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1 The Relationship Between Strength Measures and Task Performance in Specialist
2 Tactical Police

3 ABSTRACT

4 Specialist Tactical Police Officers (STPO) carry heavier on-body loads than generalist police
5 officers. Improvements in strength may mitigate the impacts of these heavier loads. The aim
6 of this investigation was to determine the correlations between absolute and relative strength
7 measures and occupational task performance in STPOs. Retrospective data were provided for
8 47 male specialist police officers from an elite Australian police unit. Data included body mass
9 (mean = 89.0±8.58 kg), strength measures (1 Repetition Maximum [RM] measures for a bench
10 press, squat, deadlift and pull-up) and task performance measures (85 kg victim drag wearing
11 15 kg of operational load and 5 km pack march wearing 40 kg of operational load). Pearson's
12 correlations were conducted to determine relationships between measures and were plotted on
13 a linear regressions model. Significant, moderate to strong correlations were found between all
14 strength measures and victim drag performance and significant negative moderate correlations
15 between relative bench press, absolute and relative squat and absolute and relative pull-up and
16 pack march times. The absolute deadlift had the strongest correlation to the victim drag
17 ($r=0.747, p<0.01$) while the relative pull-up showed the strongest correlation with pack march
18 performance ($r=-0.466, p<0.01$). The requirement to lift a portion of the dummy off the ground
19 during the victim drag may explain the increased importance of absolute strength while the
20 requirement to transport load affixed to the body may explain the importance of relative
21 strength requirements. Improvements in absolute and relative upper and lower body strength
22 may improve task performance in this population.

23 **Keywords:** SWAT, Tactical Personnel, law enforcement, elite, load carriage

24 INTRODUCTION

25 Police officers must be prepared to perform physically demanding and arduous occupational
26 tasks that require them to run, jump, crawl, climb or push/pull with maximal exertion (3, 22,
27 24). Furthermore, they may be required to perform these tasks while apprehending an
28 uncooperative suspect (28, 29) and whilst carrying occupational loads (1). On average, these
29 occupational loads can weight around 10 kg (1) and have been known to reduce officer power,
30 agility, and change of direction speed (13, 19).

31 Policing situations which are deemed extreme in nature are handled by specialist tactical police
32 officers such as those serving in Special Weapons and Tactics (SWAT) units (6). These
33 specialist tactical units of the police forces consist of specialist tactical police officers (STPO)
34 who are trained and employed to resolve critical incidents involving a threat to public safety
35 (6). The critical nature of the tasks carried out by STPOs require them to carry threat-dependent
36 weaponry, body armor, and equipment (such as breaching devices, gas masks, etc.) (6). This
37 equipment can add an additional 10 to 30 kg of load to their bodies above that of general police
38 officers (1, 5, 14). With these necessary additions to the STPOs operational load, there is
39 typically a concurrent detrimental effect on their ability to complete occupational tasks (5) and
40 an increased physiological burden (2, 4). This increased physiological burden highlights the
41 importance of developing and maintaining optimal physical fitness in STPO (7, 8, 23).

42 The requirement for STPO to be physically strong is noted in the literature, as is the fact that
43 these officers are typically stronger than the general population (17). For example, previous
44 research by Robinson et al. (25) found that both absolute and relative strength measures were
45 associated with STPO load carriage performance over repeated 5km load carriage events
46 completed as fast as possible (pack weight of 25 kg). Significant weak to strong correlations
47 were found between strength measures of 1 Repetition Maximum (1RM) deadlift (absolute $r=-$

48 0.288; relative $r=-0.403$), bench press (absolute $r=-0.360$: relative $r=-0.465$), squat (absolute
49 $r=0.452$: relative $r=-0.500$), and pull-up (absolute $r=0.452$: relative $r=0.607$) for the first march
50 with the later three measures significantly correlated with the subsequent second and third pack
51 marches (each approximately 4 months apart). Of note however, across all four of these
52 strength measures, the relative strength values were more strongly correlated to the load
53 carriage task than the absolute values. Conversely, recent work by Moreno et al. (18) found
54 that absolute deadlift measures were more strongly correlated to a 75 and 91 kg dummy drag
55 than relative measures, with the latter not being significantly related. These findings suggest
56 that while strength measures are important to the performance of tasks that can typically be
57 undertaken by STPO, the nature of the strength, be it absolute or relative, may change
58 depending on the task.

59 By understanding the different strength needs of STPO (in terms of relative or absolute
60 strength) informed conditioning practices can be put in place to better optimize officer
61 performance, especially in tasks where they may be weaker (e.g. load carriage versus a victim
62 drag). The aim of this study was to investigate the relationship between measures of strength
63 (absolute and relative) and task performance (85 kg victim drag and 5 km pack march) in
64 STPO. It was hypothesized that strength would be related to performance on both tasks and
65 that the nature of strength required (absolute and relative) would differ between tasks.

66

67 **METHODS**

68 *Experimental Approach to the Problem*

69 Retrospective data were provided from an elite Australian specialist police unit. Body mass
70 data were provided in addition to data collected for strength performance (1RM bench press,
71 1RM squat, 1RM deadlift, 1RM pull-up) as part of departmental process. Relative strength data

72 were derived by dividing 1RM scores by each individual's body mass. Furthermore, results
73 from two performance measures (85kg Victim Drag [15 kg officer load] and a 5km loaded [40
74 kg officer load] Pack March) were also obtained as part of departmental processes.

75 *Subjects*

76 Data were obtained in non-identifiable format pertaining to 47 male STPOs from an
77 Australian law enforcement agency. The strict security protocols regarding the protective
78 identity of these individuals limited all identifiable information to only body mass (mean =
79 $89.0 \pm 8.58\text{kg}$) and the resulting performance. The limitation of demographic data in this
80 population has been reported in previous literature (21). Ethics approval for this study were
81 provided by the Bond University Human Research Ethics Committee (RO1585) and
82 clearance to publish this information provided by the relevant law enforcement gatekeeper
83 approvals.

84 *Procedures*

85 Strength measures were collected over two days (Day 1 – bench press and deadlift; Day 2 –
86 squat and pull-up) with the victim drag and pack march assessments conducted in the following
87 week on independent days. Details regarding the protocols for the strength and performance
88 measures are detailed below and has been previously described in the literature (25).

89 **Strength Measures:** The intent of a 1RM test is to determine the single maximal voluntary
90 effort force that a muscle or muscle group can exert (11), and was utilized given its
91 consideration as the gold standard for non-laboratory based strength assessments (10). The
92 1RM testing protocols were conducted as previously described by Haff and Triplett (11) and
93 were always preceded by a 10-minute warm up on each day of testing. The warm up consisted
94 of self-selected exercises such as Hindu pushups with rotation, bodyweight squats, clock
95 lunges, supine gluteal bridges, 5-10kg medicine ball slams, push-ups and alternating lunges.

96 The Bench Press

97 Subjects completed the bench press testing using a 20kg Pendlay Barbell loaded with Gym
98 branded bumper weight plates, utilizing a Hammer Strength Bench rack (LifeFitness,
99 Rosemont, IL) and a Strength and Conditioning (S&C) coach for safety. Subjects were
100 instructed to lay supine on the bench with both feet flat on the floor with gluteals and scapulae
101 in contact with the bench. Grip width was slightly wider than shoulder width (at a comfortable
102 position) to ensure 90° of elbow flexion was achieved at the end of the eccentric phase of the
103 lift. The test initiated with the officer un-racking the weight and holding it with arms fully
104 extended at the midline of their sternum. The barbell was lowered at a controlled speed until
105 contact was made with the chest, and thereafter returned to the starting position above the
106 sternum. A lift was only considered successful if the gluteals and scapulae remained in contact
107 with the bench throughout the movement and the participant did not require any assistance
108 from the spotter. The final load (including bar weight) lifted correctly was measured in kg to
109 form the final score.

110 The Squat

111 The back squat utilized a 20kg Pendlay Barbell, Gym branded bumper weight plates in a
112 Hammer Strength Bench rack (LifeFitness, Rosemont, IL) with two S&C coaches as spotters.
113 The subjects were instructed to position themselves so that the barbell was in contact with
114 upper fibers of the trapezius, above the scapulae. Foot and grip placements were instructed to
115 be slightly wider than the shoulders at a comfortable position. The test began with the officer
116 removing the barbell from the rack and taking two steps back to a pause. The participant was
117 instructed to perform the squat to 90° of knee flexion before extending to full hip and knee
118 extension. The final load (including bar weight) lifted correctly was measured in kg to form
119 the final score.

120 The Deadlift

121 The deadlift protocol was completed use an a 24kg diamond-shaped barbell (Australian Barbell
122 Company, Mordialloc, VIC) loaded with Gym branded bumper weight plates (LifeFitness,
123 Rosemont, IL). A rubber matted area of the gym was utilized for the testing. The subjects were
124 positioned inside the diamond shaped barbell and instructed to place their feet shoulder width
125 apart. The officers were instructed to squat, grip the barbell and maintain a neutral neck position
126 with feet flat on the ground. The test began with a cue followed by hip and knee extension in a
127 controlled manner. Once full hip and knee extension was achieved a second cue was provided
128 to lower the weight. Displays of poor lifting technique were met with cessation of the lift and
129 an unsuccessful lift result. The final load (including bar weight) lifted correctly was measured
130 in kg to form the final score.

131 The 1 RM Pull-Up

132 Subjects completed the pull-up assessment with a Dan Baker Strength weight belt
133 (DanBakerStrength Sunshine Coast, QLD, Australia), and Gym branded bumper plates
134 attached to hang in front of the body. The officers were instructed to grip the bar wider than
135 shoulder width at a comfortable position ensuring 90° of elbow flexion at the end of the
136 concentric phase. The subjects were instructed to maintain a knee flexion at ~90° with ankles
137 crossed behind them during the movement. The test began on the with a cue to initiate the
138 concentric phase. A repetition was deemed successful if there was no swinging of the legs
139 during the movement and the chin was raised above parallel with the bar with 90° of elbow
140 flexion. 1RM values achieved were the result of adding the officer's body mass to the external
141 weight lifted.

142 Victim Drag protocol

143 The victim drag was completed using an 85kg Life Tec dummy placed with its head on the
144 starting line facing the direction of pull. A 50m long course was set up using Hart Sport cones
145 (Hart Sports, Brisbane, Australia) placed every 5m on a flat concrete surface. Subjects were
146 required to wear their tactical uniform, standard issue boots, body armour and helmet totalling
147 approximately 15kgs (loads varied slightly due to natural variations in individual clothing and
148 footwear sizes and subsequent ballistic plate sizes). The subjects were instructed to grip the
149 dummy under the arms and drag it backwards as fast and far as possible in the time allowed.
150 Each participant had 10 sec to drag the dummy as far as possible before receiving a 20 sec rest
151 where they could drop the dummy. This process was repeated 6 times, totalling 60 sec of work
152 with 120 sec of rest. The distance was scored by the number of markers passed by the feet of
153 the dummy by the end of the 6th interval.

154 **Pack March protocol**

155 The 5km pack march was completed over a course marked out on a combination of bitumen
156 and hard dirt surfaces. The subjects were required to wear their issued operational uniform,
157 boots, and body armour, alongside an unloaded primary weapon. On-body loads totalled 15
158 kgs which was measured with a Tanita BC82Fitplus scale (Tanita, Illinois, USA). In addition,
159 subjects wore an operational backpack which weighed 25 kgs (Wedderburn Ds530 Digital
160 Industrial scale), leading to a total load of 40 kg. The officers completed the 5 km march at
161 their own pace as fast as possible and time to completion was measured with a Hart Sports
162 hand held timer (Hart Sports, Brisbane, Australia). The final result was recorded in minutes
163 and seconds.

164 ***Statistical Analyses***

165 Data were received in a non-identifiable format on Microsoft Excel spreadsheets and
166 subsequently imported into a Statistical Package for the Social Sciences spreadsheet (Version

167 23) for statistical analysis. A descriptive analysis to determine means and standard deviations
168 for body mass, independent variables (absolute and relative strength measures) and dependent
169 variables (Victim Drag and Pack March performance) was performed. A priori power analysis
170 was conducted using G*Power software (Version 3.1.9.2, 2014) indicating a large effect size
171 ($p=.5$, $\alpha=0.05$) could be detected with a 95% confidence interval for the Pearson's
172 correlations given the population size. Pearson's correlations were performed on each measure
173 of strength (both absolute and relative) and both performance measures (Victim Drag and Pack
174 March). The strength of the correlations were defined as an r of between 0 to 0.19 as very weak;
175 0.2 to 0.39 as weak, 40-.59 as moderate, 60-.79 as strong and .80-1.0 as very strong (9).
176 Correlations were plotted on a backward linear regressions model and analyzed for variance
177 (r^2) between strength measures and occupational tasks. Alpha levels were set a 0.05 a priori.

178 RESULTS

179 The absolute and calculated relative results for each strength measure and the results of both
180 occupational tasks can be seen in Table 1. Table 2 shows the correlations between each strength
181 measure and task performance. For the victim drag task, all absolute strength measures
182 displayed significant ($p<.01$) and strong correlations with drag performance while the relative
183 results showed significant ($p<.01$) moderate correlations (Table 2). Of all strength measures,
184 the absolute deadlift accounted for 56% of the variance in victim drag (Figure 1). For the pack
185 march task, the relative strength measures for the bench press, squat, and pull-up displayed
186 significant ($p<.05$) weak to moderate ($p<0.01$) correlations with the pack march results, while
187 only the absolute squat and pull-up showed significantly ($p<.05$) weak correlations with pack
188 march performance. Of all the strength measures, the relative pull-up accounted for 22% of the
189 variance in the pack march (Figure 2).

190 ***Insert table 1 here***

191 ***Insert table 2 here***

192 *** Figures 2 and 3 here***

193 **DISCUSSION**

194 The aim of this study was to investigate relationships between measures of strength and task
195 performance in STPO. The results suggest that both absolute and relative strength are strongly
196 correlated with victim drag results and absolute and relative squat and pull-up strength are
197 moderately correlated with pack march results. Strength, both absolute and relative, appears to
198 be important for STPO task performance. On this basis, the development and maintenance of
199 these strength measures are an occupational requirement for STPO. Furthermore, these
200 measures are of importance in return-to-work rehabilitation and reconditioning processes
201 following injury.

202 The interpretation of these results suggest that, while relative strength was correlated with
203 victim drag performance, absolute strength may be of greater importance. The findings of this
204 study partially support the findings of Moreno et al (18). While Moreno et al. (18) (n=30
205 students) found no significant relationships between relative deadlift performance and a victim
206 drag (75 & 91 kg drag). they did find strong significant correlations between absolute deadlift
207 performance and a victim drag. Likewise, in a study measuring only absolute strength
208 measures, Hendrickson et al. (12) found significant correlations between improvements in
209 1RM bench press ($r=0.32$) and squat ($r=0.33$) (the only strength values measured) and victim
210 drag (61.4kg) performance in a group of recreationally active civilian women (n=56), One
211 potential reason why absolute strength may be of greater importance in a victim drag, as
212 opposed to relative strength, lies in the requirement of the participant to lift a portion of the
213 dummy off the ground and drag this absolute load, which is not affixed to their body and
214 remains extant regardless of the participant's body mass.

215 Conversely, a pack march requires the participant to move a worn load as part of their body
216 mass, hence this becomes a relative load. Although this is known to increase energy costs (15),
217 this may also mean that the relative strength of the carrier may be of greater importance. This
218 supposition is supported by the findings in this study, whereby relative strength measures were
219 more strongly correlated to pack march performance than absolute measures. In addition, the
220 results of this study support the findings by Robinson et al. (25) who likewise found relative
221 measures to be more strongly correlated to a pack march event than absolute measures.

222 In this study absolute pull-ups and squats were significantly, albeit weakly correlated to pack
223 march performance while absolute bench press and deadlift were not. Conversely Robinson et
224 al., (25) found all measures of an absolute bench press, squat, pull-ups and deadlift were
225 moderately to weakly correlated to one pack march event; however, the deadlift was no longer
226 significantly correlated to two later pack marches. Similarly, the study by Hendrickson et. al.
227 (12) found no significant correlation between pack march performance (3.2k m with 32.7 kg)
228 and improvements in absolute bench press or squat.

229 The different findings to that of our own study, with respects to a loaded pack march
230 performance, may be due to the different populations studied. There is an underlying
231 cardiovascular demand for performance in a loaded pack march (12, 27) which would be
232 expected to be present in tactical personnel who have been exposed to pack marching
233 previously (26). The previous study used civilians who were instructed on how to perform these
234 tasks, and therefore would likely have had little familiarity with conducting them.

235 The results of this study support research investigating optimal conditioning measures for pack
236 marching. Systematic reviews by Orr, et al. (20) and Knapik, et al. (16) highlighted that pack
237 marching can be improved by a combined resistance training and an aerobic training program.
238 However, the results of this finding suggest that while resistance training and the development

239 of strength is advised to improve load carriage performance, the development of relative
240 strength may provide of greater value for pack marching specifically.

241

242 A notable limitation to this study is the measures of strength and the occupational tasks
243 selected. These measures and tasks were those in use by the law enforcement agency and, as
244 the data provided were retrospective, were beyond the control of the researchers. However,
245 given that these measures are in use, this research informs those not only in this agency, but
246 other agencies who employ these assessments and tasks, on best means of optimizing
247 performance.

248

249 With the growing number of STPO units internationally, a greater need for research into
250 training methods and optimizing performance has become increasingly evident (7, 29). The
251 results of this study highlight the relationships between upper and lower limb strength (both
252 absolute and relative) and the performance of two key tasks performed by STPO.

253

254 **PRACTICAL APPLICATIONS**

255 Strength and conditioning programs for candidates wishing to serve in, currently serving
256 officers of, or injured officers returning to, specialist tactical police units should include the
257 development of both absolute and relative strength, utilizing maximum strength training
258 methods and movements for the upper and lower body as part of their strength / reconditioning
259 program. Furthermore, if increased performance in a victim drag is desired increases in
260 absolute strength may be of greater benefit given that the dummy represents an absolute load
261 of which a portion must be lifted from the ground and dragged. Conversely, during a pack

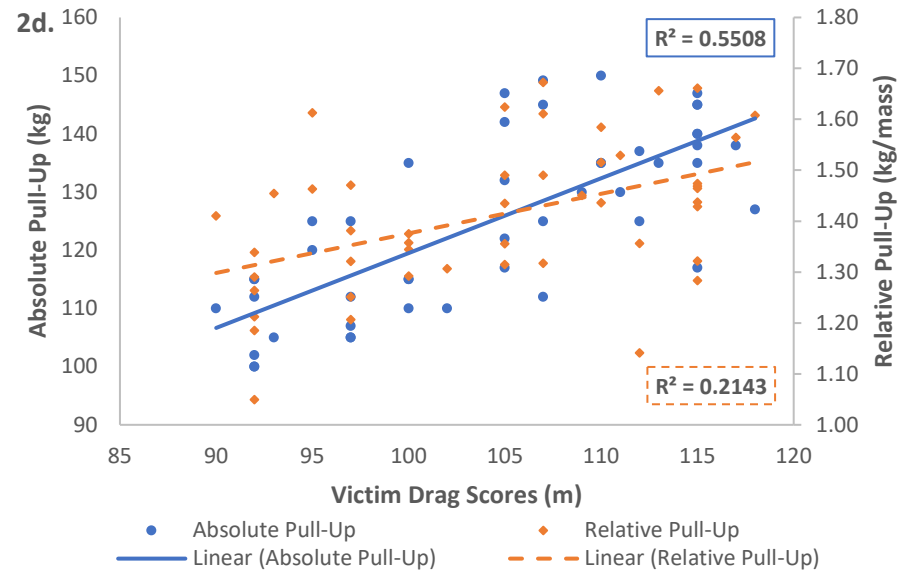
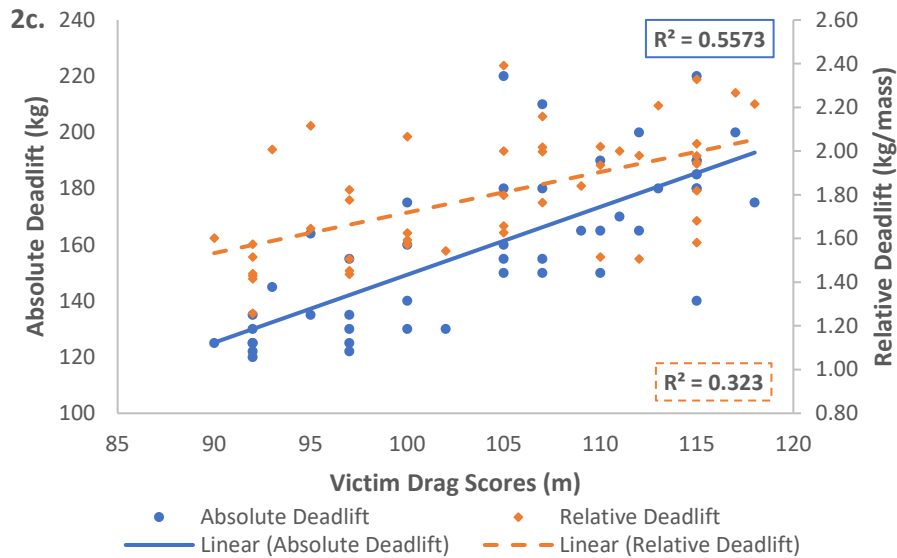
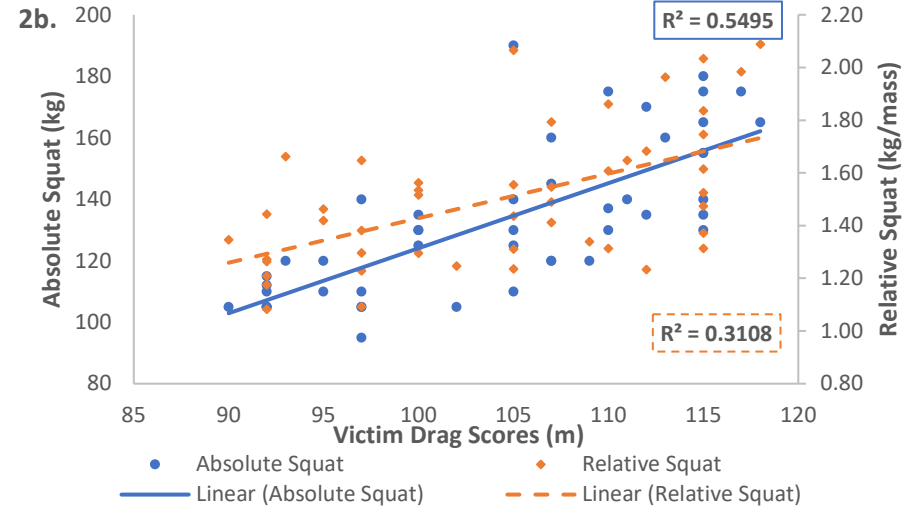
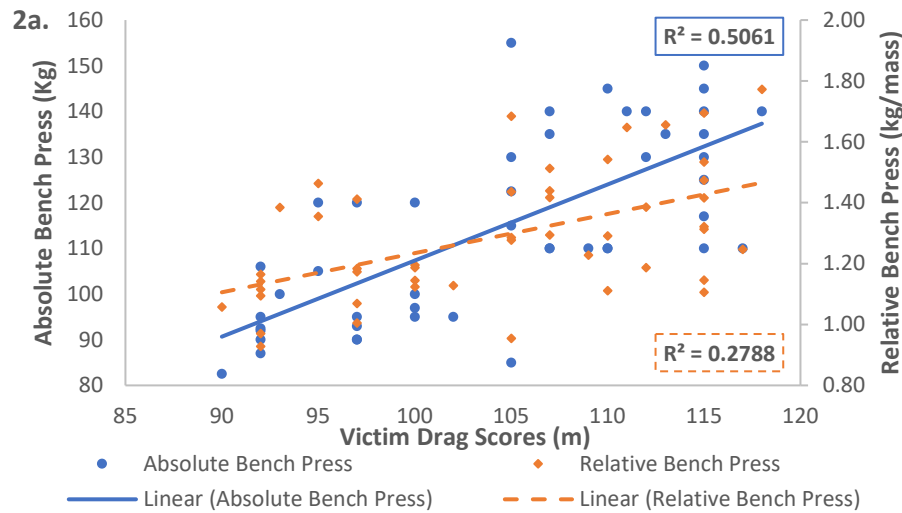
262 march, where the load is affixed to the body and must be transported by the carrier, increases
 263 in relative strength to body mass ratio may be of greater benefit.

264

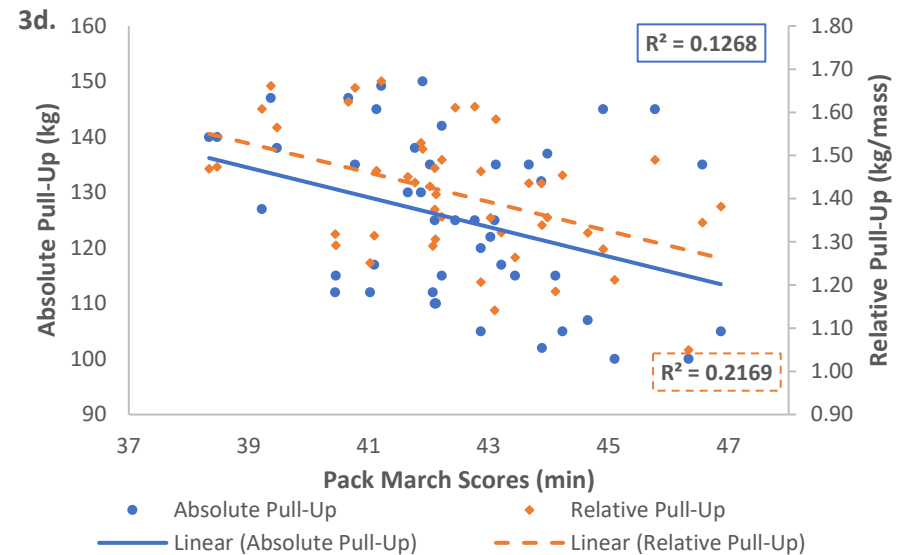
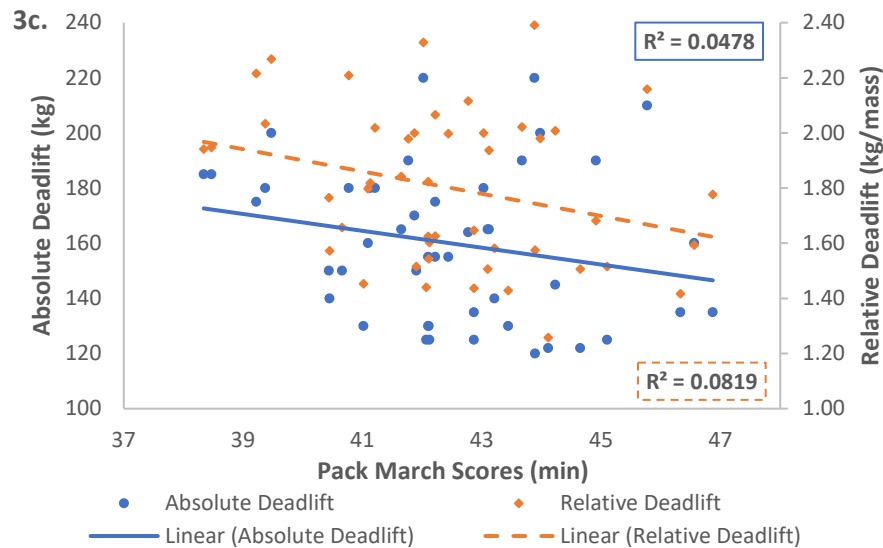
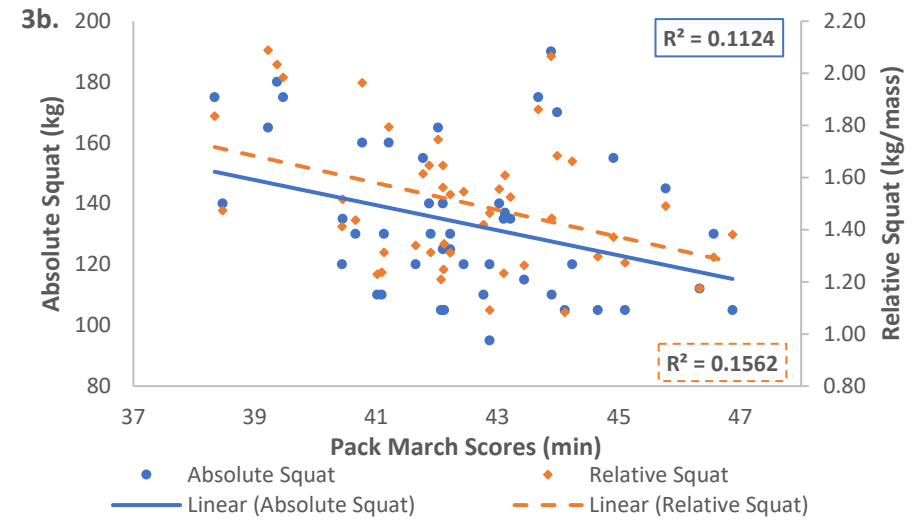
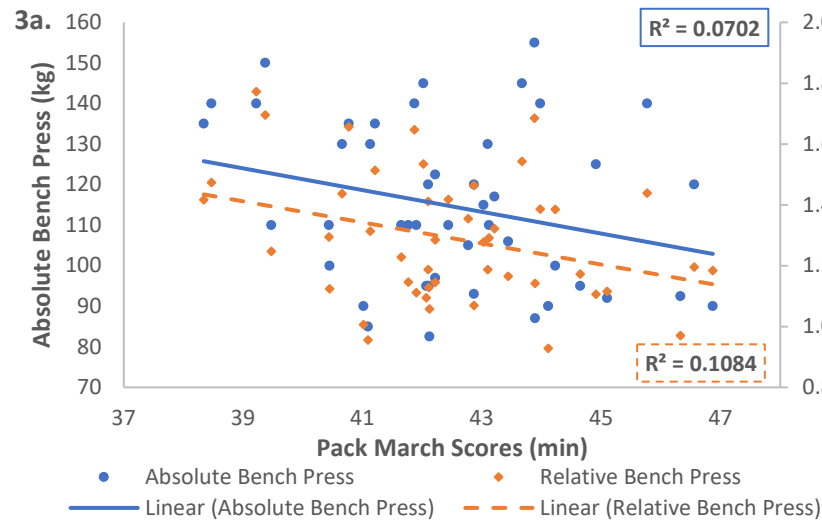
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351 **Figure 1.** Linear regression analyses for absolute and relative strength measures and victim drag performance.
 352 **2a.** Absolute/relative bench press correlation to victim drag performance, **2b.** Absolute/relative squat correlation to victim drag performance,
 353 **2c.** Absolute/relative deadlift correlation to victim drag performance, **2d.** Absolute/relative pull-up correlation to victim drag performance.



354 **Figure 2.** Linear regression analyses for absolute and relative strength measures and pack march performance.
 355 **3a.** Absolute/relative bench press correlation to pack march performance, **3b.** Absolute/relative squat correlation to pack march performance,
 356 **3c.** Absolute/relative deadlift correlation to pack march performance, **3d.** Absolute/relative pull-up correlation to pack march performance.

357 **TABLES**358 **Table 1.** Mean results from all outcome measures and demographic data supplied.

Outcome Measure	Mean results \pm SD
Body mass (kg)	89.00 \pm 8.58
Absolute Bench (kg)	114.68 \pm 20.15
Relative Bench	1.29 \pm 0.21
Absolute Squat (kg)	133.38 \pm 24.58
Relative Squat	1.50 \pm 0.26
Absolute Deadlift (kg)	159.96 \pm 27.88
Relative Deadlift	1.80 \pm 0.28
Absolute Pull-up (kg)	125.17 \pm 14.93
Relative Pull-up	1.41 \pm 0.14
Victim Drag (m)	104.40 \pm 8.61
Pack March (mins)	42.48 \pm 1.99

359 Relative measures presented as ratio of strength to body mass (1RM/Body mass).

360

361 **Table 2.** Correlation between outcome measures and performance in the victim drag and pack
 362 march performance tests.

Outcome Measure	Victim Drag	Pack March
Absolute Bench	$r = 0.711^{**}$	$r = -0.265$
Relative Bench	$r = 0.531^{**}$	$r = -0.330^*$
Absolute Squat	$r = 0.741^{**}$	$r = -0.335^*$
Relative Squat	$r = 0.557^{**}$	$r = -0.395^{**}$
Absolute Deadlift	$r = 0.747^{**}$	$r = -0.219$
Relative Deadlift	$r = 0.568^{**}$	$r = -0.285$
Absolute Pull-up	$r = 0.742^{**}$	$r = -0.356^*$
Relative Pull-up	$r = 0.465^{**}$	$r = -0.468^{**}$

363 Statistically significant at: * $p < 0.05$; ** $p < 0.01$.

