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1 **The effects of compression garment pressure on recovery from strenuous exercise**

2
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30 **ABSTRACT**

31 Compression garments are frequently used to facilitate recovery from strenuous exercise.
32 **Purpose:** To identify the effects of two different grades of compression garment on recovery
33 indices following strenuous exercise. **Methods:** Forty five recreationally active participants
34 (n=26 males and n=19 females) completed an eccentric exercise protocol consisting of 100
35 drop jumps. Following the exercise protocol participants were matched for body mass and
36 randomly but equally assigned to either a high (HI) compression pressure group, a low
37 (LOW) compression pressure group, or a sham ultrasound group (SHAM). Participants in
38 the high (HI) and low (LOW) compression groups wore the garments for 72 h post-exercise;
39 participants in the SHAM group received a single treatment of 10 minutes sham ultrasound.
40 Measures of perceived muscle soreness, maximal voluntary contraction (MVC), counter
41 movement jump height (CMJ), creatine kinase (CK), C-reactive protein (CRP) and
42 myoglobin (Mb) were assessed before the exercise protocol and again at 1, 24, 48 and 72 h
43 post exercise. Data were analysed using a repeated measures ANOVA. **Results:** Recovery of
44 MVC and CMJ was significantly improved with the HI compression garment ($p < 0.05$). A
45 significant time by treatment interaction was also observed for jump height at 24 h post
46 exercise ($p < 0.05$). No significant differences were observed for parameters of soreness and
47 plasma CK, CRP and Mb. **Conclusions:** The findings of this study indicate that the pressures
48 exerted by a compression garment affect recovery following exercise-induced muscle damage
49 (EIMD), with a higher pressure improving recovery of muscle function.

50

51 **Key Words:** Sport, external pressure, stockings, muscle function, muscle damage

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61 **INTRODUCTION**

62 Exercise that is unaccustomed or unfamiliar in nature can lead to the experience of exercise-
63 induced muscle damage (EIMD) (1,2). Symptoms associated with EIMD include decreased
64 force production, decreased range of motion (ROM) and the experience of muscle soreness,
65 all of which can negatively affect performance (3). Consequently, there is a growing interest
66 in strategies that can minimise the experience of EIMD and accelerate recovery.

67

68 Compression garments are often used to aid recovery following strenuous exercise. The use
69 of compression originates from clinical settings where limb compression is used to treat a
70 range of inflammatory conditions including lymphedema (4), deep vein thrombosis (5) and
71 chronic venous insufficiency (6). Research investigating the use of compression as a
72 recovery modality in an athletic setting remains equivocal, with some research indicating
73 favourable effects (7-10) and other research reporting no benefits (11-12). Whilst the exact
74 mechanism for the benefit of compression garments remains unclear it is thought that
75 application of compression can positively affect haemodynamics and attenuates swelling by
76 facilitating lymphatic drainage and reducing the increase in osmotic pressure experienced as a
77 result of tissue damage (13). In addition, compression is thought to provide mechanical
78 support to the injured limb which may in turn prevent force decrements (13).

79

80 One methodological disparity between studies is the level of compression exerted by the
81 garment. It is likely that the effects of a compression garment depend on the amount of
82 compression applied (14), however if the degree of compression exerted by the garment is
83 insufficient or too high, a beneficial effect is unlikely (15-16). Low levels of compression
84 may be insufficient to modulate blood flow or osmotic pressure, and levels of compression
85 that are too high may have a restrictive effect on blood flow. Optimal levels of compression
86 beneficial to performance and recovery have yet to be determined, with current
87 recommendations based upon clinical guidelines (17). However, pressures that are effective
88 in a clinical population may not be effective in an athletic population.

89

90 Improved venous return has been observed at pressures of 20-25 mmHg at the calf and thigh
91 respectively, with the authors of this study proposing pressures of 15.2-17.3 mmHg as the
92 minimum required in order to achieve elevations in venous return (18). However it should be
93 noted that these minimum pressures are estimations, calculated by assessing the cardiac
94 output response to three different levels of compression garments (10-8, 15-12 and 20-16
95 mmHg at the calf and thigh respectively). Sperlich et al. (19) investigated the effects of knee-
96 high socks that applied compression pressures of 0, 10, 20, 20 and 40 mmHg and observed no
97 effect at any pressure on cardio-respiratory and metabolic parameters during submaximal
98 running. In contrast to this, another study indicated that compression garments exerting
99 pressures of 20 and 40 mmHg may improve alpine skiing performance by enabling a deeper
100 tuck position with attenuated perceived exertion; however the authors indicated that the
101 garment exerting 40 mmHg may reduce blood flow (20).

102

103 A variety of compression pressures have been used in current research ranging from 10-12
104 mmHg (21) up to 40 mmHg (19). A major limitation with current research investigating the
105 efficacy of compression is that a large number of studies have failed to measure exact
106 interface pressures applied by the garments (4, 22-25). Previous research has highlighted
107 large variations in the degree of pressure exerted by compression garments across a
108 population, with a number of individuals receiving low levels of compression (26). This
109 variation is likely due to differences in limb size and tissue structure within a particular size
110 category of garment (22). Thus it is possible the degree of compression exerted was

111 insufficient to enhance recovery in several studies that have observed no benefit (2).
112 Knowledge of the pressures applied by compression garments is fundamental to developing
113 understanding on how a garment affects parameters of performance and recovery. Without
114 knowledge on the precise pressures applied in research studies we cannot accurately interpret
115 or compare findings (15). Therefore the aim of this investigation was to assess whether
116 garments exerting a higher degree of pressure are more effective in facilitating recovery
117 compared to garments exerting a lower pressure.

118 119 120 **METHODOLOGY**

121 **Participants**

122 Forty five recreationally active participants from any sport or training background (n=26
123 male, n=19 female) volunteered to participate in this study. Following ethical approval all
124 participants completed a health screening questionnaire and gave written informed consent.
125 Individuals with a history of musculoskeletal injury and inflammatory disorders were
126 excluded from participating in this study. All participants were asked to arrive at the
127 laboratory in a rested state and refrain from heavy exercise in the 48 h preceding the study
128 and for 72 h following the muscle damaging protocol; in addition, participants were required
129 to refrain from using any recovery strategy for the duration of the investigation. Participant
130 characteristics are presented in table 1.

131 132 **Experimental overview**

133 Participants were matched for weight and randomly, but equally assigned, to either a low
134 (LOW, n=15), or high (HI, n=15) compression treatment group, or a sham-ultrasound group
135 (SHAM, n=15). Participants reported to the laboratory for familiarisation and baseline
136 testing 1 h prior to the muscle damaging protocol. During the familiarisation participants
137 were given a full verbal explanation of how each variable was to be measured and were
138 required to undertake practice attempts of the muscle function tests until performance in each
139 of the tests reached a plateau. Following the familiarisation participants sat with their feet up
140 for 20minutes before the collection of baseline data commenced. Base line data was collected
141 for the dependent variables creatine kinase (CK), high sensitivity C-reactive protein (CRP),
142 myoglobin (Mb), global lower limb muscle soreness and quadriceps soreness, counter
143 movement jump (CMJ), and maximum voluntary contraction (MVC) of the knee extensors.
144 These variables were analysed again 1, 24, 48 and 72 h post muscle damaging protocol.
145 Participants were required to attend the laboratory for post testing at the same time of day and
146 variables were always collected in the same order.

147 148 **Muscle damage procedure**

149 The muscle damaging protocol consisted of 100 drop jumps from a 0.6 m platform.
150 Participants performed 5 sets of 20 drop jumps, with 10 seconds between each jump and a 2
151 minute rest period between sets. Participants were instructed to jump maximally upon landing
152 each jump.

153 154 **Treatment groups**

155 Participants in the LOW compression group were fitted with a full length, lower limb,
156 commercially available compression garment (MA1551b men's compression tights, 2XU, or
157 WA1552b women's compression tights, 2XU, Melbourne, Australia) fitted according to
158 manufacturer's guidelines based upon participants' height and weight. Pressure exerted by
159 the compression garment was measured using a pressure-measuring device (Kikuhime, TT
160 Medi Trade, Søleddet, Denmark), validated for use in this setting (6). Pressure was measured

161 at the front thigh at the mid-point between the superior aspect of the patella and the inguinal
162 crease and at the medial aspect of the calf at the site of maximal girth. Measurements were
163 taken at each site whilst the subject was standing in the anatomical position. Measurements
164 were repeated three times with the mean value recorded. Average pressures exerted by the
165 garments were reported as 8.1 ± 1.3 mmHg at the thigh and 14.8 ± 2.1 mmHg at the calf.

166

167 Participants in the HI compression group wore a full length lower limb clinical medical grade
168 II compression garment (Alleviant clinical class II medical stockings, Jobskin, Nottingham,
169 UK) fitted according to manufacturer's guidelines based upon leg circumference measured at
170 7 locations on the leg. These garments exerted an average pressure of 14.8 ± 2.2 mmHg at
171 the thigh and 24.3 ± 3.7 mmHg at the calf. All garments were worn for 72 h post exercise,
172 participants were only allowed to remove them to shower. Participants were each given two
173 pairs of the same garments to allow rotation when washing.

174

175 Participants in SHAM received 10 min of sham ultrasound comprised of 5 minutes each thigh
176 (Combined therapy ultrasound/inferential, Shrewsbury Medical, Shropshire, UK). A water
177 soluble ultrasound gel (Aquasonic 100 ultrasound transmission gel, Parker Laboratories,
178 Fairfield, USA) was applied to the thigh, using the ultrasound head the gel was spread across
179 the skin using circular movements. Throughout the duration of the ultrasound treatment the
180 unit was turned off and obscured from view of the participants. All treatments were applied
181 immediately following the muscle damaging protocol.

182

183 **Dependent variables**

184 **Muscle soreness:** Global lower limb muscle soreness and localised soreness in the
185 quadriceps muscle group was analysed using a 200 mm visual analogue scale (VAS) with 'no
186 pain' at 0 mm and 'unbearable pain' at 200 mm. Participants stood with their feet shoulder
187 width apart with hands on hips and were asked to perform a squat to 90° , return to standing
188 and mark their subjective feelings of pain on the scale.

189

190 **Muscle function:** Maximal voluntary contraction was assessed using a strain gauge (MIE
191 Medical Research Ltd., Leeds, UK). Participants were seated on a platform in a standardised
192 position, with their hip and knee joints flexed at 90° . The strain gauge was attached 2 cm
193 above the malleoli of the left ankle and participants were required to maximally extend the
194 knee against the device for 3 s, verbal encouragement was given for the duration. Participants
195 performed three repetitions, each separated by 1 min, with the greatest value recorded as
196 MVC. Measurements were recorded in newtons.

197

198 Counter movement jump height was assessed using a force plate (Kistler 9287BA force
199 platform, Kistler Instruments Ltd, Hamshire, UK). Participants were instructed to stand with
200 their hands on their hips and perform a maximal jump on command. Participants performed
201 three jumps the best of which was taken for analysis. Data from 5 participants (n=2 LOW,
202 n=1 HI and N=2 SHAM) were not included in the jump data analysis due to technical issues
203 with the equipment.

204

205 **Blood measures:** CK, high sensitivity CRP, and Mb were analysed from plasma blood
206 samples. Approximately 8.5 mL of blood was collected from the antecubital vein into
207 lithium heparin vacutainers. Following collection, the sample was immediately placed in a
208 refrigerated centrifuge and spun at 3500 rpm, a relative centrifugal force of 3000 g, for 20
209 minutes at 4°C to enable the separation of plasma. The plasma was immediately frozen at -
210 80°C for later analysis. Plasma CK and CRP Mb were measured using an automated

211 analyser (Advia 2400, Chemistry System, Siemens Health Care Diagnostics, USA).
212 Manufacturer's report an intra-sample CV for the analyser of <3% at high and low
213 concentrations and expected baseline sample ranges of 32-294 IU.L⁻¹ and < 3 pg.mL⁻¹ for CK
214 and CRP, respectively. Plasma Mb was analysed using an electrochemiluminescence immuno
215 assay (ECLIA) (Elecsys 2010, Roche Diagnostics GmbH, Germany). Manufacturer's report
216 an intra-sample CV for the analyser of <4% and expected values of 25-72ng.ml⁻¹.

217

218 **Statistical Analysis**

219 All data analyses was carried out using SPSS for Windows version 21, and values are
220 reported as mean ± SD. Independent samples t-tests were used to identify any differences in
221 group characteristics at baseline. All dependent variables were assessed using a treatment by
222 time repeated measures analysis of variance (ANOVA). Where a significant effect was
223 observed, interaction effects were further examined using a Bonferroni *post hoc* analysis. A
224 significance level of $p \leq 0.05$ was applied throughout. Effect sizes, using Cohen's *d*, and
225 90% confidence intervals (CI) were calculated to assess magnitude of effect on the change
226 from baseline at 1, 24, 48 and 72 h post exercise. Threshold values were set at 0.2, small; 0.5,
227 moderate; and 0.8, large.

228

229

230 **RESULTS**

231 Effect sizes and 90% CI comparing change from baseline with 1, 24, 48 and 72 h post
232 exercise can be seen for each variable in table 2. A significant time effect was observed for
233 global lower limb muscle soreness ($F_{2,639,1}=31.509, p < 0.001$) and soreness of the quadriceps
234 ($F_{2,988,1}=45.865, p < 0.001$) indicating that there was a change in muscle soreness over time.
235 Further post hoc Bonferroni tests indicated significant differences from baseline occurred at
236 all time points in both global and quadriceps soreness ($p < 0.05$). No significant group ($F_{2,42}$
237 $=1.081, p = 0.325$) or interaction effects ($F_{5,278,2}=0.861, p = 0.515$) were observed for global
238 lower limb soreness. This was consistent with the group ($F_{2,42}=0.972, p = 0.387$) and
239 interaction effects observed for quadriceps soreness ($F_{5,976,2}=0.855, p = 0.530$) (Figures 1a
240 and 1b).

241

242 Significant time effects were observed for MVC ($F_{3,084,1}=49.760, p < 0.001$), Bonferroni post
243 hoc tests indicated that a significant difference from baseline occurred at all time points ($p <$
244 0.05). Values reduced to $81.6 \pm 9.0, 84.3 \pm 6.3$ and 81.4 ± 9.2 % of baseline 1 h after the
245 damaging protocol and returning to $90.6 \pm 11.6, 99.9 \pm 9.9$ and $91.2 \pm 9.7\%$ of baseline at 72
246 h post in the LOW, HI and SHAM groups respectively. A significant treatment effect was
247 observed for MVC ($F_{2,42} = 3.832, p = 0.030$), however there was no significant time by
248 treatment interaction ($F_{6,169,2} = 1.824, p = 0.097$). Further post hoc analysis indicated the
249 significant difference occurred between the HI and SHAM groups ($p = 0.036$) (figure 2).

250

251 Significant time effects were observed for Jump height ($F_{4,1} = 11.202, p < 0.001$), further post
252 hoc analysis indicated that significant differences from baseline occurred at all time points (p
253 < 0.05) figure 3. A significant time by treatment effect ($F_{8,2} = 2.99, p = 0.004$) and a
254 significant treatment effect ($F_{2,37} = 3.741, p = 0.33$) was observed for jump height. Further,
255 post hoc analysis indicated the significant treatment effect occurred between the HI and LOW
256 compression groups ($p = 0.032$) and the time by treatment interaction occurred at 24 h post
257 exercise between the HI and LOW compression groups ($p = 0.002$) (figure 3).

258

259 Whilst an overall significant time effect was observed for CK ($F_{2,353,1} = 2.980, p = 0.021$),
260 further post hoc analysis failed to indicate a significant effect at any time point ($p > 0.05$).
261 Post exercise plasma CK values were elevated 1 h post exercise in all experimental groups
262 and remained raised for the duration of the study. No significant group ($F_{2,42} = 0.174, p =$
263 0.841) or interaction effects were observed for CK ($F_{4,706,2} = 1.383, p = 0.240$), data is
264 presented in table 3.

265
266 There was no significant time effect ($F_{4,1} = 0.615, p = 0.570$), group effect ($F_{2,11} = 0.511, p =$
267 0.558) or time by group effect ($F_{8,2} = 0.217, p = 0.858$) for CRP. This was also consistent
268 with Mb where there was also no significant time ($F_{4,1} = 1.915, p = 0.110$), group ($F_{2,11} =$
269 $0.387, p = 0.681$) or time by group effect ($F_{8,2} = 1.016, p = 0.462$) (table 3).

270

271

272 **DISCUSSION**

273 The aim of this study was to investigate the effects of different compression pressures on
274 indices of recovery following EIMD in a recreationally active population. The main finding
275 was that a garment exerting higher levels of compression is more effective in modulating
276 muscle function following exercise that induces muscle damage when compared to a garment
277 exerting lower levels of compression and a sham treatment group.

278

279 In this study muscle function decreased following the damaging protocol, this was evidenced
280 by a significant time effect for both MVC and jump height ($p < 0.05$). Recovery of strength
281 was greatest in the HI compression group with participants recovering to $99.9 \pm 9.9\%$ of
282 baseline MVC values at 72 h post exercise compared to 90.6 ± 11.6 and $91.2 \pm 9.7\%$ in the
283 LOW and SHAM group. A significant difference between treatment groups was observed for
284 MVC with the difference occurring between the HI compression group and the SHAM group
285 This observation is supported by the large effect sizes observed between the HI and SHAM
286 group between 24 – 72 h post exercise and the moderate to large effect sizes observed
287 between the LOW and HI group at the same time points. These observations suggest that
288 strength recovered at an accelerated rate over 72 h in the HI compression group.

289

290 Additionally Jump height was significantly higher 24 h post exercise in the HI group
291 compared to the LOW group, indicating that compression garments exerting higher levels of
292 compression may be beneficial in improving recovery of muscle function. The failure to
293 observe a significant treatment effect between the HI and SHAM group was unexpected,
294 however a large effect size was seen at 24h post exercise. Although this study attempted to
295 control for a placebo effect by using sham ultrasound, it is possible that the observation of
296 improved recovery in the HI group may be linked to the participant's belief that tighter
297 compression garments have a positive response on recovery; this is a limitation of the study.

298

299 Improved recovery of muscle function has been observed in previous research (9,13,27), and
300 has been attributed to an enhanced repair of the contractile elements of the muscle (13).
301 Furthermore the application of compression may provide mechanical support to the limb
302 resulting in reduced movement of the tissues and offering 'dynamic immobilisation', whilst
303 still enabling use of the limb, this has been proposed to increase motor unit activation during
304 tissue injury (13, 28). However, the exact mechanism responsible for this is unclear. Several
305 studies have failed to observe improved muscle function with the use of a compression
306 garment (11,21-22). However as the exact level of compression exerted by the garments was
307 not measured in these studies it is possible the garments used did not exert enough pressure to
308 be of benefit.

309

310 No significant between group differences were observed for global lower limb soreness and
311 soreness in the quadriceps, this is similar to previous findings (11-12,21). However, moderate
312 effect sizes were observed at 48 h post exercise between the HI and SHAM group for global
313 muscle soreness and at 24 h post exercise between the LOW and HI group for quadriceps
314 muscle soreness, indicating soreness was lower in the HI group.

315

316 The experience of DOMS arises as a result of damage to the soft tissue leading to an
317 inflammatory response which causes localised oedema in the affected limb. The presence of
318 oedema can stimulate pain afferents bringing about the experience of soreness (28). The
319 application of compression may reduce the level of oedema by attenuating the magnitude of
320 the inflammatory response thus reducing the severity of the soreness experienced (21,27).
321 Whilst a large body of research has observed reductions in perceived muscle soreness with
322 the use of compression garments (13,24,27), these studies failed to control for placebo effect,
323 this needs to be considered when interpreting findings.

324

325 Creatine kinase and Mb are released from the muscle during the experience of muscle
326 damage and as such are frequently used as markers of EIMD (21-22). Given the absence of a
327 significant time effect for Mb and a non-significant post hoc results for the time effect in CK
328 it is likely that the muscle damage protocol in this study did not cause sufficient enough
329 muscle damage for a large CK and Mb response. Previous investigations have observed
330 reductions in concentrations of CK with the application of compression (2,22). It is worth
331 noting the peak concentrations of CK observed within the control group of this study (586
332 IU.L⁻¹), is much smaller than the values observed in other studies (2194 IU.L⁻¹(7) and ~1750
333 IU.L⁻¹ (13)) all of whom found beneficial effects of compression. It is possible compression is
334 not effective at modulating clearance of CK at lower concentrations.

335

336 A number of investigations have observed reduced inflammation with the use of a
337 compression garment (9,13,21), however this study failed to observe any significant group
338 differences for the inflammatory marker CRP. Furthermore no significant time effect was
339 observed for this marker, it is possible that muscle damage was not severe enough to cause a
340 large inflammatory response. Regardless of the magnitude of the inflammatory response it
341 appears the exercise protocol was severe enough to cause pronounced performance
342 decrements and elevations in muscle soreness.

343

344

345 **PRACTICAL APPLICATION**

346 Whether compression garments exert sufficient pressure to be effective has been raised by a
347 number of investigators (21-22). This study provides evidence for the importance of
348 compression pressure in modulating parameters of recovery. The majority of previous
349 research has failed to measure exact pressures exerted by compression garments, until the
350 reporting of interface pressure occurs in research on compression it is difficult to identify
351 optimal levels of compression necessary for improving recovery. More knowledge is needed
352 on the effects of different compression pressures in order to assist practitioners in the
353 selection of a garment for a particular role.

354

355

356 **CONCLUSIONS**

357 In conclusion, a compression garment exerting higher compression pressures (14.8 ± 2.2 and
358 24.3 ± 3.7 mmHg at the thigh and calf respectively) is more effective at improving muscle

359 function than a compression garment exerting lower pressures (8.1 ± 1.3 mmHg at the thigh
360 and 14.8 ± 2.1 mmHg at the calf) and a SHAM treatment group. Furthermore, no treatment
361 group was superior in aiding the removal of plasma markers of muscle damage or
362 inflammation. The degree of pressure exerted by the garment is an important factor in
363 determining the efficacy of compression garments in recovery. These findings highlight the
364 importance of wearing a correctly fitting garment when using compression as a recovery
365 modality.
366

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440

441 **FIGURE LEGENDS**

442 **Figure 1.** Perceived ratings of global lower limb soreness (A) and quadriceps soreness (B)
443 for the LOW, HI and SHAM treatment groups. Values are presented as mean \pm SD. No
444 significant differences were observed between treatment groups. † denotes significant time
445 effect compared to baseline.

446

447 **Figure 2.** Percentage change in MVC for the LOW, HI and SHAM treatment groups. The HI
448 compression group was significantly different from the SHAM treatment group. Values are
449 presented as mean \pm SD, data was recorded in newtons and converted to a percentage change.
450 * denotes a significant difference from the HI group. † denotes significant time effect
451 compared to baseline.

452

453 **Figure 3.** Percentage change in CMJ for the LOW, HI and SHAM treatment groups. The HI
454 compression group was significantly different from the LOW compression group at 24 h post
455 exercise. Values are presented as mean \pm SD. * denotes a significant difference from HI
456 group. † denotes significant time effect compared to baseline. α denotes significant
457 interaction between HI and LOW compression groups.

458

459 **Table 1.** Participant characteristics for the low compression pressure group (LOW), high
460 compression pressure group (HI) and sham ultrasound treatment group (SHAM). Values are
461 presented as mean \pm SD.

462

463 **Table 2.** Effect sizes \pm 90% CI of the application of treatment on markers of exercise-induced
464 muscle damage.

465

466 **Table 3.** Plasma markers of CK, MB and CRP for the LOW, HI and SHAM treatment
467 groups. No significant differences were observed between treatment groups. Values are
468 presented as mean \pm SD. * denotes significant time effect was observed.

469

470 **Table 1.** Participant characteristics for the low compression pressure group (LOW), high compression pressure
471 group (HI) and sham ultrasound treatment group (SHAM). Values are presented as mean \pm SD.

	Age (yrs)	Height (cm)	Weight (kg)
LOW	29.2 \pm 4.7	173.6 \pm 11.7	73.3 \pm 17
HI	32.7 \pm 7.8	175 \pm 7.4	71.7 \pm 7.2
SHAM	28.3 \pm 4.1	174.1 \pm 9.4	71.7 \pm 10.2

472

473

474 **Table 2.** Effect sizes \pm 90% CI of the application of treatment on markers of exercise-induced
 475 muscle damage.
 476

	Post	24 h	48 h	72 h
Change from baseline				
Global soreness	-0.12 \pm 15.7	-0.12 \pm 15.9	0.35 \pm 18.8 ^a	0.31 \pm 14.3 ^a
LOW v SHAM	0.41 \pm 10.9 ^a	0.36 \pm 15.1 ^a	0.55 \pm 17.2 ^b	0.45 \pm 12.8 ^a
HI v SHAM	-0.47 \pm 13.6 ^a	-0.48 \pm 15.2 ^a	-0.17 \pm 16.9	-0.11 \pm 11.9
LOW v HI				
Quadriceps soreness				
LOW v SHAM	0.14 \pm 15.2	-0.28 \pm 18.0 ^a	0.09 \pm 18.6	0.03 \pm 16.3
HI v SHAM	0.32 \pm 13.0 ^a	0.39 \pm 16.7 ^a	0.47 \pm 19.2 ^a	0.26 \pm 15.6 ^a
LOW v HI	-0.18 \pm 11.5	-0.74 \pm 15.6 ^b	-0.38 \pm 19.1 ^a	-0.27 \pm 14.9 ^a
MVC				
LOW v SHAM	-0.02 \pm 3.8	-0.33 \pm 3.7 ^a	-0.40 \pm 3.5 ^a	0.06 \pm 4.4
HI v SHAM	-0.36 \pm 3.3 ^a	-0.80 \pm 3.7 ^c	-0.92 \pm 3.9 ^c	-0.88 \pm 4.0 ^c
LOW v HI	0.35 \pm 3.2 ^a	0.53 \pm 3.3 ^b	0.61 \pm 3.6 ^b	0.86 \pm 4.4 ^c
CMJ				
LOW v SHAM	0.25 \pm 4.2 ^a	0.60 \pm 4.2 ^b	0.86 \pm 4.0 ^c	0.62 \pm 3.3 ^b
HI v SHAM	0.10 \pm 3.5	-0.93 \pm 3.6 ^c	-0.01 \pm 4.2	-0.38 \pm 3.2 ^a
LOW v HI	-0.17 \pm 4.0	-1.30 \pm 4.5 ^c	-0.99 \pm 3.4 ^c	-1.09 \pm 3.0 ^c
CK				
LOW v SHAM	-0.46 \pm 173.7 ^a	-0.51 \pm 99.0 ^b	-0.18 \pm 64.8	-0.79 \pm 75.0 ^b
HI v SHAM	-0.73 \pm 85.4 ^b	-0.27 \pm 119.2 ^a	-0.14 \pm 125.4	0.12 \pm 153.6
LOW v HI	-0.09 \pm 190.7	-0.13 \pm 145.8	0.05 \pm 122.6	0.50 \pm 155.1 ^b
Mb				
LOW v SHAM	0.22 \pm 75.7 ^a	-0.47 \pm 96.0 ^a	-0.03 \pm 113.2	-0.73 \pm 93.1 ^b
HI v SHAM	-0.08 \pm 92.6	-0.26 \pm 111.2 ^a	0.01 \pm 140.6	-0.64 \pm 108.5 ^b
LOW v HI	0.08 \pm 84.3	-0.15 \pm 101.1	-0.03 \pm 111.8	0.01 \pm 113.0
CRP				
LOW v SHAM	0.06 \pm 0.5	0.23 \pm 0.5	0.14 \pm 0.5	0.10 \pm 0.5
HI v SHAM	-0.13 \pm 0.5	0.36 \pm 0.5	0.11 \pm 0.4	0.02 \pm 0.5
LOW v HI	0.22 \pm 0.4	-0.09 \pm 0.5	0.04 \pm 0.5	0.07 \pm 0.5

477
 478 Mean effect refers to the first names group minus the second named group, ^a indicates a small effect
 479 size, ^b indicates a medium effect size, ^c indicates a large effect size.

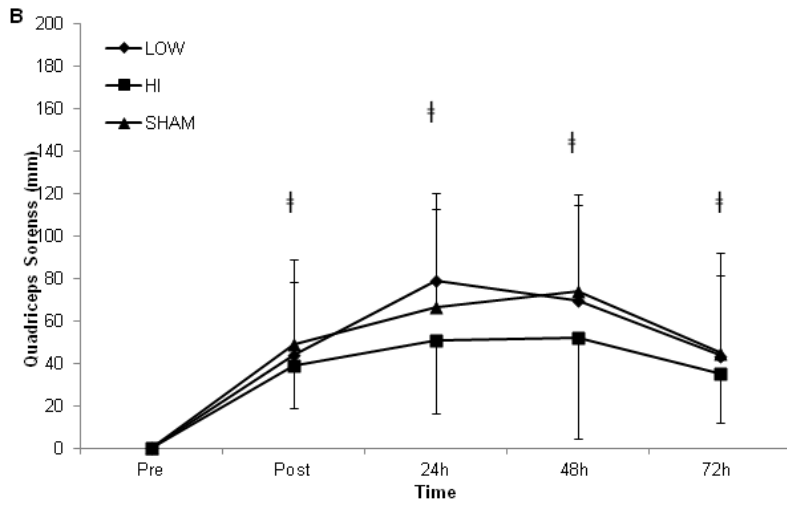
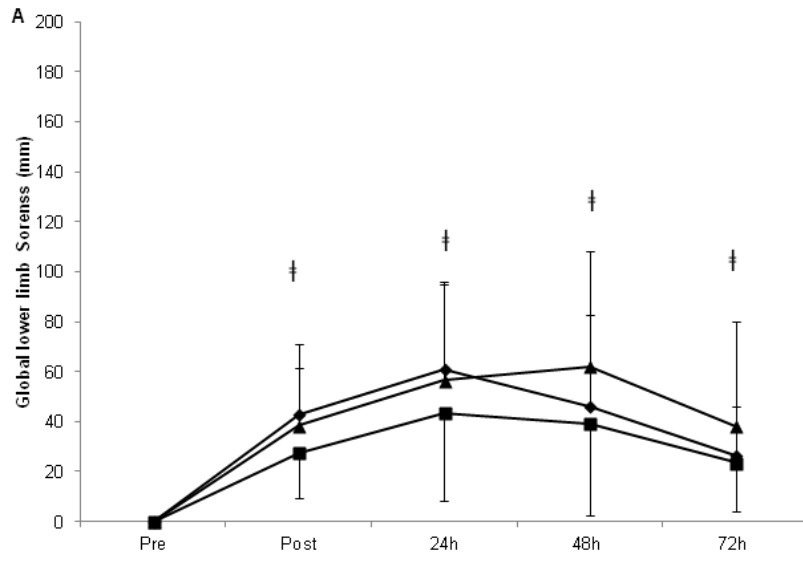
480

481 **Table 3.** Plasma markers of CK, MB and CRP for the LOW, HI and SHAM treatment groups. Values are
 482 presented as mean \pm SD.

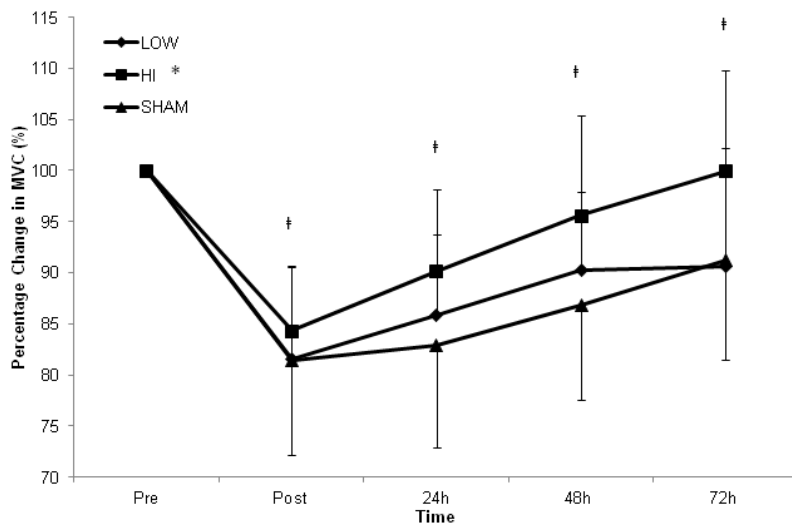
	Pre	Post	24 h	48 h	72 h
CK (IU.L⁻¹)					
LOW	184.3 \pm 152.3	418.9 \pm 722.3	368 \pm 440.7	280 \pm 259.8	168.5 \pm 82.5
HI	207.7 \pm 218.6	401.6 \pm 333.4	345.7 \pm 371.4	318.8 \pm 355.3	380.9 \pm 438.4
SHAM	217 \pm 298.5	258.2 \pm 332.9	277.3 \pm 326.4	284.9 \pm 355.4	345.1 \pm 579.7
Mb (ng.ml⁻¹)					
LOW	434.3 \pm 107.0	489.8 \pm 186.1	534.1 \pm 204.8	439.5 \pm 155.3	504.1 \pm 194.7
HI	458 \pm 182.2	571.5 \pm 155.7	519.7 \pm 145.7	454.8 \pm 261.9	566.7 \pm 159
SHAM	490.4 \pm 88.5	585.8 \pm 180	480 \pm 170.2	487.7 \pm 158.8	429.7 \pm 128.3
CRP (pg.mL⁻¹)					
LOW	2.5 \pm 0.7	2.3 \pm 0.8	2.4 \pm 1.0	2.2 \pm 1.0	2.3 \pm 0.9
HI	2.6 \pm 0.7	2.5 \pm 0.9	2.3 \pm 0.6	2.3 \pm 0.9	2.4 \pm 1.1
SHAM	2.3 \pm 0.5	2.2 \pm 0.8	2.5 \pm 0.9	2.1 \pm 1.0	2.3 \pm 1.0

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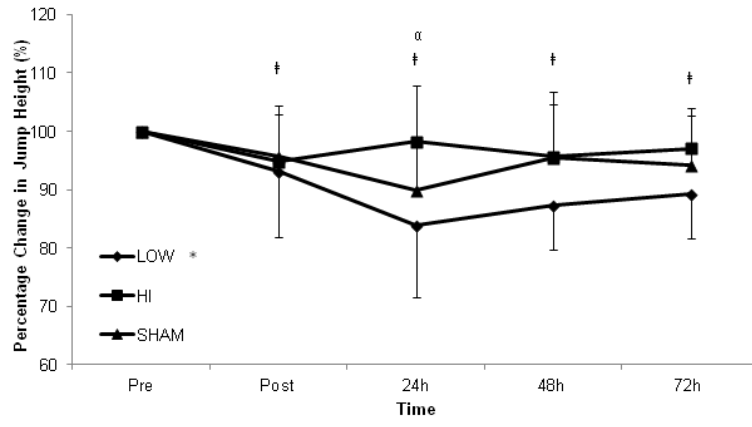
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