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1 **Achilles and patellar tendinopathy display opposite changes in elasticity: An ultrasound**
2 **shear wave elastography study.**

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22 **Running Head:** Tendinopathy: A shearwave elastography study

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31

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34

35 ABSTRACT

36 Purpose: To compare tendon mechanical properties (elastic modulus) and structural
37 properties (thickness) of healthy individuals with those with Achilles or patellar
38 tendinopathy.

39 Methods: Sixty-seven participants (22 Achilles tendinopathy, 17 patellar tendinopathy, 28
40 healthy controls) were recruited between March 2015-March 2016. Shear wave velocity
41 (SWV), an index of tissue elasticity, and tendon thickness were measured bilaterally at mid-
42 tendon and insertional regions of Achilles and patellar tendons by an examiner blinded to
43 group. Analysis of covariance, adjusted for age, body mass index and sex was used to
44 compare differences in tendon thickness and SWV between the two tendinopathy groups
45 (relative to controls) and regions. Tendon thickness was included as a covariate for analysis
46 of SWV.

47 Results: Compared to controls, participants with Achilles tendinopathy had lower SWV at the
48 distal insertion (Mean difference MD; 95% CI: -1.56; -2.49 to -0.62 m/s; $P<0.001$), and
49 greater thickness at the mid-tendon (MD 0.19; 0.05 to 0.33 cm; $P=0.007$). Compared to
50 controls, participants with patellar tendinopathy had higher SWV at both regions (MD 1.25;
51 0.40 to 2.10 m/s; $P=0.005$), and greater thickness proximally (MD 0.17; 0.06 to 0.29 cm;
52 $P=0.003$).

53 Conclusion: Compared to controls, participants with Achilles and patellar tendinopathy
54 displayed lower Achilles tendon elasticity and higher patellar tendon elasticity respectively.
55 More research is needed to explore whether maturation, aging or chronic load underlie these
56 findings and whether current management programs for Achilles and patellar tendinopathy
57 need to be tailored to the tendon.

58

59 Key words: jumper's knee; Aixplorer; ultrasound, elasticity, stiffness, musculoskeletal,

60 rehabilitation, pain

61

62 INTRODUCTION

63 Painful disorders of the Achilles and patellar tendons are a major problem in competitive and
64 recreational sports as well as the sedentary population. More than half (52%) of elite runners
65 develop Achilles tendinopathy during their lifetime,¹ while the prevalence of current or
66 previous patellar tendinopathy in volleyball or basketball athletes is similar (50-55%).²
67 Ultrasonography is widely used for diagnosis of tendinopathy, however classical ultrasound
68 findings show limited correlation with symptoms^{3,4} and lack fundamental information on
69 tissue mechanical properties.

70

71 Shear wave elastography is a relatively new ultrasound imaging technique that allows non-
72 invasive estimation of soft-tissue viscoelastic properties in vivo by measurement of Shear
73 Wave Velocity (SWV) (in meters per second) generated by the ultrasound pulse.⁵
74 Importantly, as the SWV may be determined from a relatively small region of tissue (as
75 opposed to the whole structure) it can provide direct measurement of specific regions of
76 interest within tendon,^{6,7} which is important because discrete areas of pathology are reported
77 in people with tendinopathy.⁸

78

79 Using this technique, lower elasticity was demonstrated in patients with Achilles
80 tendinopathy,^{9,10} whereas both higher¹¹ and lower¹⁰ elasticity were reported in separate
81 studies of patients with patellar tendinopathy. By estimating patellar tendon stiffness from the
82 relationship between the force applied to the tendon and its associated proximal insertion
83 displacement assessed through B-mode ultrasound, inconsistent findings are also reported (no
84 change¹² or decreased⁸ stiffness). However, this indirect method to assess tendon stiffness has
85 two major drawbacks: i) the tendon force is indirectly estimated (as the force is applied
86 externally to a body segment, rather than directly on the tendon), and ii) only global

87 properties of the whole tendon can be estimated. This is surprising given the similar
88 histological appearance in patellar and Achilles tendinopathy,¹³ but other factors, including
89 age, body composition and training might also modulate the mechanical properties of
90 tendon.¹⁴ For example, athletes with patellar tendinopathy are significantly younger (mean
91 age 23 ± 3 years), taller (mean height 185 ± 10 cm) and heavier (mean weight 77 ± 11 kg),
92 although of similar body mass index (BMI) (mean BMI 23 ± 2 kg/m²) than those without
93 symptoms.¹⁵ In comparison, participants with Achilles tendinopathy are older (mean age $53 \pm$
94 12 years) and have higher BMI (mean 35 ± 8 kg/m²) than control participants.¹⁶

95
96 Methodological differences surrounding measurement of tendon properties may also
97 contribute to the variability between studies.¹⁷ Of relevance to the shear wave elastography
98 technique for tendons, shear wavelengths can be greater than tendon thickness, leading to
99 guided wave propagation.¹⁸ Within this context, the relationship between group velocity of
100 the shear wave estimated by commercialized ultrasound shear wave elastography techniques
101 and tendon elasticity is affected by tendon thickness. Thus, information about both SWV and
102 thickness must be sought to interpret changes in SWV as changes in elasticity. In addition,
103 some authors⁹ have reported measurement artefacts during shear wave elastography
104 acquisition, including signal void areas within an elastogram. While their presence has been
105 suggested to be a potential marker of intratendinous damage,⁹ comprehensive evaluation of
106 its presence is lacking.

107
108 The purpose of our study was to determine whether tendon elasticity and thickness of healthy
109 individuals differ from those with Achilles or patellar tendinopathy using shear wave
110 elastography. We proposed that regional differences in SWV and thickness would be present
111 in those with tendinopathy compared to controls. As other factors may also modulate the

112 elastic properties of connective tissues, we also investigated the relationship between SWV
113 and age, sex and BMI. Last, we aimed to quantify elastography signal void in tendinopathic
114 and healthy tendon.

115

116 MATERIALS AND METHODS

117 Participants with or without tendinopathy were consecutively recruited by social media and
118 local advertisement between March 2015 and March 2016. Inquiries were directed to an
119 online screening questionnaire and eligible participants were invited to attend physical
120 screening by a musculoskeletal physiotherapist not involved in testing. The inclusion criteria
121 for patients with tendinopathy were self-reported tendon pain over the Achilles or patellar
122 tendon of at least 20 on a 0-100 numerical rating scale (NRS), and of duration 12 weeks or
123 more. Physical examination confirmed tendon pain on palpation and loading (by calf raise or
124 decline squat). The number of single leg calf raises or decline squats performed before pain
125 onset was recorded. Exclusion criteria were corticosteroid injection (in previous 6 months),
126 local surgery or other specific pathology (e.g., fracture, diabetes, inflammatory, systemic or
127 neurological disease, malignancy, radiculopathy). All participants were excluded if they had
128 experienced back or other leg symptoms requiring treatment or limiting work/sport in the
129 previous six months. This study was approved by the University of Queensland Medical
130 Research Ethics Committee and all participants provided written informed consent.

131

132 Participants with tendinopathy completed either the Achilles¹⁹ or Patellar²⁰ versions of the
133 Victorian Institute of Sport Assessment (VISA), to provide validated information about pain
134 and disability for their (most) affected leg. Total scores range from 0 to 100, 100 representing
135 an asymptomatic, fully performing individual. In addition to basic demographic information
136 (age, sex, height and weight), all participants completed the Active Australia Questionnaire,

137 to measure physical activity during the preceding week.²¹ Total activity time (minutes) was
138 calculated by adding the time spent in walking and moderate activity and twice the time spent
139 in vigorous activity.

140

141 *Elastography acquisition* Upon arrival participants rested in lying for five minutes prior to
142 examination using the supersonic shear imaging technique (Aixplorer version 8.2, Supersonic
143 Imagine, Aix-en-Provence, France) with 50 mm linear transducer (15-4MHz). A single
144 operator (BKC) performed all scans to eliminate inter-observer variability.²² Interday
145 reliability was examined by testing both legs in six healthy participants on two occasions
146 separated by 48 hours. Intraclass correlation coefficients (ICC) ranged from 0.71 to 0.80 for
147 measurement of SWV and 0.78 to 0.97 for thickness measurements (Table 1).

148

149 Examination was performed blind to the physical examination and group by scanning
150 bilateral patellar and Achilles tendons in a randomised order for all participants. For Achilles
151 measurements, participants lay in prone with their leg extended and ankle resting over the
152 edge of the plinth. The participant's resting ankle angle was measured using a hand-held
153 goniometer. For patellar tendon measurement, participants lay in supine, supported in 30°
154 knee flexion and neutral hip rotation. Based on previous report of the slack angle of the
155 Achilles tendon ($43.7 \pm 3.2^\circ$ plantarflexion)²³ and unpublished observations of the patellar
156 tendon, both positions were assumed to have some passive tension on the respective tendons.
157 The amount of signal void within each ROI, defined as the percentage of all pixels without
158 elastography colour was also calculated. For SWV measurement, we made sure that regions
159 with signal void were not confused with a low value. Participants were told to remain
160 completely relaxed during testing.

161

162 The ultrasound transducer head was aligned in the longitudinal plane with collagen fibres,
163 applying minimal pressure.²⁴ Tendon thickness was measured from longitudinal B-mode
164 images using the inbuilt Aixplorer distance function. For the Achilles tendon, the maximum
165 perpendicular distance between anterior and posterior tendon boundaries was measured over
166 the free tendon (2-4 cm proximal to the Achilles insertion) and immediately proximal to the
167 calcaneal attachment. For the patellar tendon, the maximum perpendicular distance
168 immediately distal to the apex of the patellar and at the midpoint between patellar and tibial
169 attachments was measured. Using the shear wave elastography mode (penetration;
170 persistence low; smoothing 5), the transducer was held for ~10 s duration, and two or three
171 measurements were repeated in each location. For the Achilles tendon, separate images were
172 collected for measurement of mid-tendon and insertional regions, while both patellar regions
173 could be visualised without moving the transducer.

174

175 *Data extraction* Elastography clips (10 s duration, sampling rate of 1.5-1.8 Hz) were
176 converted into PNG images (~20-26 images), then processed offline using customised Matlab
177 scripts (R2016a, The Mathworks, Natick, MA, USA) by a research assistant who was blinded
178 to group. The following regions of interest (ROI) were manually traced on the adjacent B-
179 mode image keeping within the peritendinous boundary: For the Achilles tendon, ROI were
180 measured at the free tendon (ROI length ~3 cm) and immediately proximal to the calcaneal
181 attachment (ROI length ~1 cm). For the patellar tendon, ROI were measured mid-way
182 between proximal and distal attachments (ROI length ~2 cm) and 0.5 cm from the apex of the
183 patella (ROI length ~0.5 cm). The mean SWV (m/s) was averaged over the ROIs of
184 consecutive images. The amount of signal void within each ROI, defined as the percentage of
185 all pixels without elastography colour, was also calculated. For SWV measurement, the
186 Matlab script ensured that regions with signal void were not confused with a low value.

187 Examples of Achilles and patellar elastograms (highlighting signal void) are provided in
188 Figure 1 and Figure 2, respectively.

189

190 *Statistical analysis* For Achilles tendinopathy (AT) and patellar tendinopathy (PT) groups,
191 only the affected leg or self-reported worst leg (in bilateral cases) was included in analysis.
192 For healthy control (HC) participants, we randomly matched Achilles and patellar tendons to
193 ensure an equivalent proportion of left/right legs in the analysed sample, as recommended by
194 previous studies.²⁵ Repeated measures ANCOVAs were used to compare tendon SWV and
195 thickness between groups (AT vs HC or PT vs HC) and regions (mid-tendon vs insertion).
196 Where significant group-by-region interaction was observed, generalised linear models
197 (GLM) were used to estimate mean differences (MD) and 95% confidence intervals (CI)
198 between groups for each tendon region. Age, BMI and sex were included as covariates in all
199 models. In addition, we included tendon thickness as a covariate in analyses of SWV, based
200 on evidence that tendon thickness may affect SWV.^{18,26} We dichotomised signal void as
201 present if it affected more than 5% of pixels within the ROI and differences between groups
202 were compared using Pearson Chi-square statistic.

203

204 Receiver operating characteristic (ROC) analysis was performed to determine the threshold,
205 specificity and sensitivity to differentiate HC from AT or PT, using the Youden's index to
206 identify the cut-point.²⁷ Finally, Pearson correlations were computed to identify relationships
207 between SWV and demographic or injury factors (the latter for tendinopathy groups only).
208 Statistical analysis was performed using SPSS (22.0 IBM Corp). Significance was set at
209 $P < 0.05$.

210

211 RESULTS

212 *Participants* Sixty-seven adults (22 with AT, 17 with PT and 28 HC who were free of tendon
213 pain) were recruited. Demographic and injury information is summarised in Table 2 and
214 reasons for participant exclusion are listed in Supplemental Figure 1. Participants with AT
215 were significantly older than those with PT ($P<0.001$) and had higher BMI than HC
216 ($P<0.001$). Total activity time was not statistically different between the three groups
217 ($P=0.343$). Similar symptom duration ($P=0.943$) and pain/disability levels ($P=0.781$) were
218 found for AT and PT groups. The resting ankle angle adopted during Achilles tendon testing
219 was not different between groups (mean plantarflexion angle $24.3\pm 5.0^\circ$).

220

221 *Achilles tendinopathy* Compared to HC, participants with AT had greater thickness at the
222 mid-Achilles (MD 95% CI: 0.19; 0.05 to 0.33 cm; $P=0.007$), but not at the Achilles insertion
223 ($P=0.80$) (group-by-region interaction, $P=0.035$, Figure 3a). Compared to HC, participants
224 with AT had lower SWV at the Achilles insertion (MD -1.56; -2.49 to -0.62 m/s; $P<0.001$),
225 but not mid-tendon region ($P=0.456$) (group-by-region interaction, $P<0.001$, Figure 3c).
226 Signal void of more than 5% of the ROI was present in four HC (8.9%) and 10 AT (45.5%)
227 cases (Pearson Chi-square $P=0.001$).

228

229 Using ROC analysis, mid-Achilles thickness above 0.64 cm, SWV below 9.7 m/s and signal
230 void above 1.5% of the ROI were identified as cut-points to differentiate HC and AT (Table
231 3). Lower Achilles SWV was associated with higher age ($r=-0.49$, $P<0.001$), greater BMI
232 ($r=-0.53$, $p<0.001$), greater pain and disability as measured by VISA-A ($r=0.49$, $P=0.046$) and
233 fewer single leg calf raises before pain onset ($r=0.646$, $P=0.001$).

234

235 *Patellar tendinopathy* Compared to HC, participants with PT had greater thickness at the
236 proximal patellar (MD 0.17; 0.06 to 0.29 cm; $P=0.003$), but not mid-patellar ($P=0.31$) region

237 (group-by-region interaction, $P=0.01$, Figure 3b). Compared to HC, participants with PT had
238 higher SWV of the patellar tendon at both regions (MD 1.25; 0.40 to 2.10 m/s; $P=0.005$,
239 Figure 3d). Signal void of more than 5% of the ROI was present in 0 HC and 3 PT (17%)
240 cases (Pearson Chi-square $P=0.021$).

241

242 Using ROC analysis, proximal patellar thickness above 0.62 cm, SWV above 6.9 m/s and
243 signal void above 0.7% of the ROI were identified cut-points to differentiate HC and PT
244 (Table 3). Lower proximal patellar SWV was correlated with age ($r=-0.368$, $P=0.013$) only.

245

246 DISCUSSION

247 Using the non-invasive ultrasound-based technique of shear wave elastography, we observed
248 lower insertional Achilles tendon elasticity and higher patellar tendon elasticity in
249 participants with tendinopathy relative to healthy controls. Lower elasticity in Achilles
250 tendinopathy is consistent with two recent studies using shear wave elastography,^{9, 10} and
251 other force-deformation methods.²⁸ However, evidence for changes in patellar tendon
252 mechanical properties in tendinopathy varies between methods^{8, 29} and studies.^{10, 11} Using
253 shear wave elastography, Zhang (2014) found significantly greater elasticity and thickness for
254 the proximal patellar tendon in 13 athletes with unilateral PT, compared to both the
255 unaffected tendon and healthy control participants.¹¹ In contrast, Dirrichs et al (2016)
256 reported lower elasticity in symptomatic compared to asymptomatic tendons in 38
257 participants with patellar tendinopathy.¹⁰ However, Dirrichs et al (2016) reported using a
258 much smaller ROI (standardised size of 1 mm) placed in the stiffest area of tendon.¹⁰

259

260 Although causal relationships cannot be inferred from this cross-sectional study, it is possible
261 that different pathobiological processes associated with maturation and aging may be at play

262 in patellar and Achilles tendinopathy, respectively. Animal work demonstrates that
263 maturation and aging have different influences on the physical, chemical and mechanical
264 properties of tendon.³⁰ In their experimental study in rats, Vogel et al (1980) observed a sharp
265 rise in elasticity during maturation and a smaller but significant decrease during aging.³⁰
266 These changes in mechanical parameters were closely related to cross-linking of collagen.
267 Significant increases in tendon elasticity with maturation³¹ may explain why adolescent
268 athletes have three times greater odds of patellar than Achilles tendinopathy.³² In our study,
269 older age was associated with lower Achilles tendon elasticity, which is in agreement with
270 previous investigations using shear wave elastography,^{7, 24} and other methods.³³ Differences
271 in chronic load may alternatively contribute to our findings. Cassel et al (2015) reported that
272 athletes with patellar tendinopathy were taller and heavier and performed higher training
273 volumes than athletes without patellar tendinopathy,³² attributes which may induce adaptation
274 by increased tendon elasticity. Conversely, sedentary lifestyles adopted by some people with
275 Achilles tendinopathy may contribute to lower elasticity. Interestingly, biomechanical studies
276 demonstrate that the effects of stress deprivation on connective tissue are more prolonged at
277 the insertion than mid-tissue region,³⁴ potentially explaining the significant reduction of
278 mechanical properties at the Achilles insertion. Of clinical importance, Achilles tendon
279 elasticity was significantly correlated with self-reported pain and disability over the
280 preceding week and with a rudimentary measure of the loading capacity of the Achilles
281 tendon.

282

283 The strengths of this study include the blinded design and concurrent investigation of two
284 different lower limb tendinopathies. We acknowledge that interpretation of differences in
285 SWV as differences in elasticity is not straightforward, as larger tendon thickness can lead to
286 a higher SWV due to the effects of guided wave propagation, independent of any change in

287 actual tissue elasticity.^{18, 35} In the present study, no between-group difference in thickness
288 was observed for the mid-patellar tendon and the Achilles tendon insertion, increasing our
289 confidence in our interpretations that mechanical properties were altered. However, it is
290 possible the technique failed to detect a less stiff (but thicker) mid-Achilles tendon. This
291 study extends upon previous ones by quantifying signal void within the measured ROI.
292 Signal void was highly specific (82-96%) to cases with tendinopathy. Although currently
293 speculative, its presence may be due to intra-tendinous swelling or tears,⁹ greater attenuation
294 of shear waves as a result of altered viscosity,²⁶ or severe matrix disruption and increased
295 anisotropy.³⁶ Further studies are needed to determine the impact of attenuation on SWV in
296 the considered region, and relate signal void to changes in matrix proteoglycan concentration
297 due to tendinopathy.

298

299 Limitations of the current study include the moderate reliability estimates, small sample size
300 and heterogenous tendinopathy population, which included participants with symptoms at
301 either mid-tendon or insertional regions. We chose to recruit both male and female control
302 participants with a range of ages, rather than individually match participants on the basis of
303 age or sex. Although not without limitation, statistical adjustment by including age, sex and
304 BMI as covariates in all models, was performed in an attempt to explore which factors
305 modulate changes in tendon properties. Other potential confounding factors such as sporting
306 history and muscle strength were not measured.

307

308 In summary, in the positions tested here, Achilles tendon SWV less than 9.7 m/s and patellar
309 tendon SWV more than 6.9 m/s showed high specificity (81% and 82% respectively) and
310 sensitivity (79% and 77%) for detecting Achilles and patellar tendinopathy respectively,

311 suggesting this method may have important clinical utility for early detection of patients at
312 risk of tendon pathology.

313

314 PERSPECTIVE

315 Achilles and patellar tendinopathy share similar histopathology, but affect different age
316 groups. The present study suggests that the two lower limb tendinopathies display different
317 mechanical properties when compared to tendons from healthy individuals. More research is
318 needed to explore whether maturation, aging or chronic load underlie these findings and
319 whether current management programs for Achilles and patellar tendinopathy need to be
320 tailored to the tendon.

321 Table 1: Inter-day reliability (48 hour interval) for measurement of tendon thickness and
 322 shear wave velocity in six healthy individuals. ICC: Intraclass correlation coefficient.
 323

Tendon region	Session 1 mean (SD)	Session 2 mean (SD)	ICC (95%CI)
Mid-Achilles	0.54 (0.22)	0.57 (0.22)	0.97 (0.92, 0.99)
Insertional Achilles	0.40 (0.08)	0.41 (0.06)	0.78 (0.47, 0.92)
Mid-patellar	0.34 (0.05)	0.34 (0.06)	0.84 (0.59, 0.94)
Proximal patellar	0.53 (0.07)	0.53 (0.07)	0.82 (0.56, 0.94)
	Shear wave velocity (m/s)		
Mid-Achilles	10.4 (1.1)	10.8 (0.8)	0.71 (0.24, 0.91)
Insertional Achilles	9.8 (1.6)	10.0 (1.2)	0.69 (0.11, 0.92)
Mid-patellar	6.1 (0.8)	6.0 (0.7)	0.71 (0.22, 0.91)
Proximal patellar	6.4 (1.2)	6.4 (1.2)	0.80 (0.42, 0.94)

324

325

326 Table 2: Demographic and injury characteristics for Healthy Control, Patellar tendinopathy
 327 and Achilles tendinopathy cohorts.

	Healthy Control	Patellar Tendinopathy	Achilles Tendinopathy
n	28	17	22
<i>Demographic information</i>			
Age (years)	38.3 (16.7)	29.4 (6.6)	47.5 (11.4)*
BMI (kg/m ²)	22.8 (2.7)	25.4 (3.3)	28.1 (5.3)*
Female sex n (%)	17 (61%)	4 (24%)*	9 (41%)
Total activity time (mins)	582.2 (451.9)	797.9 (481.3)	642.4 (491.3)
<i>Injury information</i>			
Injury duration (years)		3.8 (3.4)	3.7 (6.9)
VISA-A or VISA-P (0-100)		57.1 (14.4)	58.6 (16.5)
Worst pain (NRS, 0-10)		5.2 (2.3)	6.0 (2.1)
Average pain (NRS, 0-10)		3.4 (2.1)	4.2 (1.9)
Resting pain (NRS, 0-10)		1.2 (2.4)	1.4 (1.5)
Calf raises (repetitions to pain onset)		NA	9.7 (8.6)
Decline squats (repetitions to pain onset)		2.1 (1.7)	NA
<i>Symptom distribution n (%)</i>			
Bilateral tendinopathy		9 (53%)	14 (64%)
Proximal: distal symptoms		15 (88%): 2 (12%)	NA
Mid-tendon: insertional symptoms		NA	19 (87%): 9 (41%)

328
 329 Data represents mean (SD) unless otherwise specified. * Significant (p<0.05) differences
 330 compared to healthy controls.

331

332 Table 3: Results of Receiver Operating Characteristic analysis.

	Mean Threshold	Specificit y	Sensitivit y
Thickness			
Mid-Achilles	≥ 0.64 cm	89.3 %	72.7 %
Insertional Achilles	≥ 0.44 cm	67.9 %	59.1 %
Proximal patellar	≥ 0.62 cm	100.0 %	58.8 %
Mid-Patellar	≥ 0.33 cm	50.0 %	82.4 %
Shear wave velocity			
Mid-Achilles	≤ 6.80 m/s	68.2 %	75.0 %
Insertional Achilles	≤ 9.68 m/s	81.0 %	78.6 %
Proximal patellar	≥ 6.90 m/s	82.1 %	76.5 %
Mid-Patellar	≥ 7.03 m/s	92.9 %	35.3 %
Signal void			
Mid-Achilles	≥ 1.5 %	82.1 %	59.1 %
Insertional Achilles	≥ 5.1 %	96.4 %	38.1 %
Proximal patellar	≥ 0.7 %	96.4 %	41.2 %
Mid-Patellar	≥ 0.5 %	82.1 %	41.2 %

333

334 Thresholds for tendon thickness (in cm), shear wave velocity (in m/s) and signal void (as a

335 percentage of total ROI) to differentiate healthy and tendinopathic tendon have been

336 calculated using the Youden's index. Specificity and sensitivity were generated at these cut-

337 points.

338

339 Figure 1: Example shear wave elastograms of the Achilles tendon from healthy control (1a)
340 and Achilles tendinopathy participants (1b and 1c). Signal void highlighted (asterisk) in 1c.

341

342 Figure 2: Shear wave elastograms of the patellar tendon from healthy control (1a) and
343 Achilles tendinopathy participants (1b and 1c). Signal void highlighted (asterisk) in 2c.

344

345 Figure 3: Thickness and Shear wave velocity (SWV) of the Achilles tendon (a and c) and
346 patellar tendons (b and d) for Healthy Control (Blue), Achilles tendinopathy (Red) and
347 patellar tendinopathy (orange). Values represent mean and SD. *Significant ($P < 0.05$)

348 differences between tendinopathy and healthy control groups (determined by Generalised
349 linear model adjusted for age, body mass index, sex and thickness (for SWV measures).

350

351

352 Supplemental Content Figure 1: Recruitment numbers and participant eligibility information

353

354

355

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