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RESEARCH ARTICLE

Factors affecting powerlifting performance: an analysis of age- and weight-based determinants of relative strength

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ABSTRACT

Powerlifting (PL) is characterised by the ability to generate maximal force. However, an understanding of the factors affecting strength in PL athletes is poorly understood. Therefore, competition data were analysed from 1368 individuals during 2017. Relative strength was compared for the squat (SQ), bench press (BP) and deadlift (DL) between age groups (Sub-junior [SJ], Junior [JU], Open [OP], and Masters' I-IV [M1-M4]), weight classes (females; 47 kg, 52 kg, 57 kg, 63 kg, 72 kg, 84 kg and + 84 kg and males; 59 kg, 66 kg, 74 kg, 83 kg, 93 kg, 105 kg, 120 kg, + 120 kg) and between sexes. The results showed that relative strength was greater for males across all lifts ($P < 0.001$). Relative strength tended to decrease with increasing body mass for males (SQ, BP and DL: $P < 0.001$, $R^2 = 0.9306–0.9763$) and females (SQ, BP and DL: $P < 0.001$, $R^2 = 0.9485–0.9802$), and with increasing age for males (SQ, BP and DL: $P < 0.001$, $R^2 = 0.4742–0.6729$), and females (SQ: $P < 0.001$, BP: $P = 0.002$ and DL: $P = 0.001$, $R^2 = 0.0844–0.3705$), respectively. The findings offer important information regarding factors that affect strength performance in athletes. Coaches should consider the factors influencing strength when developing resistance training programmes or in longer term athletic development for powerlifters and other strength based sports.

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Powerlifting; bodyweight; age; gender; competition; sport

1. Introduction

In many sporting disciplines strength is an important factor in athletic development and performance. In strength sports such as Powerlifting (PL), training and competition is characterised solely by the intent to develop and express upper and lower body maximal strength. In competition, individuals with the highest total for each of the three lift types (squat [SQ], bench press [BP] and deadlift [DL]) combined, or greatest "Wilks" score (calculated coefficient score) if tied with another individual dictates results. Athletes compete in relevant weight classes further categorised into age groups (Keogh, Hume, & Pearson, 2006). Therefore, the unique training and performance characteristics of PL offer an unprecedented opportunity to explore the potential factors

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that may influence relative strength without the confounding factors (i.e. combined aerobic or tactical training) that are common in many other sports.

In other lifting sports (i.e. weightlifting), evidence exists on performance trends across the age span, between weight classes and genders (Ball & Weidman, 2017; Storey & Smith, 2012; Thé & Ploutz-Snyder, 2003). However, data from weightlifting studies is markedly different to that observed in PL, likely due to the inherent differences in the task and expression of strength (Anton, Spirduso, & Tanaka, 2004). Interestingly, performance evaluations in PL are less well explored and have instead mainly focussed on training practices (Colquhoun et al., 2017; Grgic & Mikulic, 2017; Swinton, Lloyd, Agouris, & Stewart, 2009) and injury rates (Aasa, Svartholm, Andersson, & Berglund, 2017; Brown & Kimball, 1983; Siewe et al., 2011). Thus, only a few authors have reported competition results and records (Anton et al., 2004; Ball & Weidman, 2017; Bishop, Williams, Heldman, & Vanderburgh, 2018).' In terms of relative strength, Keogh et al. (2006) reported that, based on International Powerlifting Federation data, men's records in the SQ, BP and DL can exceed five times, three times and five times the individual's bodyweight, respectively. However, it is unclear whether these records were obtained from raw or equipped scores. When analyses have accounted for sex, age and weight class Ball and Weidman (2017) found that: (i) lighter individuals can lift a greater percentage of their weight, (ii) men have a greater strength to bodyweight ratio than women and (iii) lifting performance peaks between 24 and 49 years, thereafter slowly declining with age. In addition, Bishop et al. (2018) reported that females and lighter males (< 90 kg) were strongest in the DL, whilst heavier males, especially 125 kg and above performed better on the SQ. Of further interest, Anton et al. (2004) reported that PL performance does not decline as rapidly with ageing as weightlifting. Despite these reports, a greater understanding of the underlying factors contributing to strength performance is likely to provide important information to professionals working with various PL and strength athletes.

Given the limited evidence available, the aim of this investigation is to analyse the factors that are likely to influence relative strength. Specifically, we aim to analyse relative strength subject to body mass and age both within and between male and female competitive powerlifters. It is anticipated that the findings of this investigation will help provide realistic and individualised strength and performance expectations based on athletes with similar age and body mass characteristics. Strength and conditioning professionals should consider the factors influencing strength when assessing performance or when considering longer-term athletic development in PL and potentially, other strength-based sports.

2. Methods

2.1. *Sample*

We collated individual athlete competition results from Powerlifting Australia records from the 1st of January 2017 to the 18th of November 2017. Permission was granted by Powerlifting Australia to use the publically available competition data on the Powerlifting Australia website for the purposes of this research.

2.2. Subjects

Data was collected from 1368 individuals (males: $n = 850$, females: $n = 518$) with an age range of 15–78 years. Each data set was categorised into age groups (Sub-junior (SJ) < 18 years; Junior (JU) 18–22 years; Open (OP) 23–39 years; Masters I (M1) 40–49 years; Masters II (M2) 50–59; Masters III (M3) 60–69 years; and Masters IV (M4) ≥ 70 years. In addition, data were also grouped into individual weight class for females (47 kg, 52 kg, 57 kg, 63 kg, 72 kg, 84 kg and + 84kg) and males (59 kg, 66 kg, 74 kg, 83 kg, 93 kg, 105 kg, 120 kg, + 120 kg). Due to the public availability of the data, an ethics exemption was granted for the purposes of this investigation by the Deakin University Human Research Ethics Committee.

2.3. Statistical analysis

All data was analysed using IBM SPSS Statistics v.25 (IBM, USA). Strength to body-weight ratio was calculated for all athletes at each competition by dividing their highest, successful weight for each lift (SQ, BP and DL) by their bodyweight and reported as a relative strength score. It is important to note that athlete weigh-in occurs approximately 1–2 h prior to the start of competition. Thus, nutritional and rehydration strategies may cause a slight overestimation of relative strength performance. However, this is common in many weight category based sports and considered a factor that was unable to be individually controlled for. A one-way analysis of variance (ANOVAs) were used to determine between group differences (i.e. weight class or age category). A Tukey post-hoc analysis was used to determine differences between groups when three or more groups were compared (i.e. for differences between weight class and age category). A two-way ANOVA was used to test for mean differences between sexes (MALES and FEMALES) and competition lifts (SQ, BP and DL). Post-hoc independent sample t-tests were used to detect specific sex differences for the SQ, BP and DL, respectively. Statistical significance was set at $P < 0.05$ with no adjustment made for multiple comparisons (Drachman, 2012). Effects sizes (Cohen's d) were calculated using the formula $d = M_1 - M_2/\mathrm{SD}_{\mathrm{pooled}}$. Calculations were grouped into moderate $d \geq 0.5 < 0.79$ or large $d \geq 0.80$. Only interactions with a moderate or large effect sizes were reported in the results section along with the upper and lower 95% confidence interval (95% CI). Additionally, the coefficient of determination, represented by Peasron's r (r^2) was calculated to show the strength of the association between relative strength and age, and relative strength and body weight. The closer the value to 1, the greater the strength of the relationship. All results are displayed as mean ± SD, with raw data presented in (Tables 1 and 2).

Table 1. Absolute weights lifted in each age category for the SQ, BP and DL for males and females.

		SJ	JU	OP	M1	M2	M3	M4
Females	*SQ*	120.4 ± 37.1	119.2 ± 27.1	117.2 ± 24.6	110.6 ± 24.0	103.7 ± 26.0	70.0 ± 18.7	114.0 ± 47.3
	BP	64.2 ± 23.4	62.0 ± 14.9	65.1 ± 13.4	65.8 ± 13.5	61.4 ± 16.0	45.4 ± 7.0	63.3 ± 18.4
	DL	136.3 ± 35.3	136.5 ± 27.28	141.1 ± 25.0	134.6 ± 25.9	132.5 ± 23.9	104.1 ± 18.3	141.1 ± 43.2
Males	*SQ*	169.1 ± *43.5*	194.1 ± 41.2	209.8 ± 43.7	182.5 ± 40.7	159.1 ± 56.7	137.3 ± 45.0	171.1 ± 94.4
	BP	104.0 ± 25.3	123.7 ± 25.7	138.5 ± 31.3	127.5 ± 28.8	117.1 ± 42.0	98.7 ± 28.7	108.1 ± 53.8
	DL	191.8 ± 40.8	224.5 ± 43.4	239.6 ± 39.3	212.7 ± 35.3	180.8 ± 38.7	171.5 ± 39.3	211.6 ± 70.3

Table 2. Absolute weight lifted in each weight class for the SQ, BP and DL for males and females.

		47 kg	52 kg	57 kg	63 kg	72 kg	84 kg	+ 84 kg	
Females	*SQ*	95.8 ± 20.6	101.1 ± 22.6	109.2 ± 24.5	105.4 ± 24.4	116.4 ± 23.3	122.8 ± 26.6	131.9 ± 34.3	
	BP	55.0 ± 12.4	57.1 ± 12.8	61.2 ± 13.7	59.4 ± 13.3	63.9 ± 13.7	68.1 ± 15.2	71.6 ± 14.8	
	DL	121.2 ± 15.7	127.5 ± 25.1	134.0 ± 26.4	129.4 ± 24.1	139.9 ± 26.1	143.5 ± 26.5	141.1 ± 27.1	
		59 kg	66 kg	74 kg	83 kg	93 kg	105 kg	120 kg	+ 120 kg
Males	*SQ*	150.4 ± 48.7	162.7 ± 30.7	178.7 ± 40.2	187.9 ± 38.75	202.0 ± 33.3	204.9 ± 45.1	219.3 ± 49.7	268.0 ± 77.5
	BP	91.4 ± 24.6	101.2 ± 26.8	113.9 ± 26.1	123.87 ± 24.5	132.0 ± 24.7	136.4 ± 29.9	145.3 ± 37.3	172.6 ± 41.4
	DL	170.4 ± 48.5	192.5 ± 28.8	209.4 ± 39.4	219.6 ± 44.4	234.3 ± 35.7	239.4 ± 42.9	244.2 ± 39.4	270.4 ± 54.8

3. Results

3.1. *Descriptive statistics*

Of the collated data, 303 males and 186 females competed twice, 91 males and 54 females competed three times, 20 males and 8 females competed four times, 8 males and 3 females competed five times and only 3 males competed six times.

3.2. *Sex*

Figure 1 shows the strength to bodyweight ratio for the SQ, BP and DL between sexes. The results of a two-way ANOVA revealed a significant GROUP interaction between males and females ($P < 0.001$). Post-hoc analyses showed that males had significantly greater lift to bodyweight ratio compared to females for the SQ (2.23 ± 0.50 vs 1.67 ± 0.40, $P < 0.001$, $d = 1.20$, 95% CI = 1.09, 1.32), BP (1.45 ± 0.31 vs 0.93 ± 0.23, $P < 0.001$, $d = 1.84$, 95% CI = 1.71, 1.97) and DL (2.59 ± 0.53 vs 2.02 ± 0.46, $P < 0.001$, $d = 1.13$, 95% CI = 1.01, 1.25), respectively. When compared to SQ performance it was found that males were able to lift 65.0% and 116.1% of this weight on the BP and DL, respectively. Females were able to lift 55.7% and 121.0% of SQ weight on the BP and DL, respectively.

3.3. *Weight class*

Figure 2a shows the strength to bodyweight ratio for the SQ, BP and DL between weight classes for males. Results of a one-way ANOVA revealed a significant GROUP main effect for the SQ across weight classes for males ($F = 29.343$, $P < 0.001$). The 59 kg weight class had the highest relative strength score (2.60 ± 0.83) which was greater than 83 kg (−10.8%, $d = 0.53$, 95% CI = 0.17, 0.88), 93 kg (−13.5%, $d = 0.81$, 95% CI = 0.45,

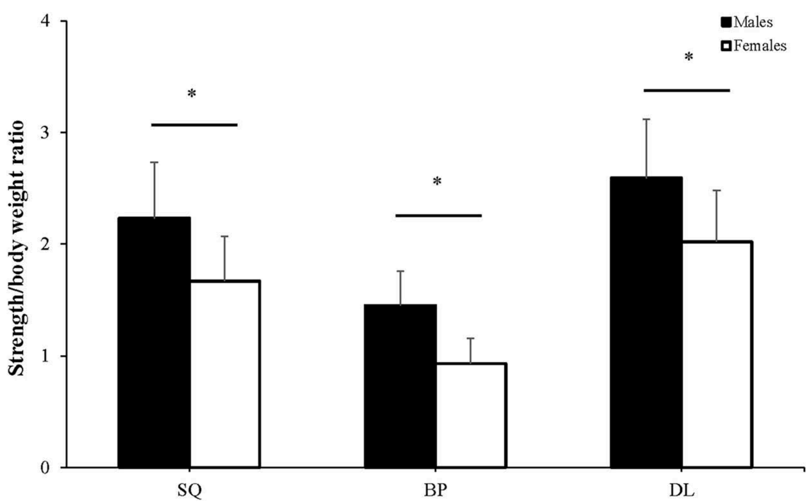

Figure 1. Relative strength ratios for each of the SQ, BP and DL between genders. * indicates a significant difference between males and females.

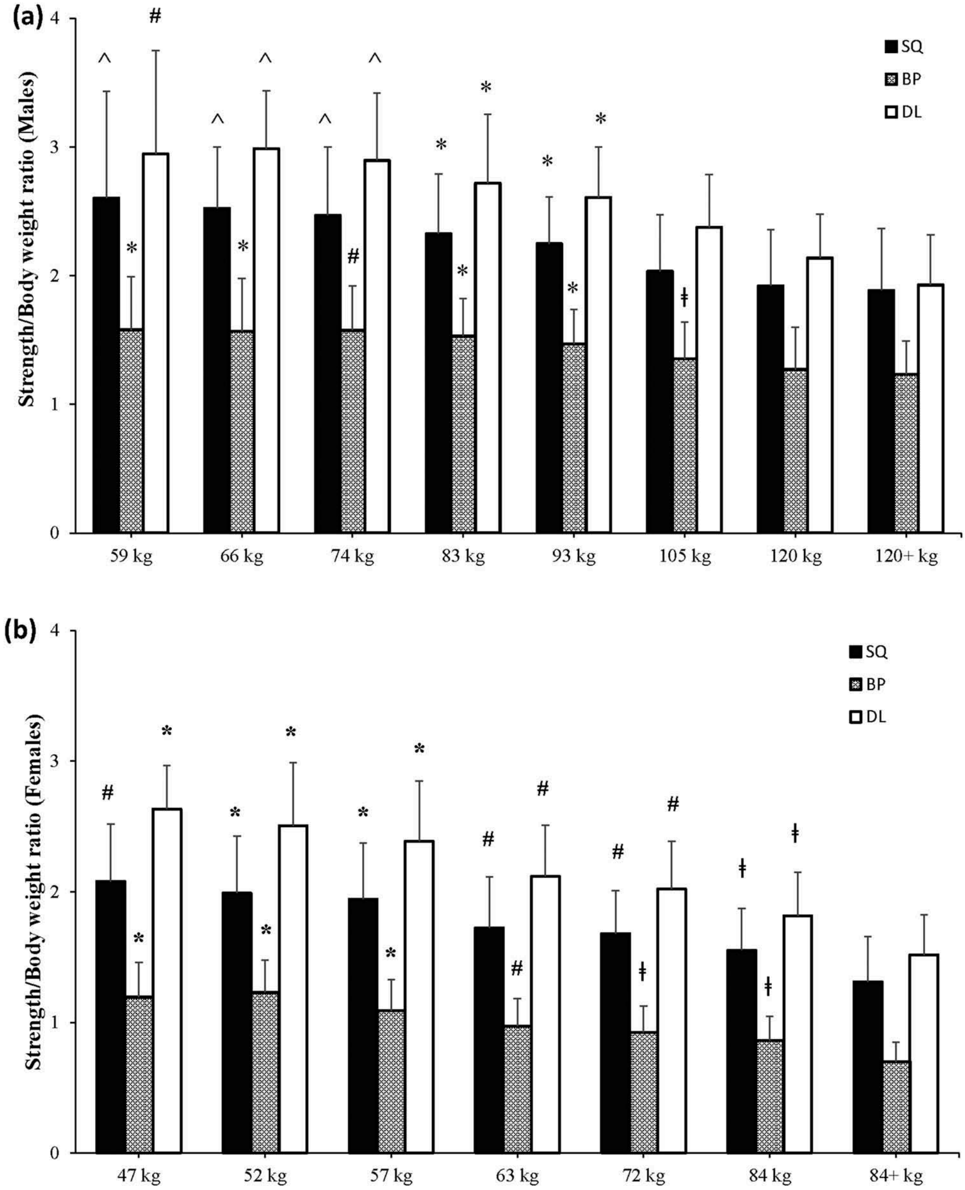

Figure 2. Relative strength ratios for each of the SQ, BP and DL for (**a**) males across weight classes. * indicates a difference to ≥ 105 kg, # indicates a difference to ≥ 93 kg, ^ indicates a difference to ≥ 83 kg and ǂ indicates a difference to ≥ 120 kg; and (**b**) females across weight classes. * indicates a difference to ≥ 63 kg, # indicates a difference to ≥ 84 kg and ǂ indicates a difference to + 84kg.

1.16), 105 kg (−21.9%, d = 1.09, 95% CI = 0.72, 1.46), 120 kg (−26.2%, d = 1.17, 95% CI = 0.75, 1.58) and + 120 kg (−27.3%, d = 1.12, 95% CI = 0.67, 1.56) classes, respectively. A significant GROUP main effect was also observed for the BP across weight classes for males (F = 20.099, P < 0.001). The 59 kg and 74 kg weight classes had the highest relative strength score (1.58 ± 0.41, respectively) which was greater than 105 kg (−14.6%, d = 0.73, 95% CI = 0.39, 1.07), 120 kg (−19.6%, d = 0.87, 95%

CI = 0.50, 1.24) and + 120 kg (−22.2%, *d* = 1.11, 95% CI = 0.71, 1.50) classes, respectively. A significant GROUP main effect was also observed for the DL across weight classes for males ($F = 51.146$, $P < 0.001$). The 66 kg weight class had the highest relative strength score (2.99 ± 0.45) which was greater than 83 kg (−9.4%, *d* = 0.53, 95% CI = 0.25, 0.80), 93 kg (−12.7%, *d* = 0.95, 95% CI = 0.67, 1.22), 105 kg (−20.7%, *d* = 1.47, 95% CI = 1.16, 1.78), 120 kg (−28.4%, *d* = 2.17, 95% CI = 1.77, 2.56) and + 120 kg (−35.5%, *d* = 2.51, 95% CI = 2.04, 2.95) classes, respectively.

Figure 2(b) shows the strength to bodyweight ratio for the SQ, BP and DL between weight classes for females. Results of a one-way ANOVA revealed a significant GROUP main effect for the SQ across weight classes for females ($F = 32.816$, $P < 0.001$). The 47 kg weight class had the highest relative strength score (2.08 ± 0.44) which was greater than 63 kg (−17.3%, *d* = 0.91, 95% CI = 0.40, 1.42), 72 kg (−19.2%, *d* = 1.18, 95% CI = 0.67, 1.68), 84 kg (−25.5%, *d* = 1.58, 95% CI = 1.03, 2.11) and + 84 kg (−37.0%, *d* = 2.10, 95% CI = 1.49, 2.68), respectively. A significant GROUP main effect was also observed for the BP across weight classes for females ($F = 44.986$, $P < 0.001$). The 52 kg weight class had the highest relative strength score (1.23 ± 0.25) which was greater than 63 kg (−18.5%, *d* = 1.02, 95% CI = 0.52, 1.52), 72 kg (−22.7%, *d* = 1.32, 95% CI = 0.82, 1.81), 84 kg (−27.7%, *d* = 1.66, 95% CI = 1.12, 2.17) and + 84 kg (−41.2%, *d* = 2.86, 95% CI = 2.22, 3.46), respectively. A significant GROUP main effect was also observed for the DL across weight classes for females ($F = 64.588$, $P < 0.001$). The 47 kg weight class had the highest relative strength score (2.63 ± 0.33) which was greater than 57 kg (−9.1%, *d* = 0.55, 95% CI = 0.01, 1.07), 63 kg (−19.4%, *d* = 1.33, 95% CI = 0.80, 1.84), 72 kg (−23.2%, *d* = 1.66, 95% CI = 1.14, 2.17), 84 kg (−30.8%, *d* = 2.45, 95% CI = 1.86, 3.02) and + 84 kg (−42.2%, *d* = 3.5, 95% CI = 2.80, 4.23) classes, respectively.

Table 3 shows the relationship between the SQ, BP and DL and weight class or age category. The results show a linear relationship for a decline in relative strength performance with increasing weight across all lifts for males (R^2 = 0.9306–0.9763), and females (R^2 = 0.9485–0.9802), respectively. The relationship across age categories was not as strong for males (R^2 = 0.4742–0.6729), and females (R^2 = 0.0844–0.3705).

3.4. *Age category*

Figure 3(a) shows the strength to bodyweight ratio for the SQ, BP and DL between age categories for males. Results of a one-way ANOVA revealed a significant GROUP main effect for the SQ across age category for males ($F = 27.952$, $P < 0.001$). The JU category had the highest relative strength score (2.34 ± 0.46) which was greater than M1 (−10.8%, *d* = 0.84, 95% CI = 0.36, 1.31), M2 (−13.5%, *d* = 1.12, 95% CI = 0.55, 1.66),

Table 3. Strength of the linear relationship for SQ, BP and DL relative strength when compared with weight class and age category.

		SQ	BP	DL
Weight class				
Male	R^2 =	0.9763	0.9363	0.9306
Female	R^2 =	0.9605	0.9485	0.9802
Age category				
Male	R^2 =	0.6729	0.5340	0.4742
Female	R^2 =	0.3705	0.1457	0.0844

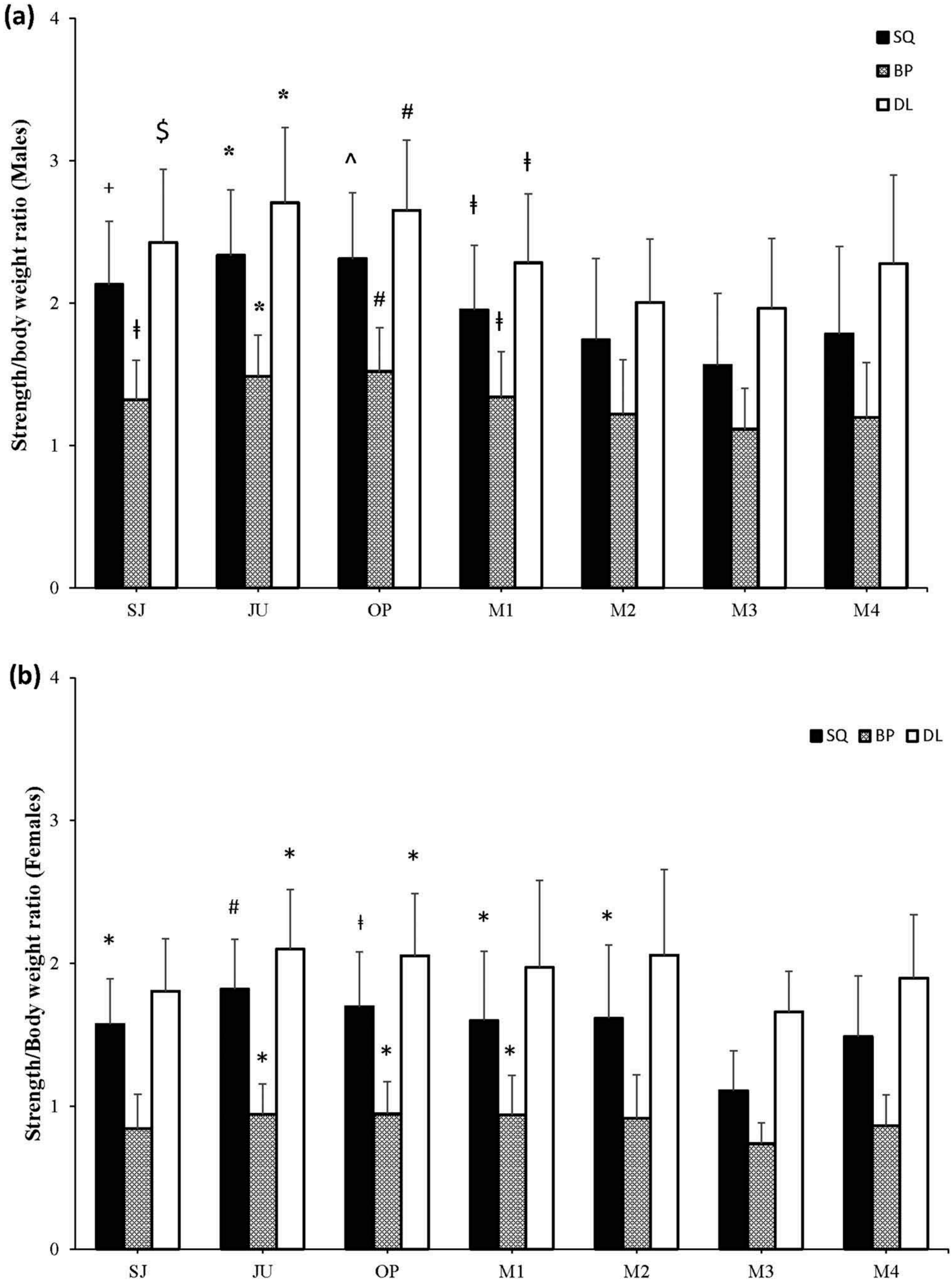

Figure 3. Relative strength ratios for each of the SQ, BP and DL for (**a**) males across age categories. * indicates difference to all except OP, # indicates a difference to all except JU, ^ indicates a difference to all older categories, ǂ indicates a difference to M3, $ indicates a difference to JU, OP, M2 and M3, + indicates a difference to JU, M2, M3 and M4; and (**b**) females across age categories. * indicates difference to M3, indicates a difference to all older categories, ǂ indicates a difference to M2 and M3.

M3 (−21.9%, $d = 1.58$, 95% CI = 0.91, 2.19) and M4 (−27.3%, $d = 0.99$, 95% CI = 0.43, 1.52) categories, respectively. A significant GROUP main effect was also observed for the BP across age category for males ($F = 25.099$, $P < 0.001$). The OP category had the highest relative strength score (1.52 ± 0.31) which was greater than SJ (−13.2%, $d = 0.65$, 95% CI = 0.40, 0.90), M1 (−11.8%, $d = 0.58$, 95% CI = 0.35, 0.81), M2 (−19.7%, $d = 0.95$, 95% CI = 0.64, 1.26), M3 (−27.0%, $d = 1.33$, 95% CI = 0.94, 1.71) and M4 (−21.1%, $d = 1.01$, 95% CI = 0.72, 1.31) categories, respectively. A significant GROUP main effect was also observed for the DL across weight classes for males ($F = 24.426$, $P < 0.001$). The JU category had the highest relative strength score (2.70 ± 0.53) which was greater than SJ (−10.4%, $d = 0.53$, 95% CI = 0.26, 0.90), M1 (−15.6%, $d = 0.80$, 95% CI = 0.53, 1.08), M2 (−25.9%, $d = 1.34$, 95% CI = 0.96, 1.71), M3 (−27.4%, $d = 1.40$, 95% CI = 0.97, 1.83) and M4 (−15.6%, $d = 0.78$, 95% CI = 0.42, 1.14) categories, respectively.

Figure 3(b) shows the strength to bodyweight ratio for the SQ, BP and DL between age categories for females. Results of a one-way ANOVA revealed a significant GROUP main effect for the SQ across age category for females ($F = 10.196$, $P < 0.001$). The JU category had the highest relative strength score (1.82 ± 0.35) compared to the SJ (−13.7%, $d = 0.72$, 95% CI = 0.27, 1.17), M1 (−12.1%, $d = 0.54$, 95% CI = 0.25, 0.82), M2 (−11.5%, $d = 0.50$, 95% CI = 0.17, 0.82), M3 (−39.1%, $d = 2.07$, 95% CI = 1.50, 2.62) and M4 (−18.1%, $d = 0.92$, 0.35, 1.48) categories, respectively. A significant GROUP main effect was also observed for the BP across age category for females ($F = 3.528$, $P = 0.002$). The OP category had the highest relative strength score (1.52 ± 0.31) compared to the M3 (−22.1%, $d = 0.91$, 95% CI = 0.47, 1.35) category, respectively. A significant GROUP main effect was also observed for the DL across weight classes for females ($F = 3.776$, $P = 0.001$). The JU category had the highest relative strength score (2.10 ± 0.42) compared to the SJ (−13.8%, $d = 0.70$, 95% CI = 0.25, 1.15), M3 (−21.0%, $d = 1.08$, 95% CI = 0.56, 1.60) and M4 (−9.6%, $d = 0.50$, 95% CI = −0.05, 1.06) categories, respectively.

4. Discussion

The purpose of this investigation was to investigate the factors that influence relative strength in PL athletes. Specifically, we investigated the effects of sex, age and body mass on subsequent strength to bodyweight ratios for the SQ, BP and DL, respectively. Collectively, the results showed that the upper and lower body relative strength of males was significantly greater than females. In addition, there was a tendency for relative strength to decrease in heavier athletes, with athletes in the 59–66 kg and 47–52 kg classes having the highest peak relative scores for males and females, respectively. A tendency for relative strength to decrease was also observed with ageing. The results also suggest that relative strength peaks either as a JU or OP lifter. Based on the findings, it appears that relative strength is strongly influenced by sex, age and body mass. These factors should be considered when working with various athletes in PL or other strength based sports.

The findings of this report showed that the relative strength of males was greater than females in both upper and lower body movements (i.e. SQ, BP and DL). Although this result is not surprising, the underpinning factors are worthy of discussion. For example, it is known that males generally have a greater percentage of lean muscle mass and fast twitch fibres than females (Markovic & Sekulic, 2006). In addition, male androgen hormones can increase neuromuscular excitability and efficiency (Bonifazi, Ginanneschi, Della Volpe, & Rossi, 2004), and overall strength development (Bhasin, Storer, Bermna, Callegari, Clevenger, Phillips, Bunnel, Tricker, Shirazi & Casaburi, 1996). Therefore, from a fundamental perspective the underlying physiological mechanisms likely explain a large portion of the relative strength differences between sexes. Differences in the proportion between upper and lower body strength were also found for each sex. Anatomically and bio-physiologically the discrepancies in upper body strength (i.e. BP) between males and females, when expressed as a proportion of lower body strength, specifically the SQ is not surprising. Males are known to have larger upper body muscle fibres enabling greater amounts of force production (Heyward, Johannes-Ellis, & Romer, 1986; Miller, MacDougall, Tarnopolsky, & Sale, 1993). Despite this discrepancy, the difference appears to be confined only to upper body strength expression, with the DL; a primarily lower body posterior chain exercise, showing no difference between the sexes when expressed as a percentage of SQ performance.

The results also revealed that relative strength declined linearly as a function of body mass. These findings are similar to those reported by Mattiuzzi and Lippi (2014) in weightlifters, however this relationship has not always been established. A performance bias towards individuals in intermediate weight classes has been reported by Markovic and Sekulic (2006) and Dooman and Vanderburgh (2000). Despite this data, less evidence is available in powerlifters. Brechue and Takashi (2002) have shown that fat-free mass positively correlates with PL performance. In particular, relative SQ and BP strength peaked in the 59 kg and 74 kg, and DL 66 kg class for males, respectively, and females the SQ and DL peaked in the 47 kg class with BP peaking in the 52 kg class. One possible explanation for these findings is that the ratio of lean muscle to fat mass likely declines with increasing weight category, creating a relatively favourable bias towards the lighter weight classes. Evidence from American football research also reports an increase in body fat percentage with increasing athlete weight (Kraemer et al., 2005). Although it was not possible to account for the percentage of body fat in this investigation, it is evident that an increase in fat mass typically associated with heavier athletes will negatively impact relative strength, despite an absolute score that may be greater than lighter counterparts. Although these results were observed in PL athletes, the findings are also likely to extend to other weight category based sports requiring a strength component during performance.

A decline in strength ratios for the SQ, BP and DL was also found with increasing age. The current findings revealed that peak strength to bodyweight ratios occurred as a JU for the SQ and DL, and as an OP lifter for the BP in both males and females, respectively. In slight contrast to our findings, research by Ball and Weidman (2017) have reported that strength peaks between the ages of 20–49. It is likely that the high relative strength observed in the JU categories for Australian powerlifters can at least be partly explained by: (i) influence of neural factors in strength adaptations in younger individuals (Ozmun, Mikesky, & Surburg, 1994), (ii) lack of accumulation of muscle/and or fat mass increasing overall body weight (Legerlotz, Marzilger, Bohm, & Arampatzis, 2016) and (iii) the popularity of the sport in young lifters. In fact, it has been shown that younger individuals show a greater improvement in 1RM strength following resistance training compared to older counterparts (Lemmer et al., 2000). Despite this increase, it is unlikely that as a JU, individuals have acquired peak muscle mass, suggesting that other factors besides muscle cross-sectional area (i.e. neuromuscular development) have an important role in the findings (Legerlotz et al., 2016). Furthermore, consideration must also be given to the effect of rapid skill acquisition in individuals with potentially less training experience (i.e. SJ and JU), and should therefore be considered when evaluating changes in strength performance as a result of training versus learning (Falk & Tenebaum, 1996). Conversely, a reduction in relative strength with ageing can be explained by several physiological factors. It is well established that strength declines are related to physiological factors as part of the ageing process (i.e. reduced lean muscle mass, decreased fast twitch fibre composition and reduced level of circulating hormones) (Graves, Pollock, & Carroll, 1994). Interestingly, it appears that the rate of decline between trained and sedentary individuals is similar (Pearson et al., 2002). However, this effect appears to be more rapid in strength (3% per year) than endurance activities (0.12–0.23% per year), especially from the age of 30–40 years (Galloway, Kadoko, & Jokim, 2002). Declines in performance with ageing have also been shown in weightlifting (Meltzer, 1994), however this response is not as pronounced in PL. Collectively the results suggest that extraneous age related processes can impair strength performance in PL, with relative strength performance generally favouring JU athletes for lower body movements and OP lifters in the BP.

The results of this investigation offer novel information regarding the factors affecting relative strength in competitive powerlifters. Collectively the findings suggest that (i) males are relatively stronger than females, (ii) relative strength declines as age increases, usually peaking as a JU and OP lifter, and (iii) lighter weight classes can generally lift a greater percentage of bodyweight compared to heavier competitors. Based on the findings, coaches and athletes alike should consider using these results to accurately set competition performance targets based on similar collective athlete profiles. Extraneous factors that are likely to affect performance, such as sex, age and body mass should also be considered as a means of developing individualised training programmes, evaluating athletic development and evaluating competition performance.

Disclosure statement

No potential conflict of interest was reported by the authors.

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