostic and therapeutic resources ahead of time in future large sports events. Also, such data may be used to establish screening programmes prior to competition. For instance, it has been reported that asymptomatic ultrasound-detected Achilles tendon abnormalities are predictive of future clinically salient tendinopathy.[9 10] Also, these data are potentially useful in the context of non-elite, amateur athletes, as tendon injuries commonly also occur in this population. While previous papers have reported imaging-detected sports injuries incurred during previous summer and winter Olympic games, those publications reported injuries based on joint distribution.[11–13] In this paper, our aim is to describe the prevalence, distribution and severity of tendon abnormalities during the Rio de Janeiro 2016 Summer Olympic Games.

METHODS

All National Olympic Committee (NOC) medical teams reported the daily occurrence (or non-occurrence) of injuries on a standardised medical report form. Concurrently, we retrieved the same information on all athletes treated for injuries in the polyclinic and all other medical venues by the Organizing Committee of the Olympic Games Rio de Janeiro 2016 medical staff. We used the athlete accreditation number to control for duplicates resulting from athletes being treated for the same condition by both the NOC and the Rio de Janeiro 2016 medical staff. With duplicates, we retained the NOC data. Our study and intent to publish the data were approved the by IOC. Both referral to the radiology department and choice of modality (MRI vs ultrasound) were based on decisions by the medical staff of each team or the sports medicine physician at the polyclinic for those teams that did not have their own medical staff. However, after performing the initial study, radiologists could recommend additional imaging with another modality, and in these cases, the decision was made by both radiologists and clinicians.

Data collection

We recorded all sports injuries reported by the NOC medical teams and the polyclinic and medical venues by the Organizing Committee medical staff. Diagnostic imaging was performed through

Table 1 Most commonly injured tendons by discipline

	Most commonly injured tendon(s) (n)	Other tendons (n)	Total N (%)
Track and field*	Achilles (15)	Hamstring (9), peroneus longus (7), peroneus brevis (5), tibialis posterior (3), patellar (2), supraspinatus (2), flexor hallucis longus (2), gluteus maximus/medius (2), rectus femoris (1), common flexor at the elbow (1), adductor longus (1), iliotibial band (1), quadriceps (1), flexor digitorum longus (1), infraspinatus (1)	54 (34.6)
Judo	Supraspinatus (3), subscapularis (3)	Infraspinatus (2), common flexor at the elbow (2), common extensor at the elbow (2), pectoralis major (1), flexor carpi ulnaris (1), hamstring (1)	15 (9.6)
Gymnastics: artistic	Supraspinatus (5)	Infraspinatus (2), tibialis posterior (2), Achilles (1), subscapularis (1), flexor digitorum longus (1)	12 (7.6)
Volleyball	Supraspinatus (5)	Patellar (4), infraspinatus (1), quadriceps (1)	11 (7)
Weightlifting	Vastus lateralis (2), quadriceps (2)	Common flexor (1), common extensor (1), extensor carpi radialis brevis (1), extensor carpi radialis longus (1), extensor carpi ulnaris (1), patellar (1)	10 (6.4)
Tennis	Supraspinatus (3)	Extensor carpi ulnaris (2), infraspinatus (2), patellar (1), common extensor at the elbow (1)	9(5.7)
Handball	Achilles (1), infraspinatus (1), supraspinatus (1), peroneus longus (1), hamstring (1), tibialis posterior (1)	N/A	6 (3.8)
Basketball	Achilles (2)	Infraspinatus (1), supraspinatus (1), patellar (1), quadriceps (1)	6 (3.8)
Aquatics (swimming)	Supraspinatus (4)	Subscapularis (1)	5 (3.2)
Beach volleyball	Patellar (2)	Flexor hallucis longus (1), supraspinatus (1)	4 (2.6)
Rugby	Achilles (1), extensor digitorum (1), supraspinatus (1)	N/A	3 (1.9)
Hockey	Hamstring (1), patellar (1), supraspinatus (1)	N/A	3 (1.9)
Taekwondo	Infraspinatus (1), tibialis anterior (1), tibialis posterior (1)	N/A	3 (1.9)
Boxing	Common flexor at the elbow (1), flexor carpi radialis (1), supraspinatus (1)	N/A	3 (1.9)
Wrestling	Teres minor (1), supraspinatus (1), hamstring (1)	N/A	3 (1.9)
Aquatics (water polo)	Supraspinatus (1), infraspinatus (1)	NA	2 (1.3)
Shooting	Extensor carpi radialis longus (1), extensor carpi ulnaris (1)	N/A	2 (1.3)
Triathlon	Adductor longus (2)	N/A	2 (1.3)
Cycling–MTB	Adductor longus (1)	N/A	1 (0.6)
Cycling–road	Supraspinatus (1)	N/A	1 (0.6)
Fencing	Common extensor (1)	N/A	1 (0.6)
Total			156

*Track and field events included running–sprinting, throwing, jumping, hurdles and heptathlon.
MTB, mountain bike; N/A, not applicable.

the official IOC clinic within the Olympic Village, using 3T Discovery MR750w and 1.5T Optima 450 MRw MR scanners and Logiq E9 XD Clear and portable Logiq E ultrasound machines (all machines by GE Healthcare, Brazil). Data acquired in venues other than the official IOC clinic (some NOCs had their own clinics) were not included in this study. MRI protocols consisted in three planes acquisition of fluid-sensitive images (including fat-suppressed T2-weigthed and fat-suppressed proton density weighted) and T1-weighted images in two planes as appropriate for each anatomical location. Imaging data were retrospectively collected from the Radiological Information System (RIS), Centricity RIS-i provided by GE Healthcare Brazil. Demographic information was also collected for all athletes diagnosed with tendon abnormalities on imaging in an anonymised fashion. These data were stratified according to gender, age, participating country, type of sport and anatomical body part.

Imaging interpretation

All MRIs and ultrasound images were reviewed for the presence of tendon abnormalities by three board-certified musculoskeletal radiologists, centrally and independently. Any difference in opinion was adjudicated through mutual consensus following discussion. Scoring of MRI abnormalities was blinded to reports. Tendon abnormalities were graded on fluid-sensitive images, according to morphological changes and other associated features. On MRI, morphological changes were graded according to a 0–4 point scale based on morphology, similar to a previously published scoring system,[14] which was modified to include 'isolated peritendinous fluid' and 'intratendinous hyperintensity': 0—isolated peritendinous fluid without morphological/signal changes; 1—intratendinous hyperintensity without morphological abnormality; 2—tendinosis defined as abnormal tendon morphology (thickening and/or irregular contour) with or without signal changes; 3—partial tear; 4—complete tear.

Because ultrasound is a real-time examination and highly operator dependent, ultrasound images were reviewed in conjunction with the original reports extracted from RIS. The musculoskeletal radiologists that performed ultrasound in athletes in the polyclinic during the games were experienced musculoskeletal radiologists in sports injuries. The severity of tendon abnormalities was based on a previously published classification system, which was modified to include 'isolated peritenidnous fluid'[14]: 0—isolated peritendinous fluid without morphological/echogenicity abnormalities; 1—abnormal morphology and/or echogenicity (tendinosis) without tear; 3—partial tear; 4—complete tear.

Table 2 Distribution of MRI-detected and ultrasound-detected abnormalities and associated features

MR-detected abnormalities	n (%)	Ultrasound-detected abnormalities	n (%)
Isolated fluid around tendon: no tendon abnormality	14 (11.2)	Isolated fluid around tendon: no tendon abnormality	8 (25)
Isolated hyperintensity: no morphological abnormality	37 (29.6)		
Tendinosis without tear	44 (35.2)	Tendinosis without tear	19 (59.4)
Partial tear	26 (20.8)	Partial tear	4 (12.5)
Complete tear	4 (3.2)	Complete tear	1 (3.1)
Total	125 (100)	Total	32 (100)

Confidentiality and ethical approval

We used the athlete accreditation number to query the IOC athlete database for the age, gender and nationality of injured athletes. We treated all information with strict confidence and deidentified our medical database after the Games. Informed consent was waived since all data in our epidemiological study were anonymised and unidentifiable. We obtained approval from the IOC to use anonymised imaging and demographic data for publication. Data were collected, stored and analysed in strict compliance with data protection and athletes' confidentiality.

RESULTS

In total, 11 274 athletes (5089 women (45%), 6185 men (55%)) from 207 Olympic teams (206 NOCs and the Refugee Olympic Team) participated in the study. NOC and Rio de Janeiro 2016 medical staff reported 1101 injuries. Centralised review of radiological images revealed 156 tendon lesions (including isolated peritendinous fluid, isolated signal changes, tendinosis and tears) in 109 athletes (51.2% male), aged 18–39 years (mean 26.8, SD 4.73). Thirty-two tendon abnormalities were seen on ultrasound, while MRI detected 125 tendon lesions. Only one athlete had both MRI and ultrasound for the same tendon abnormality. The same athlete had two MRIs over a period of 6 days due to worsening tendon abnormality.

Table 1 shows the frequency of involvement of different tendons by discipline. Overall, tendon abnormalities were most commonly found in track and field athletes (34.6% of all tendon lesions), followed by judo (9.6%), gymnastics (7.6%), volleyball (7%), weightlifting (6.4%) and tennis (5.7%). Prevalence of tendon lesions was less them 5% for all other disciplines and was the lowest for fencing and mountain bike and road cycling (0.6% each). Specifically, the Achilles tendon was the most commonly involved tendon in track and field events (15), basketball (2), handball (1) and rugby (1). The supraspinatus tendon was the most commonly involved in volleyball (5), gymnastics (5), aquatics–swimming (4), judo (3) and tennis (3).

The distribution of both MRI-detected and ultrasound-detected tendon abnormalities is presented in table 2. In more than half of the cases, tendon lesions consisted of a partial tear or morphological changes (ie, tendinosis): 56% of MRI-detected abnormalities and 72% of ultrasound detected lesions. Complete tears were found in 3%, on both MRI and ultrasound. Tables 3 and 4 show distribution of tendon abnormality by involved tendon and severity of abnormality, both in MRI (table 3) and ultrasound (table 4).

Table 3 Distribution of tendon abnormalities by MRI-detected severity of abnormality

	Most commonly injured tendon (n)	Other tendons (n)	Total
Complete tear	Common flexor at the elbow (2)	Common extensor at the elbow (1), Achilles (1)	4
	Supraspinatus (9)	Hamstring (4), patellar (3), peroneus brevis (2), adductor longus (1), subscapularis (1), pectoralis major (1), Achilles (1), common extensor (1) and flexor (1) at the elbow, flexor carpi ulnaris (1), teres minor (1)	26
Tendinosis	Supraspinatus (8)	Achilles (6), infraspinatus (6), patellar (6), hamstring (4), quadriceps (3), subscapularis (3), adductor longus (2), peroneus longus (1), rectus femoris (1), tibialis posterior (1), common extensor at the elbow (1), extensor carpi ulnaris (1), gluteus maximus/medius (1)	44
Isolated hyperintensity	Supraspinatus (14)	Infraspinatus (4), quadriceps (2), patellar (2), extensor carpi radialis longus (2), hamstring (2), extensor carpi ulnaris (2), extensor carpi radialis brevis (1), common flexor (1) and extensor (1) at the elbow, subscapularis (1), Achilles (1), peroneus longus (1), gluteus maximus/medius (1), flexor carpi radialis (1), extensor digitorum (1)	37
Isolated fluid around tendon	Tibialis posterior (4)	Peroneus longus (3), flexor hallucis longus (3), flexor digitorum longus (2), vastus lateralis (2)	14

Table 4 Distribution of tendon abnormalities by ultrasound-detected severity of abnormality

	Most commonly injured tendon (N)	Other tendons (N)	Total
Complete tear	Peroneus brevis (1)	N/A	1
Partial tear	Adductor longus (1), infraspinatus (1), iliotibial band (1), hamstring (1)	N/A	4
Tendinosis	Achilles (11)	Hamstring (2), common flexor (1) and extensor (1) at the elbow, extensor carpi ulnaris (1), infraspinatus (1), patellar (1), rectus femoris (1)	19
Isolated fluid around tendon	Peroneus longus (3)	Peroneus brevis (2), tibialis posterior (2), tibialis anterior (1)	8

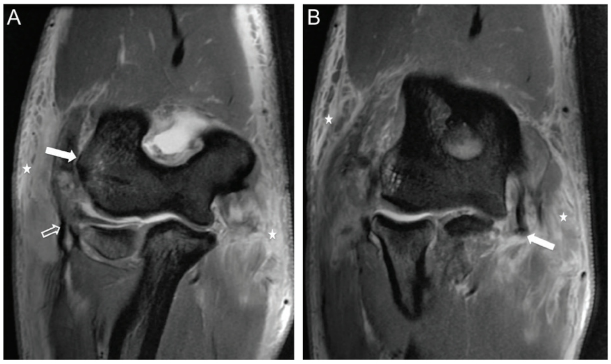

Figure 1 A 22-year-old male weightlifter with complete tears of the common extensor and flexor tendons. (A, B) Coronal fat-suppressed proton-density-weighted MRI show (A) complete rupture at the insertion of the common extensor tendon (arrow) with retraction of the distal stump (empty arrow) and (B) complete rupture of the common flexor tendon (solid arrow). Note diffuse soft tissue oedema and haematoma (stars).

DISCUSSION

In this paper, we present the prevalence and distribution of sports-related tendon lesions in elite athletes who competed at the Rio de Janeiro 2016 Summer Olympic Games. More than one-third of tendon abnormalities were found in track and field athletes (34.6%) and almost one-quarter were among runners and sprinters (23.7%). While an overall description of imaging-detected tendon abnormalities is not available for previous Olympic Games, the large proportion of tendon abnormalities among track and field athletes is in line with a prior report from Bethapudi *et al* showing that a high percentage (35%) of imaging studies during the London Olympic Games 2012 were for track and field athletes.[15]

It is important to note that the decision of performing ultrasound and/or MRI was made by the medical staff of each team or the sports medicine physician at the polyclinic. In addition, the rate of utilisation of ultrasound and MRI was significantly different, with MRI being more frequently used than ultrasound.[1] Only one athlete in our series had both ultrasound and MRI. Therefore, we cannot compare the diagnostic performance between ultrasound and MRI in the detection of tendon abnormalities based in our study. For note prior publications have shown ultrasound to be equally accurate for the diagnosis of rotator cuff tendon injuries[16] and even more accurate than MRI for posterior tibial tendon dysfunction.[17]

It is also worth noticing that some National Olympic teams had their own ultrasound scanners, and therefore, this cohort is likely to underestimate the overall frequency of tendon injuries at the games.

Achilles tendon abnormalities were seen mostly in track and field athletes, followed by basketball, gymnastics, handball and rugby. These findings are similar to prior descriptive reports on the London Summer Olympics 2012.[12] Of 20 cases of Achilles tendon abnormalities, 11 were diagnosed on ultrasound. The use of ultrasound for diagnosis of Achilles tendon lesions is well established and made easy by the tendon's superficial anatomic location and the ease of comparison with the contralateral side.[18]

High involvement of the Achilles tendon among runners and sprinters is explained by the fact that the Achilles sustains the primary propulsive forces during running via the contraction of gastrocnemius and soleus muscles.[19] Unfortunately, no prior imaging was available for comparison, which limited our ability to assess for pre-existing tendon abnormalities. With that regard, the possibility of precompetition imaging screening data would be helpful for the detection of chronic lesions and possibly preventive measures.[9] During running, as much as 6–8 times the body weight can be transmitted through the Achilles, which approaches its maximum tensile strength.[19] In addition to the Achilles, tendon abnormalities among runners and sprinters involved almost exclusively the lower extremity, with the hamstring and peroneus longus representing half of the remaining lesions.

Overall, 31.4% of reported tendon lesions involved the rotator cuff (n=49), more than half of which involved the supraspinatus tendon. The supraspinatus was the most commonly involved tendon in volleyball, judo, tennis, gymnastics and aquatics–swimming. Disciplines involving throwing, such as volleyball, result in significant loading to shoulder restraints, including bony (humeral head and scapula) and soft tissue structures (rotator cuff and capsulolabral structures),[20] which explains the high prevalence of tendon injuries to the shoulder.

In addition, we found 10 tendon abnormalities to the elbow, most commonly in judo athletes (figure 1) (two abnormalities to the common extensor and two to the common flexor tendons), followed by weightlifting (two cases). The more common occurrence of abnormalities of tendons at the elbow in judo athletes is also in line with prior findings from the Summer Olympic Games 2012.[11] Despite the prevalence of elbow injuries in throwing athletes,[21–23] we found no tendon abnormalities at the elbow in elite throwing athletes during the Rio de Janeiro 2016 Games, which is also similar to the London Summer Olympic Games 2012, during which one case of common flexor injury was reported in a javelin thrower.[11]

CONCLUSION

We reported 156 tendon abnormalities in 109 athletes during the Rio de Janeiro 2016 Summer Olympic Games. MRI was mainly used for diagnosis of these tendon abnormalities. The prevalence of abnormalities varied substantially between disciplines. Analysis of injury mechanisms may be helpful to better direct prevention strategies.

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What are the findings?

- A total of 156 tendon abnormalities were detected on imaging during the Rio de Janeiro 2016 Summer Olympic Games.
- The prevalence of imaging-detected abnormalities varied between disciplines.
- Imaging-detected tendon abnormalities were most common in track and field athletes.

How might it impact on clinical practice in the future?

- Identification of high-risk disciplines for specific tendons.
- Establishing preventive measures of tendon injuries for both elite and amateur athletes.
- Providing data for precompetition screening of tendon injuries for future large competition events.

Competing interests AG is the President of Boston Imaging Core Lab (BICL), and a Consultant to Merck Serono, AstraZeneca, Pfizer, GE Healthcare, OrthoTrophix, Sanofi and TissueGene. FWR and MDC are shareholders of BICL. LE is a consultant to Arthrex and Smith and Nephew.

Ethics approval Medical research ethics committee of the South-Eastern Norway Regional Health Authority (no. S-07196C).

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. Guermazi A, Hayashi D, Jarraya M, *et al*. Imaging of sports injuries at Rio de Janeiro 2016 Summer Olympic Games: analysis of utilization of diagnostic imaging services. *Radiology (accepted)* 2016.
2. International Olympic Committee. *Olympic charter*. Lausanne, Switzerland: International Olympic Committee, 2015. https://stillmed.olympic.org/Documents/olympic_charter_en.pdf
3. Junge A, Engebretsen L, Mountjoy ML, *et al*. Sports injuries during the Summer Olympic Games 2008. *Am J Sports Med* 2009;37:2165–72.
4. Engebretsen L, Steffen K, Alonso JM, *et al*. Sports injuries and illnesses during the Winter Olympic Games 2010. *Br J Sports Med* 2010;44:772–80.
5. Engebretsen L, Soligard T, Steffen K, *et al*. Sports injuries and illnesses during the London Summer Olympic Games 2012. *Br J Sports Med* 2013;47:407–14.
6. Soligard T, Steffen K, Palmer-Green D, *et al*. Sports injuries and illnesses in the Sochi 2014 Olympic Winter Games. *Br J Sports Med* 2015;49:441–7.
7. Steffen K, Moseid CH, Engebretsen L, *et al*. Sports injuries and illnesses in the Lillehammer 2016 Youth Olympic Winter Games. *Br J Sports Med* 2017;51:29–35.
8. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med* 1992;14:82–99.
9. McAuliffe S, McCreesh K, Culloty F, *et al*. Can ultrasound imaging predict the development of Achilles and patellar tendinopathy? A systematic review and meta-analysis. *Br J Sports Med* 2016;50:1516–23.
10. Comin J, Cook JL, Malliaras P, *et al*. The prevalence and clinical significance of sonographic tendon abnormalities in asymptomatic ballet dancers: a 24-month longitudinal study. *Br J Sports Med* 2013;47:89–92.
11. Bethapudi S, Robinson P, Engebretsen L, *et al*. Elbow injuries at the London 2012 Summer Olympic Games: demographics and pictorial imaging review. *AJR Am J Roentgenol* 2013;201:535–49.
12. Elias DA, Carne A, Bethapudi S, *et al*. Imaging of plantar fascia and Achilles injuries undertaken at the London 2012 Olympics. *Skeletal Radiol* 2013;42:1645–55.
13. Crim JR. Winter sports injuries. The 2002 Winter Olympics experience and a review of the literature. *Magn Reson Imaging Clin N Am* 2003;11:311–21.
14. Bachmann GF, Melzer C, Heinrichs CM, *et al*. Diagnosis of rotator cuff lesions: comparison of US and MRI on 38 joint specimens. *Eur Radiol* 1997;7:192–7.
15. Bethapudi S, Campbell RS, O'Connor P. Perspective on imaging services at the London 2012 Olympic and Paralympic Games. *Skeletal Radiol* 2014;43:1201–3.
16. Vlychou M, Dailiana Z, Fotiadou A, *et al*. Symptomatic partial rotator cuff tears: diagnostic performance of ultrasound and magnetic resonance imaging with surgical correlation. *Acta Radiol* 2009;50:101–5.
17. Arnoldner MA, Gruber M, Syré S, *et al*. Imaging of posterior tibial tendon dysfunction-comparison of high-resolution ultrasound and 3T MRI. *Eur J Radiol* 2015;84:1777–81.
18. Dong Q, Fessell DP. Achilles tendon ultrasound technique. *AJR Am J Roentgenol* 2009;193:W173.
19. Schepsis AA, Jones H, Haas AL. Achilles tendon disorders in athletes. *Am J Sports Med* 2002;30:287–305.
20. Malone T, Hazle C. Diagnostic imaging of the throwing athlete's shoulder. *Int J Sports Phys Ther* 2013;8:641–51.
21. Kijowski R, Tuite M, Sanford M. Magnetic resonance imaging of the elbow. Part I: normal anatomy, imaging technique, and osseous abnormalities. *Skeletal Radiol* 2004;33:685–97.
22. Oshlag BL, Ray TR. Elbow injuries in the young throwing athlete. *Curr Sports Med Rep* 2016;15:325–9.
23. Daruwalla JH, Daly CA, Seiler JG. Medial elbow injuries in the throwing athlete. *Hand Clin* 2017;33:47–62.