# Value of Sonography Combined With Clinical Assessment to Evaluate Muscle Injury Severity in Athletes

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**Context:** Predicting when an athlete can return to sport after muscle injury is a major concern.

**Objective:** To determine whether combining objective clinical and ultrasound findings at presentation accurately predicted time to sport resumption in athletes with muscle injuries.

Design: Cohort study.

Setting: Sports medicine clinic.

**Patients or Other Participants:** A total of 93 consecutive patients, 87 male and 6 female, were seen over a 1-year period for sudden-onset muscle pain while engaging in a sporting activity within the last 5 days and inability to continue the training session or game.

Intervention(s): Standardized physical examination and sonogram.

**Main Outcome Measure(s):** Statistical associations between clinical and sonographic features at presentation and time to sport resumption (<40 days or  $\geq$ 40 days) were evaluated using multivariate models. Correlations between time to sport resumption predicted by a sports medicine specialist and actual time to sport resumption were evaluated using the Spearman rank correlation coefficient.

**Results:** The 93 patients had 95 injuries, caused by muscle contraction in 86 cases and impact in 9 cases. Only 7 injuries had normal sonogram findings. Late sport resumption was associated with 4 clinical criteria (bruising, tenderness to palpation, range-of-motion limitation compared with the other limb, and increased pain with isometric contraction during passive limb straightening) and 4 sonographic criteria (disorganized fibrous tissue, intramuscular hematoma, intermuscular hematoma, and power Doppler signal). The Spearman rank correlation coefficient between predicted and actual times was 0.669 (P<.0001) for mild exercise resumption and 0.804 (P<.0001) for full sport resumption.

**Conclusion:** A combination of physical and sonographic data collected during the acute phase of sport-related muscle injury was effective in predicting time to sport resumption.

Key Words: diagnostic imaging, contusions, strains, sports, return to sport

#### Key Points

- Sonography was useful for diagnosing acute sport-related muscle injuries, monitoring the course of the injuries, and guiding the drainage of fluid if needed.
- In combination with the objective physical findings, sonographic findings were beneficial in predicting injury severity and time to resumption of sport.

S keletal muscle injuries are common in athletes and account for most of the soft tissue injuries sustained during sporting activities.<sup>1</sup> Muscles can be injured by direct impact (contusion) or by overstretching (strain). In a typical sports medicine practice, up to 30% of patients present with muscle strains related to overstretching, which is common in sprinting events and contact sports such as soccer, basketball, and rugby.<sup>2,3</sup> As with other athletic injuries, the main objective of the initial evaluation is to evaluate injury severity, which governs the time to return to sport. Premature sport resumption can result in recurrent injuries.<sup>4</sup>

Sonographic and magnetic resonance imaging (MRI) findings at presentation help predict the time to resumption of full competition.<sup>5–8</sup> A hematoma visualized by sonography or MRI indicates macroscopic structural damage to the muscle. However, the size of the hematoma does not accurately reflect the severity of the injury.<sup>9</sup> Furthermore, clinical features were more useful than MRI for predicting the duration of rehabilitation.<sup>10</sup> Although not widely used in the United States,<sup>6</sup> sonography of the extremities is commonly performed in many other countries to evaluate muscle injuries. Sonography is used not only by radiologists but also by sports medicine specialists as a complement to the physical examination.<sup>11</sup>

The aim of our study was to evaluate whether a combination of objective clinical and sonography findings at presentation accurately predicted the time to sport resumption in athletes with muscle injuries.

#### METHODS

#### **Participants**

Between January 2, 2006, and December 15, 2006, a sports medicine specialist (Y.G.) at a sports medicine center in France evaluated consecutive patients seeking advice for sudden-onset muscle pain during a sporting activity within the last 5 days

with inability to continue the training session or game.<sup>12</sup> Exclusion criteria were a history of injury to the same muscle group or chronic muscle injury within the last 12 months. The study was approved by our local ethics committee. Oral informed consent was obtained from each patient before study inclusion.

#### **Clinical Examination**

We asked each patient to score the worst injury-related pain on a visual analog scale, indicate whether a popping sound was heard at the time of the injury, and list the number of days after the injury that muscle pain was present during everyday activities. A specialist with 20 years of experience in sports medicine and sonography performed a standardized physical examination. This specialist scored 6 criteria: bruising, tenderness to palpation, pain upon isometric contraction, pain upon passive straightening of the limb, range-of-motion limitation compared with the other limb, and pain exacerbation with isometric contraction upon passive straightening of the limb.

# Sonography

Immediately after the clinical examination, the same sports medicine specialist performed a muscle ultrasound scan (En-Visor; Koninklijke Philips Electronics N.V., Amsterdam, The Netherlands) with a 5- to 12-MHz linear probe. The physician looked for changes in muscle echogenicity (ie, disorganized fibrous tissue), intramuscular hematoma, intermuscular hematoma (in the fascia separating 2 muscle groups), and power Doppler signals.

#### **Prediction of Time to Sport Resumption**

At the end of the visit, the sports medicine specialist evaluated the severity of the muscle injury and predicted the time to resumption of mild exercise and to resumption of full sporting activities.

# Follow-Up

Patients whose initial sonogram showed an intramuscular or intermuscular hematoma were routinely reevaluated by the same physician. All patients received the same written, standardized rehabilitation program. In patients with hematoma, physiotherapy was started only after the hematoma was no longer visible on sonography.

Four months after the initial evaluation, patients were interviewed on the phone by a second physician, who collected the answers to the following 2 questions: "How many days after your injury did you resume jogging (ie, mild exercise)?" and "How many days after your injury did you resume full training or competition (ie, the preinjury level of exercise)?" The interviewer was blinded to the clinical and sonographic data.

#### **Statistical Analysis**

Data were analyzed using SPSS (version 15.0; SPSS Inc, Chicago, IL). The patients were separated into 2 outcome groups, depending on whether the time from injury to sport resumption at the preinjury level was shorter than 40 days (early sport resumption) or 40 days or longer (late sport resumption). We chose the 40-day threshold based on an earlier study<sup>13</sup> showing that the performance of patients with hamstring injuries was more than 90% of the values of the uninjured leg after 42 days. Associations between variables collected at the initial evaluation and the outcome group were assessed by univariate analysis using the  $\chi^2$  test (or Fisher exact test where appropriate) and the Mann-Whitney test. Variables yielding P values smaller than .05 were entered into a multivariate regression model with forward selection. Variables yielding P values smaller than .05 in this model were considered predictors of early or late sport resumption. Correlations between predicted and actual times to sport resumption were evaluated using the Spearman rank correlation coefficient. We also evaluated the positive likelihood ratio for late sport resumption.

# RESULTS

#### **Participants**

We included 93 patients, 87 male and 6 female, aged 14 to 57 years (mean,  $29.4 \pm 10.1$  years), who had 95 injuries (Table 1). Two patients each experienced 2 separate injuries to different muscles during the recruitment period. Of the 93 patients, 72 (77.4%) had no previous history of muscle injury. Of the 95 injuries, 88 (92.6%) were associated with sonographic abnormalities. The injury was caused by impact in 9 cases (extrinsic origin) and by muscle contraction in 86 cases (intrinsic origin). Of the 95 injuries, 16 (16.8%) were in recreational athletes and 79 (83.2%) in competitive athletes (including 17 national-level and international-level athletes).

# **Sport Resumption Outcomes**

All patients eventually returned to their preinjury level of sporting activities. The time to sport resumption was less than 40 days for 34 injuries (35.8%) and 40 days or longer for 61 injuries (64.2%). In the early-resumption group, mean time to jog-

Table	1.	Topographic	Distribution	of the	95	Muscle	Ini	uries
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Limb	Muscle Group	Muscle	Number of Injuries	
Lower limb (n=94, 98.9%)	Hamstrings (n = 48)	Biceps femoris	31	
		Semimembranosus	12	
		Semitendinosus	5	
	Quadriceps (n = 19)	Rectus femoris, anterior head	18	
		Rectus femoris, posterior head	1	
	Adductors (n=8)	Adductor longus	6	
		Adductor magnus	2	
	Triceps surae ( $n = 19$ )	Medial gastrocnemius	17	
		Soleus	2	
Upper limb (n=1, 1.1%)		Biceps brachii	1	

ging was  $14.9\pm7.2$  days and mean time to full sporting activity was  $22.9\pm9$  days. Corresponding times in the late-resumption group were  $39.6\pm2.4$  and  $68.3\pm5.1$  days, respectively. For the 7 injuries with normal ultrasound findings, time to resumption of preinjury sporting activities ranged from 14 to 24 days.

#### **Clinical Criteria at First Evaluation**

Findings from the initial evaluation are reported in Table 2. Criteria associated with late sport resumption were an initial visual analog pain score of more than 6, more than 3 days with muscle pain during everyday activities, a popping sound at injury, and 4 of the 6 physical examination criteria (bruising, tenderness to palpation, range-of-motion limitation compared with the other limb, and increased pain with isometric contraction during passive straightening of the limb).

# **Sonographic Findings**

Findings from the initial sonogram with the positive likelihood ratios are shown in Table 3. The sonogram was normal for only 7 injuries. An intramuscular hematoma was the diagnosis for 55 injuries, including 9 caused by an impact and 46 caused by muscle contraction. Of the 9 hematomas caused by impact, 3 were unchanged at the second sonogram, 10 days after the first sonogram. The hematoma was in the rectus femoris anterior head in 1 case and in the rectus femoris posterior head in 2 cases. These 3 hematomas were drained under sonogram guidance. Reevaluation 8 to 10 days after the second sonogram

showed satisfactory clinical and sonographic outcomes. None of the 46 hematomas associated with muscle contraction injuries necessitated drainage. The second sonogram showed a spontaneous decrease in size in all 46 cases, and only 8 cases necessitated a third sonogram, which was conducted on day 21 and showed resorption of the hematoma.

In 47 injuries, the sonogram showed an intermuscular hematoma. (Seven injuries were combined intermuscular and intramuscular hematomas.) Spontaneous resorption occurred in all but 2 injuries; 1 necessitated 2 aspirations and the other, 3 aspirations.

#### Physician's Prediction of Time to Sport Resumption Based on Clinical and Sonographic Criteria

The Spearman rank order correlation coefficient between predicted and actual times was  $0.669 \ (P < .0001)$  for mild exercise and  $0.804 \ (P < .0001)$  for full sport resumption (Figures 1, 2). One patient decided not to resume sporting activities after his muscular injury. The association between predicted and actual times to full sport resumption and positive likelihood ratios are shown in Table 4.

# DISCUSSION

Muscle injuries are among the most common sport-related injuries.<sup>1</sup> The cause is usually overstretching (86 of 95 injuries in our study) and less often a direct impact (9 injuries). Imaging may not be necessary in all cases, and a thorough physical

#### Table 2. Clinical Severity Criteria on Physical Examination by Early or Late Sport Resumption

	Resumption of Sport, No. (%)				
Criterion	Early, <40 d (n=34 injuries)	Late, ≥40 d (n=61 injuries)			
Initial visual analog pain score >6 (n=46)	7 (20.6)	39 (63.9)ª			
Muscle pain during everyday activities >3 d (n=25)	2 (5.9)	23 (37.7)ª			
Popping sound at injury (n=32)	5 (14.7)	27 (44.3)ª			
Bruising (n=11)	1 (2.9)	10 (16.4)ª			
Tenderness to palpation (n = 72)	19 (55.9)	53 (86.9)ª			
Pain on isometric contraction (n=31)	8 (23.5)	23 (37.7)			
Pain on passive limb straightening (n=80)	24 (70.6)	56 (91.8)			
Range-of-motion limitation $>15^{\circ}$ relative to uninjured limb (n = 36)	6 (17.6)	30 (49.2)ª			
Pain on isometric contraction with passive limb straightening (n=55)	11 (32.4)	44 (72.1) <sup>a</sup>			

<sup>a</sup>*P*<.05 between the early-resumption and late-resumption groups.

# Table 3. Sonographic Findings in the Early and Late Sport Resumption Groups

		Resumption of Sport, No.				
Sonographic Finding	Finding Present?	Early (<40 d)	Late (≥40 d)	Positive Total Likelihood Ratio <i>P</i> Value		
Disorganized fibrous tissue	+ -	22 12	54 7	79 19	1.37	.008
Intramuscular hematoma	Total + -	34 8 26	61 47 14	95 55 40	3.3	< .001
Intermuscular hematoma	Total +	34 10 24	61 37 24	95 47 48	2.1	.005
Doppler signal	Total +	24 34 9	61 40	48 95 49	2.5	.0001
	– Total	25 34	21 61	46 95		



Figure 1. Scatterplot of predicted and actual times to resumption of mild exercise.



Figure 2. Scatterplot of predicted and actual times to resumption of full sport activities.

examination, including careful palpation,<sup>3</sup> can provide valuable information about the nature of the injury.<sup>8</sup> Nevertheless, imaging not only confirms the diagnosis of muscle injury but also supplies information that helps to predict the time to sport resumption in professional and recreational athletes.

Recent advances in ultrasound technology provide detailed images that are as accurate as MRI for the evaluation of muscle injuries.<sup>7</sup> The MRI studies have produced insights into the locations and natural history of muscle lesions, which in turn have helped to improve the interpretation of sonography.<sup>9,14-17</sup> Several groups<sup>5,8,15</sup> compared the performance of sonography and MRI. Among them, a prospective study<sup>14</sup> showed that sonography was as useful as MRI for assessing acute hamstring injury (48 injuries in our study).

We found that sonographic features of muscle injury (disorganized fibrous tissue, intramuscular hematoma, intermuscular hematoma, and positive Doppler signal) were associated with the time to sport resumption. We did not evaluate the size of the muscle lesion or hematoma or the change over time. We believe that neither the size of the muscle lesion nor the size of the hematoma (if present) helps to predict the time to sport resumption. Instead, the changes in the hematoma over time guide treatment decisions. However, we agree that we do not yet have a valid argument for or against this possibility. Sonography is a widely available, safe, and inexpensive tool for monitoring hematoma size and guiding needle aspiration. In our study, 3 of 9

 Table 4. Concordance Between Predicted and Actual

 Times to Sport Resumption

Actual T	ime, No.			
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<40 d	≥40 d	Iotal	Likelihood Ratio	P Value
31	18	49	8	<.001
3	43	46		
34	61	95		
	Actual T <40 d 31 3 34	Actual Time, No.         <40 d	Actual Time, No.           <40 d	Actual Time, No.         Positive           <40 d

intramuscular hematomas caused by direct impact and none of the 46 intramuscular hematomas caused by muscle contraction necessitated drainage, suggesting that the impact injuries were more severe. Of 46 intermuscular hematomas, only 2 necessitated drainage, but both necessitated multiple procedures (2 aspirations for 1 injury and 3 aspirations for the other injury), in keeping with earlier findings.<sup>18</sup>

Doppler imaging is useful for evaluating blood flow in skeletal muscle.<sup>19</sup> However, limited data are available on Doppler imaging of sport-related muscle injuries. A positive Doppler signal allows the detection of even minor strain injuries. Whether persistence of the Doppler signal over time suggests a longer recovery period may warrant evaluation. Contrastenhanced sonography has been reported to improve the evaluation of muscle blood flow<sup>20</sup> and acute muscle injury,<sup>21</sup> but in our experience, contrast-enhanced sonography did not substantially improve the assessment of acute muscle injuries.

Sonography is being increasingly used by specialists, most notably to investigate the musculoskeletal system<sup>22</sup> and as a complement to the physical examination.23 We found that combining the clinical and sonographic features at presentation was effective for predicting the time to recovery. The correlation coefficient between the predicted and actual times was acceptable for the time to mild exercise resumption and good for the time to full sport resumption. Accurate prediction of time to recovery is crucial for athletes, coaches, managers, and teams. No consensus guidelines exist for safe sport resumption after muscle injury without risk of recurrence and with the best chance for optimal performance.<sup>4</sup> Some athletes may return to their sporting activities before healing is complete, which may result in suboptimal performance.24,25 Accurate information about the time needed for full rehabilitation may lead to better compliance of athletes with their rehabilitation programs and less pressure from their clubs.

Compared with ultrasound, MRI seems to be superior for diagnosing and predicting the outcome of muscle injuries. The MRI measurements of lesion size, including height on longitudinal sections above the cross-sectional surface, may be useful.<sup>8</sup> However, the available data are limited and contradictory, particularly regarding the influence of initial lesion size on time to healing<sup>13,26</sup> and recurrence risk<sup>27</sup> after acute hamstring strains.

We studied a broad range of muscle injuries, including impact and intrinsic injuries, at a variety of sites in athletes at different performance levels. Many factors influence the ability of an athlete to return to full competition. In a previous study<sup>12</sup> conducted in the same population as the present study, we found that compliance with the rehabilitation program did not influence time to recovery. Consequently, we did not include adherence to rehabilitation in the variables assessed in the cur-

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rent research. Nevertheless, a study investigating a homogeneous population composed of athletes at a specific level with hamstring injuries due to muscle contraction would be useful.

In conclusion, sonography is useful for diagnosing acute sport-related muscle injuries, monitoring the course of the lesions, and guiding the drainage of fluid collection if needed. When used in combination with objective physical findings, sonography is effective in predicting injury severity and hence time to sport resumption.

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