

Case Report

Rupture of the Medial Head of the Gastrocnemius Muscle in Late-Career and Former Elite Jūdōka: A Case Report

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- Sprains and strains

Abstract

Introduction: In 1883 Powell in *The Lancet* for the first time described a clinical condition incurred during lawn tennis, and which involved a calf injury that most commonly resulted from sprinting acceleration or a sudden change in running direction, and which hence became known under the name “tennis leg”. In the present case report we describe for the first time how, a similar injury arises from a very different way of moving that may occur during the practice of jūdō.

Case presentation: A 52-year-old male former elite jūdō athlete of African-American ethnicity, during the entry for performing a jūdō shoulder throw, upon pushing off with the front part of his right foot while making an inward turning motion and simultaneously stretching his right knee, heard a snapping sound in the mid-portion of his right calf accompanied by a sudden sharp pain and immediate loss of functionality. Ultrasonography and clinical findings were consistent with a partial rupture of the distal part of the medial head of the right gastrocnemius muscle.

Differential diagnosis: Achilles tendon rupture, arterial aneurysm, Baker’s cyst, deep venous thrombosis, ischemic necrosis, tendon strain or rupture of the plantaris or soleus muscles, tendon strain or rupture.

Treatment: Proper acute care (P.R.I.C.E.-principle [Protection-Rest-Ice-Compression-Elevation]) and rehabilitation were adhered to, which contributes to excellent prognosis of partial gastrocnemius ruptures.

Uniqueness of the study: “Tennis leg” as previously described has not been associated with practicing jūdō.

Conclusion: Simultaneous active plantar flexion or dorsiflexion of the foot and extension of the knee, as may occur during entry for some standing jūdō throws, puts the gastrocnemius muscle at risk for rupture. Predisposing factors are its high density in type-2 fast-twitch muscle fibers, reduced neoangiogenesis, increased non-immuno-hematopoietic cell content, muscle fatigue, adipositas athletica, metabolic syndrome, male gender, and age-related sarcopenia.

ABBREVIATIONS

BMI: Body Mass Index; P.R.I.C.E.: Protection-Rest-Ice-Compression-Elevation

INTRODUCTION

In 1883 Powell [1] in *The Lancet* described a clinical condition which he termed “lawn tennis leg”. The condition involved a muscle strain injury, *i.e.* an incomplete rupture of the

inside of the calf muscle (gastrocnemius) (Figure 1), resulting from a powerful contraction such as that experienced during a sprinting acceleration or a sudden change in running direction. Similarly to the a “tennis elbow”, the name “tennis leg” has remained popular ever since, even though the sport of tennis may not have a monopoly of this type of injury [2-5]. For example, according to Nsitem et al. [6], the prevalence of this injury is 12% in professional soccer players. Currently, to the best of our knowledge, no literature data on the prevalence of this specific

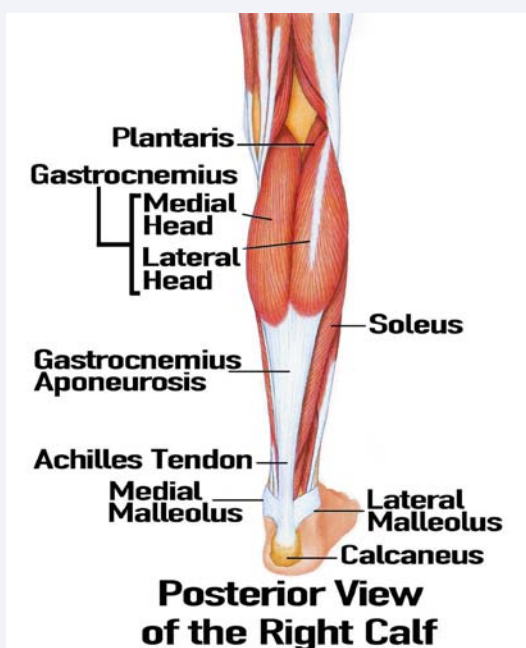


Figure 1 Anatomy of the posterior calf of the right leg (Modified after [2], by kind permission of Pearson Benjamin Cummings, Inc., All rights reserved).

injury in *jūdō* are available. However, according to Pocecco et al. [7] the proportion of general strains among all injuries incurred in *jūdō*, as reported in the literature, ranges from 7 to 33.8%, while the number of all injuries in *jūdō* that affect the lower leg and ankle has been reported to range from 3.7-14.0% [7]. In the present case report we describe rupture of the medial head of the gastrocnemius muscle in *jūdō*. Because unlike tennis, *jūdō* is a contact sport, the etiology and circumstances are likely to

be different, hence requiring instructors, coaches and veteran practitioners alike to recognize these circumstances in order to effectively prevent this injury from occurring.

CASE PRESENTATION

A 52-year-old male veteran *jūdō* athlete of African-American ethnicity during entry for *uchi-komi* [a repetition-training drill exercise] of *jūdō*'s shoulder throw *ippon-seoi-nage* 一本背負投 [one-point shoulder-back-carrying throw] (Figure 2), upon pushing off with the front part of his right foot while making an inward turning motion and simultaneously also stretching his right leg, heard a snapping sound in the mid-portion of his right calf. This sound was accompanied by a sudden sharp pain and immediate loss of functionality and stability causing him to instantaneously fall over. It is at this at the point of stretching that an eccentric muscle tear occurred.

Demonstration of *ippon-seoi-nage* 一本背負投 [one-point shoulder-back-carrying throw] from (*tsuri-komi hairi-kata* 釣込入方 [lifting and pulling entry]). One pushes off on the front part of one's right foot while making a backward turning motion with the left side of the body. While approaching the final body position to carry out the throw one also stretches the turning left leg, while the opponent is lifted on the shoulder and back. It is at this at the point of stretching that an eccentric muscle tear occurred.

The subject was a former elite *jūdō* athlete and 100m sprinter with well developed leg muscles. Since the end of his competitive *jūdō* career 20 years ago, he has been and today still is active in *jūdō* as a senior instructor and coach and also regularly goes jogging. The subject does not consume alcohol, and has no known dehydration or predisposing factors in terms of coagulation defects or muscular disease, although he had a long history of tendinitis in various locations (elbow, shoulder, groin) but not in his right leg. However, between 2005 and 2009 he did have



Figure 2 White arrows indicate the location of the injury in the right calf caused by the simultaneous rotation and eccentric stretching of the right leg during practice of *ippon-seoi-nage* 一本背負投 [one-point shoulder-back-carrying throw].

symptoms of borderline metabolic syndrome arising from severe chronic sleep deprivation and obesity, resulting in a Body Mass

Index (BMI= $\frac{\text{body mass}_g}{\text{height}_m^2}$) of 41.7 despite a (self-reported)

caloric intake that was never excessive (<2300 kcal/d). Lipidemia remained normal throughout these periods, and since 2012 his BMI has been 30 thanks to returning to his normal exercise rhythm and night sleep.

Investigations

On physical examination, the entire upper and mid-portion of the right calf was found painful, tight and cramped up, with significant diffuse swelling, muscle weakness and loss of range of motion. Further clinical findings included absence of any visual ecchymosis or skin discoloration. The subject had no noticeable foot pronation. Severe pain in the injured area prevented performing the Thompson Test (movement of the dorsiflexed foot upon squeezing the calf while in supine position) or toe-raises during the acute phase. Some plantar flexion was possible while in lying position, but without virtually any strength left, certainly not enough to allow the subject to bear weight on his foot. Hence the subject was unable to perform any single-leg toe raises. Pain increased upon rubbing the affected extremity. On palpation there were no noticeable traumatic or degenerative abnormalities of the Achilles tendon present, such as eventual crepitation, nor any noticeable thickening of the paratenon, and Wells' Score was negative. The subject had no history of clotting protein deficiencies, polycythemia or hyperhomocysteinemia, no recent surgery, inflammatory or autoimmune diseases. The differential diagnosis of a rupture of the distal part of the medial head of the right gastrocnemius muscle and an intact soleus, plantaris and Achilles tendon was confirmed by physical examination and diagnostic ultrasound imaging. A large hematoma was present located between gastrocnemius and the soleus muscles.

Differential diagnosis

- Achilles tendon rupture
- Arterial aneurysm
- Baker's cyst [8,9]
- Deep venous thrombosis or venous thromboembolism [8-10]
- Ischemic necrosis of the gastrocnemius muscle
- Plantaris tendon strain or rupture [11-13]
- Soleus tendon strain or rupture [11]

Treatment

Proper and immediately applied first aid (P.R.I.C.E.-principle) limited the injury [14]. In the absence of any available bandages in the training hall where the injury took place, and improvisatory compression bandage was made using *jūdō* belts. As soon as having arrived home, ice was continued inside a compression bandage with the leg put in elevation. Over the next few days treatment continued including icing and topical application of non-steroidal anti-inflammatory gels (sodium diclofenac

2%, niflumic acid 2.5%) and sprays (indomethacine 1%), a compression bandage, compression socks and rest, in agreement with recommendations in the relevant medical literature [15]. Neither invasive treatment with platelet-rich plasma, nor use of anticoagulants were considered in the light of warnings from other authors that the latter may provoke hemorrhaging and hematoma in the leg which could precipitate a compartment syndrome of the calf [16]. In order to enhance soft-tissue healing and slow down muscle wasting during the recovery period of inactivity, prompt dietary changes were made [17,18] to include extra daily consumption of soy protein (20 g/d), lecithin (7 g/d), collagen (7 g/d of Super Collagen type 1 & 3, NeoCell Corp., Santa Ana, CA), and 15 mg 2.8% precipitated, dispersed colloidal silicic acid anhydride (silicon dioxide) (Hübner GmbH & Co., Ehrenkirchen, Germany). Dietary modifications were continued until week 4.

Three weeks after the injury ultrasonographic evaluation still showed the presence of a well-localized anechoic zone interposed between the medial head of the gastrocnemius (G) and the medial soleus representing a residual intermuscular hematoma containing approximately 7 cc of predominantly lysed blood and some fibrinous septa (Figure 3). Using a 21G needle the anechoic zone was percutaneously drained under ultrasound guidance resulting in its collapse with prompt restoration of the normal apposition of the gastrocnemius and soleus muscles. At this point the subject was sufficiently pain-free to initiate active exercise rehabilitation. Exercise was preceded by topical application of a camphor- and methyl nicotinate-based rubefacient for warm-up and to accelerate resorption of the hematoma [19] and gentle massage and passive stretching [20]. A compression and supportive training bandage was affixed using a 7.5 cm × 4.5 m Tensoplast® (BSN Medical GmbH, Hamburg, Germany) adhesive bandage.

Outcome and follow-up

The subject wore an adhesive bandage during training until six weeks post-injury. Prior to each training session the subject continued applying a topical rubefacient followed by stretching through heel-raises and eccentric loading of the gastrocnemius muscle and Achilles tendon. The adhesive bandage, warm-ups, stretching and temporarily modifying sports practice were sufficient to address any eventual fear of re-injury, which in this subject was low, nevertheless. At six weeks post-injury the subject had full motion of the injured limb and was able to complete daily running sessions and weekly routine *jūdō* training without any pain sensation. The subject's gastrocnemius muscle had normalized in diameter without any thickening, discoloration or palpable abnormalities. For safety reasons he did avoid practicing with the left leg, the same combined rotation/stretching movement that had led to the injury.

DISCUSSION

Injury mechanism

Despite the rarity of gastrocnemius ruptures in the *jūdō* injury literature, one particular other incident comes to mind. Legendary Japanese former *jūdō* Olympic and World champion Yamashita Yasuhiro 山下泰裕 describes his ordeal during the

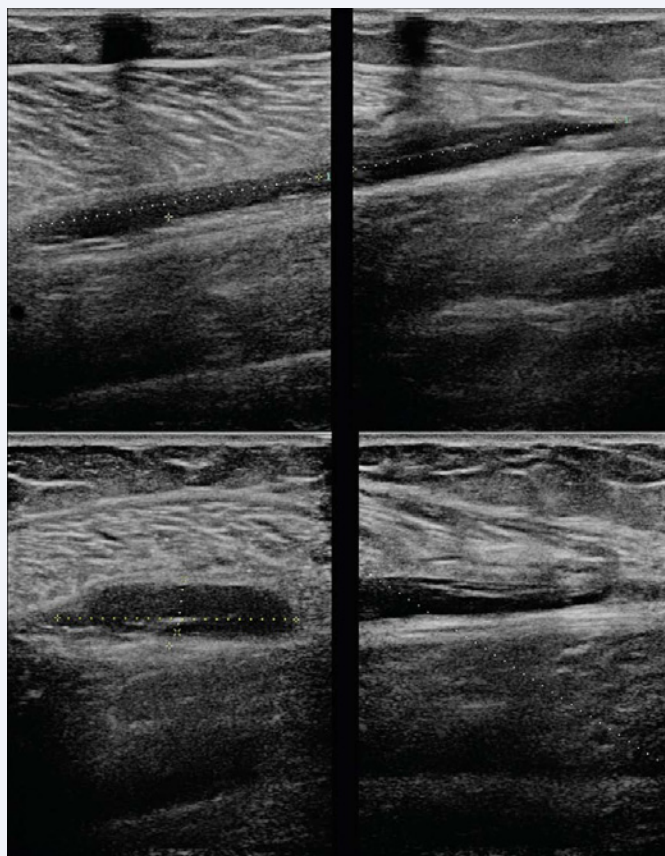


Figure 3 Ultrasound serial longitudinal images of the calf taken 20 days post-trauma showing sequels of a rupture of the distal part of the medial head of the right gastrocnemius muscle with a well-localized hypoechoic zone interposed between the medial head of the gastrocnemius and the medial soleus, showing a 7cc residual intermuscular hematoma typical of an approximately 10×4 mm tear.

1984 Los Angeles Olympics as follows: “Despite warming up carefully before the fight, I met with unexpected disaster in the second round against Arthur Schnabel of West Germany. I turned in for *uchi-mata* 左内股 [inner thigh throw] but felt a sudden pain in my pivoting foot. I walked as normally as possible in order not to let Schnabel know of the injury. However, it must have been obvious because there was a general stir among the spectators. There was a torn muscle in my right calf.” (...) [21] (Figure 4).

Despite being seriously injured, Yamashita showed exceptional perseverance, still won the match and went on to also win the semi-final and the final hence securing the 1984 Olympic *jūdō* title in the Open Weight class. Although his exhibition of great athleticism was well-published at the time, a recent systematic literature review of sports injuries in *jūdō* [7] does not list the injury. Neither does a prospective study on *jūdō* competition injuries by Green et al. [22] mention this or any other kind of calf injury. However, according to Cantanese this injury has been observed “several times” during *jūdō* tournaments [23]. The likely explanation for the apparent discrepancy between the findings of these authors probably consists in the injury indeed occurring in *jūdō* yet not having caught the attention of investigators or previous studies, or reference texts [24], at least not in the West; in Japanese, a very limited number of papers have touched upon the topic [25-27].

Interestingly though, this type of injury in *jūdō* is not related

to poor technique. On the contrary, it is particularly those who are very skilled and who have developed the ability to enter throws smoothly from every angle using advanced *hairi-kata* 入り方 [entering techniques] that require extensive rotation on the supporting forefoot, who are at risk. Because of the biomechanics involved [28], the injury is likely to occur mostly in forward throws. In *jūdō*, the injury also seems to be associated with being of the male gender.

The calf muscle or *triceps surae* consists of three separate muscles (the gastrocnemius, soleus, and plantaris muscles) of which the aponeuroses unite to form the Achilles tendon [29] (Figure 1). Anatomically, the medial head of the gastrocnemius muscle arises from the medial femoral condyle whereas its lateral head originates from the posterior aspect of the lateral femoral condyle. The gastrocnemius muscle has a biarthrodial architecture bridging two joints (*i.e.*, the knee and ankle). Some authors point out that it spans in fact three joints also including the subtalar joint rather than just two [8,16,30]. Because of this characteristic structure of the gastrocnemius muscle, the excessive stretches and rapid forceful contractions of its high density in type-two fast-twitch muscle fibers make it highly susceptible for strains, especially its medial head.

Patients tend to injure their calves during active plantar flexion or dorsiflexion of the foot and simultaneous extension of the knee, which implies simultaneous active contraction

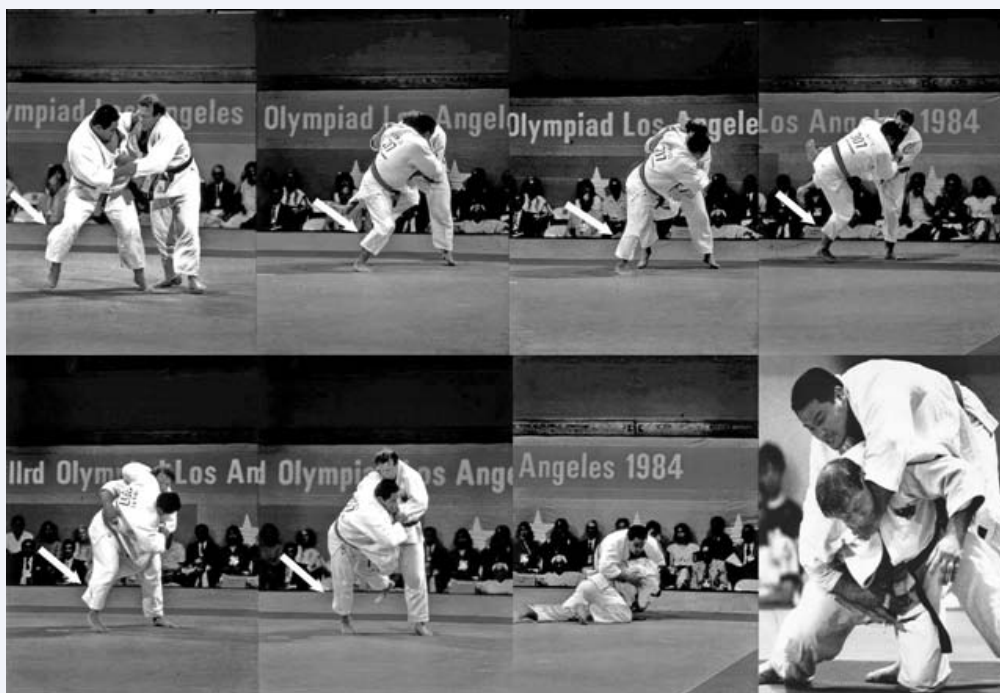


Figure 4 Former Olympic *jūdō* champion Yamashita Yasuhiro 山下泰裕 (back number #307), during the second round of the Open Weight Category of the 1984 Los Angeles Olympic Games, pushes himself off on his right foot to enter *hidari ō-uchi-gari* 左大内刈 [left major inner reaping throw], then switches to *hidari uchi-mata* 左内股 [left inner thigh throw] requiring him to change direction from back to front and pivot on his right foot meanwhile stretching his right knee, while his entire body mass and part of the opponent's body mass are supported by his right foot, hence overloading his right gastrocnemius muscle causing it to rupture (Pictures were taken on August 11, 1984, and supplied courtesy of David Finch, copyright 1984, www.judophotos.com, all rights reserved).

and passive fusiform stretching of the gastrocnemius muscle [8,16,30,31]. The mechanism of injury thus involves an eccentric contraction which tends to produce a snapping sound that conjures up the image of a cracking whip [29]. Many patients indeed report an audible or palpable “pop” in the medial aspect of the posterior calf [10]. This phenomenon has led to its French names “*claquage du mollet*” and “*coup de fouet*” [snap of a whip] which historically also have entered other languages including English.

During this kind of injury the muscle fibers of the medial head of the gastrocnemius muscle become detached from the distal aponeurosis. Ultrasound findings typically include disruption of the normal fiber alignment at the musculotendinous junction. Together with some retraction of the fibers this may well be the only ultrasound sign in small ruptures, whereas big ruptures show the presence of a large hematoma and fluid collection between the gastrocnemius and soleus muscles [11,12]. There is a consensus to classify myotendinous strains as first degree (stretch injury), second degree (partial tear), and third degree (complete rupture) [6].

Injury rate

Although the exact frequency of partial and total tear is not known, most patients seem to develop partial tears. In this respect, about one-third to three quarters of such injuries tend to be partial tears. Large hematomas usually correspond to complete rupture. Kwak et al. [10] found that out of 22 patients (age range: 30-45 years) with a suspected gastrocnemius tear,

seven patients (31.8%) suffered a partial rupture of the medial head of the gastrocnemius muscle, whereas the remaining 15 patients were diagnosed with a complete rupture. Fluid collection was present in 20 patients (90.9%), the thickness of the hematoma being significantly greater than the one seen in patients with partial tears [10]. In a study by Bianchi et al. [8] fifty-one patients with partial and 14 with complete tears were included. Ultrasonographic diagnosis showed that twenty-four patients with partial tears had small lesions (less than 2 cm) whereas 41 had larger partial lesions or complete tears. The authors reported that in patients with small tears, examined within few hours of the trauma, the absence of a definite hypo echoic or anechoic hematoma made detection of the tear difficult. However, careful evaluation of the distal portion of the medial head revealed that muscle fibers and septa did not reach the aponeurosis [8]. The authors identified that the majority of these injuries affected the most antero-medial portion of the medial head and diagnosis might be missed if this region was not meticulously ultrasonographically evaluated [8].

Injury risk factors

In terms of circumstances this injury appears to favor warm-up or later stages of a training session or contest when muscle fatigue combined with impaired coordination are more prevalent [16]. Eccentric contraction-induced compromise of muscle function and, in the extreme, muscle damage has been linked to a loss of Ca^{2+} homeostasis and ensuing rapid and sustained elevation of intracellular Ca^{2+} ($[Ca^{2+}]_i$). Transient Ca^{2+} accumulation in the

cytosol incurs loss of force production, whereas the sustained elevated levels of $[Ca^{2+}]_i$ lead to muscle damage, including disrupted sarcomeres and membranes, apoptosis and necrosis, and eventually to muscle regeneration [32].

Especially, the middle-aged, often poorly conditioned patient who engages in strenuous physical activity or the so-called “weekend warrior” is at risk. Factors that may predispose a person to these kind of injuries possibly are weight-cycling [33], age-related sarcopenia [34-36], *adipositas athletica*-related systemic effects (e.g. bioactive peptides released by adipose tissue that influence muscle and tendon structure), fat deposition in muscle (primarily intracellular) associated with insulin resistance [37], and reduced neoangiogenesis as is sometimes seen in type-2 diabetes-associated chronic tendinopathies of the Achilles tendon and aponeurosis [38,39]. Hidestrand et al. [40] also showed important age-dependent problems in muscle regeneration, i.e. a subset of myoblasts taking on an altered phenotype, which is marked by high high stem-cell antigen (Sca-1) expression. These cells do not participate in muscle regeneration, and instead may contribute to muscle fibrosis in aged muscle [40].

Recommended treatment

When the injury occurs, an imaging examination is generally recommended to rule out other diseases, assess the severity of the tear, and its prediction of and actual repair in time [8]. Percutaneous aspiration of the hematoma during the acute phase is not recommended, as the hematoma usually will recur [8,10,16]. However, during the revalidation phase, ultrasonography-guided transcutaneous evacuation of lysed or whole blood is recommended. If needle aspiration is not completely successful, then an endotracheal surgical approach may offer solace. One week after similar surgical intervention, Cicvarić et al. [41], observed only a thin remaining hypo echoic area during ultrasonography where previously the hematoma was prominently present. Two weeks after surgery, patients were able to walk painlessly, and six weeks post-surgery they had regained normal walking activity [41]. Whether surgical intervention for debridement and evacuation of hematoma eventually leads to better muscle functionality and long-term prevention of reoccurrence of ruptures has not been established. However, Bianchi et al. [8] in nine patients, examined one year or more after the trauma and who were clinically asymptomatic, found during ultrasonography that a hyper echoic area, probably corresponding to fibrous tissue, had interposed itself between the medial head and the soleus muscle. Similarly, Shields et al. [42] found that in twenty-five patients with acute tears of the medial head of the gastrocnemius evaluated in follow-up from 1 to 3 years after injury, Cybex II testing revealed no significant difference in the plantar flexion strength of the noninjured and injured extremity after healing. All patients in their study successfully returned to their previous level of athletic activity.

It is recommended that rehabilitative exercises should isolate the soleus and gastrocnemius muscles by varying knee flexion [29]. In this way and at this stage, passive stretching of the injured muscle helps elongate the maturing intermuscular scar and prepares the muscle for further conditioning and strengthening [43]. Even though there has been some controversy in the literature with regard to the beneficial effects of stretching,

careful analysis by Woods et al. [20] showed that many of those disagreements were due to conflicting definitions, and that certain techniques and protocols have shown a positive outcome on deterring injuries. As a result, a warm-up and stretching protocol should be implemented prior to physical activity as part of soft-tissue injury prevention [20]. With returning range of motion strengthening should begin with unloaded isometric contraction. Ten days after the injury, the developing scar has the same tensile strength as the adjacent muscle [29] and further progression of rehabilitative exercises can begin. Isometric, isotonic, and then dynamic training exercises can be added in a consecutive manner as each type of exercise is completed without pain. If so desired, application of other physical therapy modalities, including massage, ultrasound and electrical stimulation, could also be added at this stage [29].

Uniqueness of the study

“Tennis leg” as previously described has not been associated with practicing *jūdō*, which as a combat sport creates specific etiological circumstance and predisposing factors.

CONCLUSIONS

Active dorsiflexion of the foot and extension of the knee during *jūdō* movements, hence implying simultaneous active contraction and passive fusiform stretching of the gastrocnemius muscle, present a textbook scenario for rupturing the antero-medial portion of the medial head of the gastrocnemius muscle. Meticulous ultrasonographical evaluation presents a quick and thorough diagnosis of the injury. Most of these tears of the gastrocnemius muscle are only partial tears and tend to heal well if proper acute treatment and revalidation are adhered to. Proper warm-up and stretching are recommended to prevent the injury from occurring [20,31], especially in late-career and veteran *jūdōka*.

Learning points/Take-home messages

- Simultaneous active plantar flexion or dorsiflexion of the foot and extension of the knee, as may occur during entry for some standing *jūdō* throws, puts the gastrocnemius muscle at risk for rupture of the distal part of its medial head.
- Predisposing factors are its high density in type-two fast-twitch muscle fibers [29], reduced neoangiogenesis [38,39], increased nonimmunohematopoietic cell content [40], muscle fatigue [40], age-related sarcopenia, male gender, *adipositas athletica*, metabolic syndrome, and type-2 diabetes [37].
- Prognosis of partial ruptures is excellent if proper acute care (P.R.I.C.E.-principle) and rehabilitation are adhered to.

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jūdō 2nd dan black belt, stood as models for the *jūdō* throws in Figure 2. Llyr C. Jones, PhD, London, and Wolfgang Dax-Romswinkel, *Nordrhein-Westphälisches Dan-Kollegium im Nordrhein-Westphälische Judo-Veband e.V.*, Germany, provided assistance with archival research. David Finch, Maidstone, Kent, United Kingdom, took and generously provided the photographs included in Figure 4.

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