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Case Report

Lesions in the legs do not preclude ultra-marathon running for 100 days without pain: case report

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Abstract

There is an increasing interest in participation in ultra-endurance events and a concomitant need to understand their effects on health. The effects of extremely prolonged running on leg joints, ligaments, tendons and menisci have not been explored sufficiently. The aim of the present single case study was to use ultrasonography to estimate the effects of a self-paced 8-10 hours daily running for 100 days on the morphology of joints in an experienced 47-year-old ultra-marathon runner. Examination before the start of the 100 days of running revealed already multiple but mostly mild, painless lesions in different joints of both legs. The presence of these lesions did not significantly exacerbate or cause pain during the racing. Iliotibial band bursitis and Achilles paratenonitis were however aggravated, and mild semitendinosus bursitis was a novel finding during the examination after running 8000 km in 100 days. These results are impressive because preparation for this 8000 km running was only ~5 weekly hours of training. In conclusion, this runner displayed multiple lesions in the leg joints at the start but was able to increase running volume by ~10-fold for >100 consecutive days without significantly exacerbating the pre-existing skeletomuscular abnormalities or inducing pain.

Keywords: Ultra-endurance, Ultrasonography, Ligament, Tendon, Meniscus

Introduction

Human physical and mental capacities sometimes exceed expectations. Some devoted individuals are able to run, ride or swim ultra-long distances on a nearly daily routine[1]. Running is a particularly attractive mode of exercise as it requires minimal gear and provides substantial health benefits. Although humans have evolved as exceptionally capable endurance runners, inappropriate or excessive loading can lead to overuse injuries, which are characterised by morphological soft tissue abnormalities such as edema, tendonitis and increased connective tissue deposition or fragmentation which can cause pain and interrupt training and physical conditioning[2-4]. During long-distance running, the tendons absorb most of the stress because the muscle length changes little during low-amplitude movements[5]. There is some evidence to suggest that in ultra-endurance events, including multistate ultra-marathon runs, resilience of the "chassis" structures to demands of the extreme exercise volumes is a bottleneck in humans[2]. This suggests that acute monitoring of joint, tendon and ligament morphology, and health is needed for better understanding of the responses of the human body to extreme mechanical volume overload.

While previous studies of ultra-endurance athletes have focused mainly on their metabolic and cardiovascular demands[1,6-8], description of the effects of ultra-endurance exercise on musculoskeletal alterations is lacking. Ultrasound observation is useful in revealing various malformations, lesions and inflammation-mediated morphological changes, such as swelling[9,10].

These changes might be more pronounced in people who perform exceptionally high-volume exercise. The aim of this case study was to identify alterations in the lower limb joints in an experienced runner in response to daily running averaging almost two classical marathons with a total accumulated distance of about 8000 km over >100 consecutive days.

The authors have no conflict of interest.

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Materials and methods

Participant

To commemorate the centenary of Lithuanian independence, a 47-year-old distance runner (height 1.70 m; weight 65.0 kg before the event) performed a 7985-km run from Dakar (Senegal) to Vilnius (Lithuania). He had 32 years of running training experience and had been racing relatively rarely and mostly in the distances up to classical marathons (42.2 km) during the period between ages 20 to 37 years, after which he switched to focusing on ultra-marathons during the latest 10 years of his athletic career. Before the event, he had completed 20 ultra-marathon races, the longest of which was from Los Angeles to New York (5013 km). His preparation for the current event during the last 12 weeks was relatively mild in terms of training volume (and was even lower the weeks before), but was consistent and included mostly running for 4 to 6 hours per week split into 4 to 5 sessions one of which was long run. In addition, the subjects is an acting fireman, and besides his professional activities he also puts a lot of emphasis on physical condition exercise in the gym where he performs routines of core stability and other strength endurance conditioning exercises for 1 to 2 hours per session 5 to 6 times per week for most weeks of the year. Before volunteering for the study, the subject read and signed a written informed consent form consistent with the principles outlined in the Declaration of Helsinki. Approval for the study was obtained from the Institutional Board before the investigation began.

Event

The course crossed through different landscapes and environments, and the subject's progress was monitored using a ViaGPS tracking device (SPOT GEN3, Covington, Louisiana, USA). He ran every day from about 6 am until 3-5 pm for 102 consecutive days and averaged 77.7 km (range, 44-95 km) per day. The intensity of the running/jogging was similar for all days, and the pace depended mainly on the course profile and environmental conditions and was adjusted by the athlete himself. The surface of all the distance was asphalt. The altitude along the course ranged between 10-1150 m above sea level. The temperature varied from 42°C in West Africa to -5°C in Lithuania. For safety and logistical reasons, the runner was assisted during the entire event, which allowed him to focus solely on running. His energy intake fluctuated between 6000 and 8000 kcal per day (as calculated by the food providing members of the supporting team and the experienced athlete himself; the diet had been planned by the professional dietician and then followed thoroughly during the event), and his body weight decreased by 4 kg during the event. The runner regularly consumed vitamin and mineral supplements in addition to regular meals.

Ultrasonography

The knee, ankle and foot of both legs were examined according to standard ultrasound protocols provided by the European Musculoskeletal Radiology Society (ESSR) (for details, see www.essr.org) using two ultrasound systems: Mindray M7 was used before the event, and Mindray M9 (Shenzhen Mindray Bio-Medical Electronics Co. Ltd., China) was used after the event, both times with linear L14-6Ns transducer (10-12 MHz). The joints were scanned to identify the pathological changes indicated in Table 1.

Table 1. Checklist for pathological ultrasonography findings

Anatomical structures	Pathological changes	Description
Joint	Effusion	Present or not
Tendon	Enthesophyte	Present or not
	Tenosynovitis	Present or not
	Tendinosis	Grade 1, 2, 3
	Tear	Partial or full thickness
Ligaments	Knee ligaments injury	Grade 1, 2, 3
	Ankle ligaments injury	Grade 0, 1, 2, 3
Meniscus	Protrusion or extrusion	Present or not
	Peripheral tears	Present or not

Tendon degenerative changes or tendinosis were evaluated according to the grading system of Ingwersen et al[11]. Grade 1 represents degenerative areas of fibrillar disruption involving <25% of the length of the tendon, Grade 2 involves 25-50% of the height of the tendon and Grade 3 involves >50% of the length of the tendon. All anatomical structures examined are listed in Table 2. The ultrasound examination was performed by a radiologist with 10 years of experience in musculoskeletal ultrasound assessment. The images were stored and later analysed independently by two radiologists blinded to the details of the study. The presence of pathology was confirmed if both radiologists agreed with the diagnosis.

Results

The pathological findings and anatomical structures evaluated are listed in Table 2. More abnormalities were found in the left than in the right leg.

A small peripheral tear of the right knee medial meniscus was found before the event. After 100 days of running ultra-marathons, the medial meniscus tear appeared to be unchanged.

After ultra-marathon running, only mild suprapatellar effusion was seen on both sides (Figure 1). Grade 1 tendinosis of the quadriceps femoris tendon appeared similarly before and after the run. Before the run, the athlete exhibited moderate iliotibial band bursitis of the left knee (Figure 2), and the amount of anechoic fluid in this bursa increased after the run. Signs of semitendinosus bursitis in the left knee were also found after the event (Figure 3).

Table 2. Anatomical structures and pathological findings before and after ultra-marathon running for >100 consecutive days.

Anatomical structures	Right side		Left side	
	Before	After	Before	After
Knee joint	No findings	Mild suprapatellar effusion	No findings	Mild suprapatellar effusion
Quadriceps femoris tendon	Tendinosis (Grade 1)	Tendinosis (Grade 1)	Tendinosis (Grade 1)	Tendinosis (Grade 1)
	Small enthesophytes	Small enthesophytes	Small enthesophytes	Small enthesophytes
Patellar tendon	No findings	No findings	No findings	No findings
Iliotibial band	No findings	No findings	Moderate iliotibial band bursitis	Severe iliotibial band bursitis
Collateral ligaments	No findings	No findings	No findings	No findings
Medial meniscus	Small meniscal and parameniscal cysts	Small meniscal and parameniscal cysts	Small peripheral horizontal tear	Small peripheral horizontal tear
Lateral meniscus	No findings	No findings	No findings	No findings
Posterior knee	No findings	No findings	No findings	Semitendinosus bursitis
Pes anserinus	No findings	No findings	No findings	No findings
Talocrural and subtalar joints	No findings	No findings	No findings	No findings
Peroneus tendons	No findings	No findings	No findings	No findings
Anterior tibiofibular ligament	No findings	No findings	No findings	No findings
Anterior talofibular ligament	No findings	No findings	Grade 1	Grade 1
Tibialis anterior	No findings	Tendinosis (Grade 1)	No findings	No findings
	No findings	Mild tenosynovitis	No findings	No findings
Extensor hallucis longus	No findings	No findings	No findings	No findings
Extensor digitorum longus	No findings	No findings	No findings	No findings

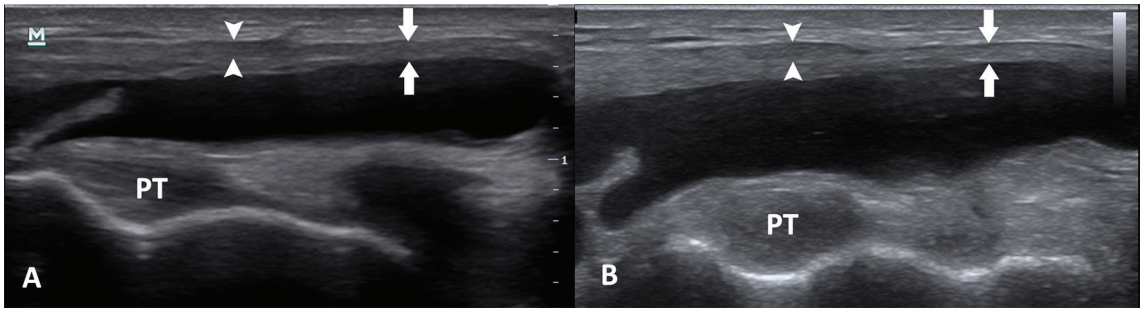

Figure 1. Encapsulated (arrows) iliotibial band bursitis of the left knee before (A) and after (B) the event with an enlarged bursa. Arrowheads indicate an oblique view of iliotibial band. PT, popliteal tendon.

Ankle and foot

Before the event, the runner exhibited a full tear of the flexor hallucis longus tendon. After the event, the myotendinous junction of the flexor hallucis longus appeared to have more fibrotic changes, but the retraction ends of the torn tendons remained the same.

Before the event, the paratenon of the Achilles tendons appeared to be hypoechoic and thickened medially on both sides. After the event, the changes were more prominent on both sides (Figure 4).

After the event, mild tenosynovitis and Grade 1 tendinosis of the right tibialis anterior was found. Before the ultra-marathon, the anterior talo-fibular ligament of the left ankle appeared to be thickened and hypoechoic with a blurred fibrillar pattern related to a Grade 1 sprain. However, the appearance did not change after the event.

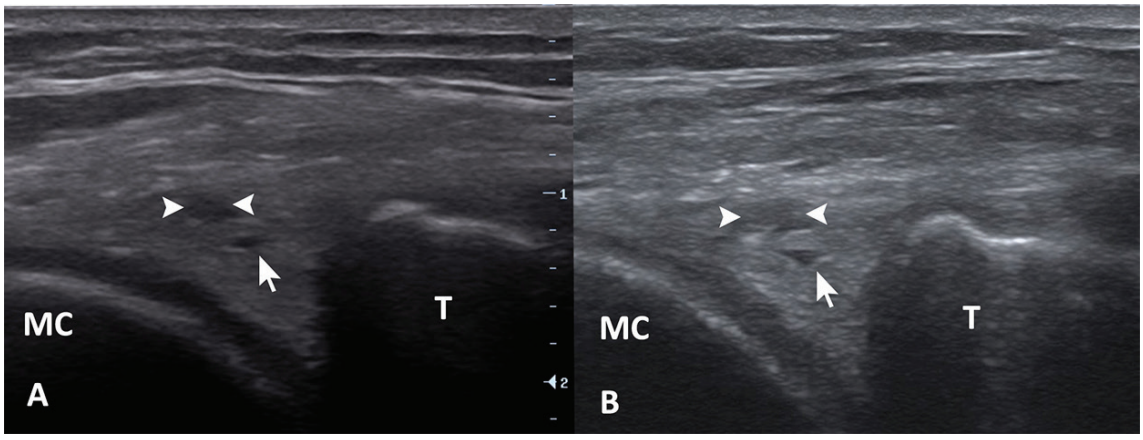

Figure 2. Ultrasound image of the medial meniscus of the right knee before (A) and after (B) the event. The small communicating intra-meniscal (arrow) and para-meniscal (arrowheads) cysts appear without changes. MC, medial condyle of the femur; T, tibia.

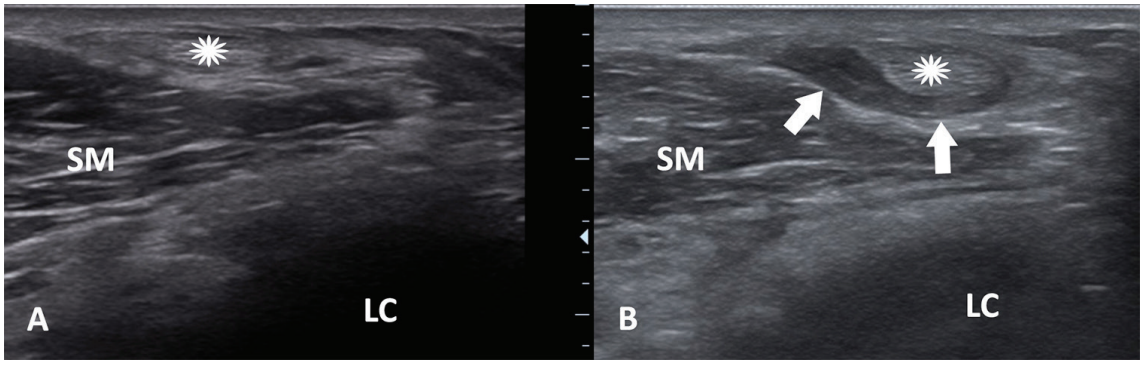

Figure 3. (A) Normal ultrasound image of the left posterior knee. (B) Signs of semitendinosus bursitis above the semimembranosus muscle (SM) after the event. LC, left condyle of the femur.

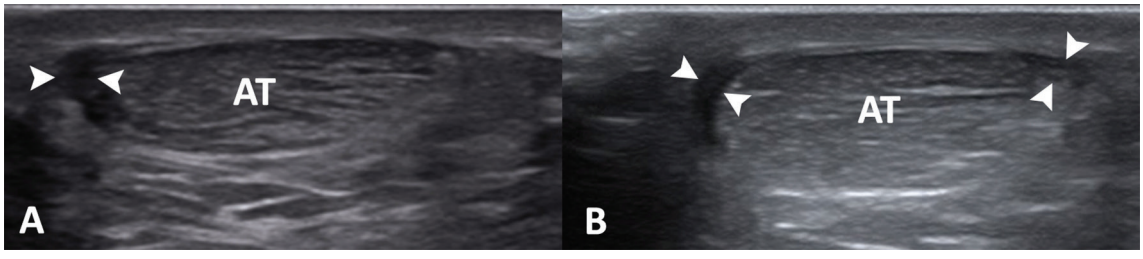

Figure 4. (A) Ultrasound image of the left Achilles tendon before the event showing the thickened and hypoechoic paratenon (arrowheads) on the lateral side. (B) After the event, paratenonitis appeared on both sides. AT: Achilles tendon.

Discussion

In the present case study, we found that the ultra-endurance runner presented with considerable leg joint abnormalities before running almost 8000 km for >100 days. The sonographic examination before the event revealed quadriceps femoris tendon tendinosis with enthesophytes, iliotibial band bursitis, a medial meniscus tear of the right knee and a full-thickness tear of the left flexor hallucis longus. Notably, the ultra-marathon running did not significantly worsen these changes except that the iliotibial band bursitis and Achilles paratenonitis were more prominent and mild semitendinosus bursitis appeared after the event. The runner did not feel any pain except on the last day because of the more severe iliotibial band bursitis in the left leg.

The baseline ultrasound findings were not surprising because soft tissue abnormalities are relatively common in athletes and recreational runners[12], including ultramarathon runners[2]. Overuse from running may lead to a broad range of musculotendinous disorders, of which, Achilles tendinopathy is the most frequent[13-15]. Running >40 miles weekly is associated with an increased risk of leg injury[12]. In accordance with these observations, several changes in the runner's joints were found before the event. Despite tears of the right knee medial meniscus and left flexor hallucis longus he successfully completed the ultra-marathon, running on average almost two classical marathons per day for >100 successive days. The runner was also able to cope with the changes in the quadriceps femoris tendon and iliotibial band, as well as the worsening of the Achilles paratenonitis.

We did not systematically record the runner's subjective perceptions, but his recall was that pain was absent through almost the entire distance except the last 60 km. This is consistent with other findings of an apparent discrepancy between tendon pain and abnormalities of tendon structure[16-18]. A sensation of pain appeared on the lateral side of his knee on the final day and was associated with more evident ultrasonographic signs of iliotibial band bursitis compared with baseline. This is a common complaint experienced in activities that require repetitive hip and knee flexion and extension. Excessively repetitive motions may cause the iliotibial band to become irritated and painful. More marked manifestation of Achilles paratenonitis and newly developed semitendinosus bursitis after the event were also present and likely reflect an inflammatory response[19]. There is extensive evidence to suggest that ongoing tendon degeneration involves inflammation-mediated responses[20,21]. The pain and swelling disappeared gradually within 4 weeks after the event and did not require medical treatment. It remains unclear why some soft tissue is more sensitive than others. In the present study, the anatomical structures in the left leg had more abnormalities than those in the right leg. This may be related to body asymmetry and biomechanical factors affecting his running technique[12].

There is some evidence that when injuries or structural fatigue of the leg tissues are present, ultra-runners adopt smoother running style with shorter and more frequent strides "saving" the structures from a more profound damage[7,22]. This could potentially explain why the runner did not experience more severe pathological alterations of the structures in response to that highly increased daily locomotion volume. Because of the very long distance, the relatively low speed (average of ~8.5 km/h) was probably another key factor precluding exacerbation of most of the existing minor lesions. This is in line with other findings from ultramarathon runners where cartilage of the ankle joints shows adaptive plasticity during the multiday event[23,24]. Also, in a case study of ultra-endurance triathlete with extensive training and competitive history of over 35 years, no serious pathological findings in the joints of the lower limbs were evident when thoroughly investigated using MRI[25]. However, a comparable average running speed in similar multistage ultra-endurance race still induced lesions that led to drop out of a significant proportion of participants[2].

One limitation of the current study was the absence of biomechanical monitoring, which may have helped explain the causes of some of the runner's injuries and changing in running pattern to avoid damaging the tissues further. We also recognise the uniqueness of both the subject and the event, which in no way allows us to generalise to other athletes performing ultra-endurance events with relatively mild preparation (only 4-6 hours of training per week) and not an entirely intact musculotendinous and skeletal structure (e.g., multiple lesions were seen in the sonographic inspection before the event). That is, in neither way we do recommend that athletes should abruptly increase their running volume by more than 10-fold and to continue this for >100 consecutive days. We also emphasise that the runner ran over more variable terrain (hilly in parts) and ambient conditions (e.g., high temperatures) than he had prepared for. We conclude that it is remarkable how well his body was able to cope with such highly increased metabolic and mechanical demands.

Conclusion

Even though the initial ultrasound examination of the runner revealed many pathological changes, such as quadriceps femoris tendon tendinosis with enthesophytes, iliotibial band bursitis, medial meniscus tear of the right knee and even a fullthickness tear of the left flexor hallucis longus, consecutive daily ultra-marathon running for >100 days did not significantly worsen his condition. The only condition that was worsened by the run was iliotibial band bursitis, while Achilles paratenonitis and mild semitendinosus bursitis appeared after the event.

References

1. Maufrais C, Millet GP, Schuster I, Rupp T, Nottin S. Progressive and biphasic cardiac responses during extreme mountain ultramarathon. Am J Physiol Heart Circ Physiol 2016 15;310(10):H1340-1348.

2. Schütz UHW, Schmidt-Trucksäss A, Knechtle B, Machann J, Wiedelbach H, Ehrhardt M, et al. The TransEurope FootRace Project: longitudinal data acquisition in a cluster randomized mobile MRI observational cohort study on 44 endurance runners at a 64-stage 4,486 km transcontinental ultramarathon. BMC Med 2012;10:78.
3. Tenforde AS, Yin A, Hunt KJ. Foot and Ankle Injuries in Runners. Phys Med Rehabil Clin N Am 2016; 27(1):121-37.
4. Arnold MJ, Moody AL. Common Running Injuries: Evaluation and Management. Am Fam Physician 2018; 97(8):510-6.
5. Kopper B, Csende Z, Trzaskoma L, Tihanyi J. Stretch-shortening cycle characteristics during vertical jumps carried out with small and large range of motion. J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol 2014;24(2):233-9.
6. Abernethy PJ, Eden B. Changes in blood glucose levels during a 1005-km running race: a case study. Br J Sports Med 1992;26(1):66-8.
7. Millet GY, Morin J-B, Degache F, Edouard P, Feasson L, Verney J, et al. Running from Paris to Beijing: biomechanical and physiological consequences. Eur J Appl Physiol 2009;107(6):731-8.
8. Karstoft K, Solomon TP, Laye MJ, Pedersen BK. Daily marathon running for a week--the biochemical and body compositional effects of participation. J Strength Cond Res 2013;27(11):2927-33.
9. Mickevičius M, Degens H, Kesminas R, Rutkauskas S, Satkunskienė D, Vadopalas K, et al. Early anterior knee pain in male adolescent basketball players is related to body height and abnormal knee morphology. Phys Ther Sport Off J Assoc Chart Physiother Sports Med 2018;32:273-81.
10. Sconfienza LM, Albano D, Allen G, Bazzocchi A, Bignotti B, Chianca V, et al. Clinical indications for musculoskeletal ultrasound updated in 2017 by European Society of Musculoskeletal Radiology (ESSR) consensus. Eur Radiol 2018; doi: 10.1007/s00330-018-5474-3.
11. Ingwersen KG, Hjarbaek J, Eshoej H, Larsen CM, Vobbe J, Juul-Kristensen B. Ultrasound assessment for grading structural tendon changes in supraspinatus tendinopathy: an inter-rater reliability study. BMJ Open 2016;6(5):e011746.
12. Gallo RA, Plakke M, Silvis ML. Common leg injuries of long-distance runners: anatomical and biomechanical approach. Sports Health 2012;4(6):485-95.
13. Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med 2002;36(2):95-101.
14. Zafar MS, Mahmood A, Maffulli N. Basic science and clinical aspects of achilles tendinopathy. Sports Med Arthrosc Rev 2009;17(3):190-7.
15. Lopes AD, Hespanhol Júnior LC, Yeung SS, Costa LOP. What are the main running-related musculoskeletal injuries? A Systematic Review. Sports Med Auckl NZ 2012;42(10):891-905.
16. Malliaras P, Cook J. Patellar tendons with normal imaging and pain: change in imaging and pain status over a volleyball season. Clin J Sport Med Off J Can Acad Sport Med 2006;16(5):388-91.
17. Ooi C-C, Schneider ME, Malliaras P, Jones D, Saunders S, McMahon A, et al. Sonoelastography of the Achilles Tendon: Prevalence and Prognostic Value Among Asymptomatic Elite Australian Rules Football Players. Clin J Sport Med Off J Can Acad Sport Med 2016;26(4):299-306.
18. Mickevičius M, Rutkauskas S, Sipavičienė S, Skurvydas A, Jürimäe J, Degens H, et al. Absence of Bilateral Differences in Child Baseball Players with Throwing-related Pain. Int J Sports Med 2016;37(12):952-7.
19. Heckman DS, Gluck GS, Parekh SG. Tendon disorders of the foot and ankle, part 2: achilles tendon disorders. Am J Sports Med 2009;37(6):1223-34.
20. Kjaer M. Role of extracellular matrix in adaptation of tendon and skeletal muscle to mechanical loading. Physiol Rev 2004;84(2):649-98.
21. Rees JD, Stride M, Scott A. Tendons - time to revisit inflammation. Br J Sports Med 2014;48(21):1553-7.
22. Morin J-B, Samozino P, Féasson L, Geyssant A, Millet G. Effects of muscular biopsy on the mechanics of running. Eur J Appl Physiol 2009;105(2):185-90.
23. Schütz UHW, Ellermann J, Schoss D, Wiedelbach H, Beer M, Billich C. Biochemical cartilage alteration and unexpected signal recovery in T2* mapping observed in ankle joints with mobile MRI during a transcontinental multistage footrace over 4486 km. Osteoarthritis Cartilage 2014;22(11):1840-50.
24. Schütz UHW, Billich C, Schoss D, Beer M, Ellermann J. MRI Cartilage Assessment of the Subtalar and Midtarsal Joints During a Transcontinental Ultramarathon - New Insights into Human Locomotion. Int J Sports Med 2018;39(1):37-49.
25. Zingg MA, Pazahr S, Morsbach F, Gutzeit A, Wiesner W, Lutz B, et al. No damage of joint cartilage of the lower limbs in an ultra-endurance athlete - an MRI-study. BMC Musculoskelet Disord 2013;14:343.