Is powerlifting a viable method for engaging adults of all ages in resistance training? A retrospective, longitudinal population analysis with comparison to population norms

Supplementary materials:
See manuscript data

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ABSTRACT

Background: In Australia, one third of people ≥15 years participate in regular resistance training and 90% of those do not meet current health guidelines. All age groups should be encouraged to engage in regular resistance exercise, to maintain strength and function. Objectives: To identify trends in powerlifting competition participation in Australia by sex and age group from 1968-2022, and to compare the strength of powerlifting competitors to population age- and sex-based normative values. Method: The number of unique participants and total competition entries for each year were analysed using Australian powerlifting competition data. Subdomains of age and sex were investigated, and mean ± SD, frequency, range, and trend analyses were reported. Participants were classified according to United Nations age classifications to identify trends in participation by group. Comparisons to population strength norms were explored descriptively. Results: We included 21,514 individual competitors from 1,942 powerlifting competitions between 1968–2022. Participation rates demonstrated exponential growth (R2 = 0.86) with 51.1% of participants aged 18-35 years at commencement and 16% aged ≥ 36 years. Strength comparison to available population norms demonstrates superior upper- (bench-press [almost all competitors above 70th percentile) and lower-body (squat [majority rated 'excellent') strength. Conclusions: Superior strength levels of powerlifters compared to population norms are not surprising and further the evidence base for this sport as an effective way to develop muscular strength, with low injury risk and flexible participation requirements. We advocate for public health promotion and additional support for 'grassroots' powerlifting as an underutilised tool for community health.

INTRODUCTION

Powerlifting is a maximum strength-based sport whereby athletes perform the squat, bench press, and deadlift. During three-lift competitions, athletes attempt to accumulate the highest overall total score by summing the best lift from three attempts within each lifting discipline [1] in age, bodyweight and sex categories. Modern powerlifting originated in the 1960s after weightlifting (e.g. clean and jerk and snatch movements), of which the latter has been an Olympic sport for more than 50 years [1]. Currently, there are many federations and organisations that coordinate and regulate competitions within nations and more globally [2]. Thus, competition rules differ slightly depending on federation affiliation and competition type (e.g., raw/classic versus equipped events). Regardless, performance is based on the maximal expression of upper- and lower-body strength. Importantly, participation in powerlifting is open to a broad age demographic with school-aged children through to older adults (e.g., Master's IV category; >80 years) who can partake in competitions at various levels (e.g., novice/community level competitions through to world championship events).

Encouraging lifestyle behaviours that improve health, physical function, and independence is crucial for the individual and community [3, 4]. Indeed, greater upper- and lower-body muscular strength is associated with a lower risk of mortality in adults, irrespective of age [5]. Hence, governing bodies worldwide recommend performing strengthening activities at least two days per week [6, 7]. However, despite the documented benefits of regular physical activity, including,

but not limited to, improved quality of life [8], bone mass [9], aerobic fitness [10], cognitive function [11], muscle strength [12], coordination and balance [13], only 32.5% of Australians aged ≥15 years participate in strength-based exercise [14] with up to 90% of this group still not meeting training frequency recommendations [15]. Indeed, poor muscle strength in older adults is a significant contributor to the global healthcare financial burden [16, 17] and is becoming increasingly recognised as a risk factor in young adult mortality [18]. In school-aged youth, resistance training has been shown to have a positive effect on cognition and academic outcomes, indicating the benefit of including strength based activities in the school curriculum to support student learning [19]. More promisingly, Australian participation trends across the lifespan show that individuals performing muscle-strengthening activities as part of sport, recreation, or exercise is beginning to increase - almost two-fold from 2001 to 2010 [15]. Thus, individuals must be continually encouraged to meet or exceed the minimum levels recommended by governing bodies.

Considering this, we sought to examine the longitudinal participation trends of Australian powerlifting – a strength-focused sport inclusive of all ability levels, with further analysis to identify age- and sex-based participation trends. Finally, we explored the strength of powerlifting participants within various age classifications compared to reported community-based norms, which to our knowledge has not been previously compared. We hypothesised that powerlifting participation has increased over time and that the strength levels of powerlifting participants

overall would be well above the reported norms for community dwelling people of the same age and sex. As such, the data may support powerlifting as a growing, accessible strength-based physical activity opportunity across the lifespan with likely population health benefits that extend beyond competition participation.

METHODS

This study is a retrospective, longitudinal population analysis. We collated individual athlete data from all sanctioned powerlifting competitions held in Australia from 1968 – 2022, sourced from the publicly available records on openpowerlifting.org. Therefore, the data presented here does not include unsanctioned or unaffiliated competitions that may have been held throughout the analysis period. The university Human Research Ethics Committee provided ethical approval for this investigation.

We present descriptive statistics as mean ± SD, frequency, range [lower limit – upper limit], and trend analyses to explore Powerlifting participation trends in Australia. Independent samples t-tests and one-way ANOVAs were used to determine statistical significance between group means, where data were compared between groups. A p-value of < 0.05 was considered statistically significant. All analyses were completed using SPSS statistical software (v22, IBM). To assess trends by age groups over time, participants were classified into age categories based on those defined by the United Nations [20]. These age classifications are presented below:

1. Children – aged 1 - 11 years

2. Adolescents – 12 - 17 years
3. Young adults – 18 – 35 years
4. Middle-aged adults – 36 – 59 years
5. Older adults – 60 – 79 years
6. Very old adults – 80+ years

Normative data for strength to bodyweight ratios of the general population for the squat and bench press were sourced from the Cooper Institute (Dallas, TX) and reported in the American College of Sports Medicine (ACSM) guidelines for exercise testing and prescription [21]. The ACSM does not provide normative data for the deadlift, nor could other peer-reviewed published norms for the deadlift be found, therefore, this lift was excluded from this part of the analysis. Comparisons of strength to bodyweight ratios were only conducted for data where athletes competed in Raw, Wrapped, or Single-ply competition. This was done to minimise the influence of athletes competing in equipped competitions (where the weight able to be lifted is higher due to assistive equipment) on the data, and to provide a better comparison to general population norms where such equipment is unlikely to be used. Not all age classifications could be identically matched to data for community strength levels. Hence, groupings were matched as reasonably as possible and are described in each figure.

RESULTS

We collated data from 21,524 individuals (males n = 14,720; females n = 6,804) with 62,730 competition entries across 1,942 events between 1968 - 2022. Bodyweight and age data were missing for n = 322 individuals and n = 13,321 competition entries, respectively. In the total sample, mean age ± SD [range] and bodyweight at first participation were 28.40 ± 10.26 [8-87.5] years (n = 15,231) and 82.59 ± 20.79 [20.0 – 215.6] kg (n = 21,367) respectively. Demographic variables for all included cases are presented in Table 1.

Table 1. Demographic information for the included sample at first recorded competition participation (n=21,524). 'Missing' refers to the number of entries with unavailable data for each metric.

			Total Sample n = 21,524	**Male n = 14,720**	**Female n = 6,804**
Age (years) at first participation		M ± SD	28.84 ± 10.26	27.99 ± 10.12	30.33 ± 10.34
		Min-Max	8 - 87	8 - 87	9 – 78
		Missing (n)	*6,293*	*5,015*	*1,278*
Bodyweight (kg) at first participation		M ± SD	88.43 ± 19.91	88.43 ± 19.91	70.01 ± 16.67
		Min-Max	20.0 - 215.60	20.0 - 215.60	38.60 - 167.70
		Missing (n)	*157*	*122*	*35*
First participated competition year		M ± SD	2013 ± 9	2010 ± 11	2014 ± 9
		Min-Max	1968 - 2022	1968 - 2022	1977 - 2022
		Missing (n)	*0*	*0*	*0*
			n = 6,670	n = 9,418	n = 5,429

United Nations age classification	Children (1- 11 years)	n (%)	21 (0.1%)	9 (0.1%)	12 (0.2%)
	Adolescents (12 – 17 years)	n (%)	912 (4.2%)	670 (4.6%)	242 (4.5%)
	Young adults (18 – 35 years)	n (%)	10,971 (51.0%)	7,117 (48.4%)	3,854 (71.0%)
	Middle-aged adults (36 – 59 years)	n (%)	2,695 (12.5%)	1,470 (10.0%)	1,225 (22.6%)
	Older adults (60 – 79 years)	n (%)	246 (1.1%)	150 (1.0%)	96 (1.8%)
	Very old adults (80+ years)	n (%)	2 (<0.0%)	2 (<0.0%)	0 (0.0%)
Participation frequency	Number of competitions per participant	Min-Max	1 - 163	1 – 163	1 - 60
		mean ± SD	2.92 ± 4.33	2.93 ± 4.62	2.89 ± 3.63
Equipment	Raw/Classic	n (%)	24,507 (58.1%)	15,627 (56.0%)	8,880 (62.2%)
	Wraps	n (%)	12,503 (29.6%)	8,107 (29.0%)	4,396 (30.8%)
	Other	n (%)	5,185 (12.3%)	4,182 (15.0%)	1,003 (7.0%)
	Missing	n (%)	*0 (0.0%)*	*0 (0.0%)*	*0 (0.0%)*
SD: Standard Deviation.					

Participation trends

Participation rates increased over time for males and females, with a substantial increase between 2011 to 2019 and a sharp decline in 2020. The number of unique participants per calendar year for the total sample, males, and females, is presented in Figure 1A. Overall participation trends in the total sample were best explained by an exponential growth pattern (formula: $y = 44.004e^{0.0892x}$, R^2 = 0.8629), whilst male and female growth patterns were best described by third-order polynomials (R^2 = 0.8977 and 0.9167 for males and females,

respectively). The total number of competition entries per year (including multiple participations by the same participant in the same calendar year) followed a similar trend to those seen for the number of unique participants.

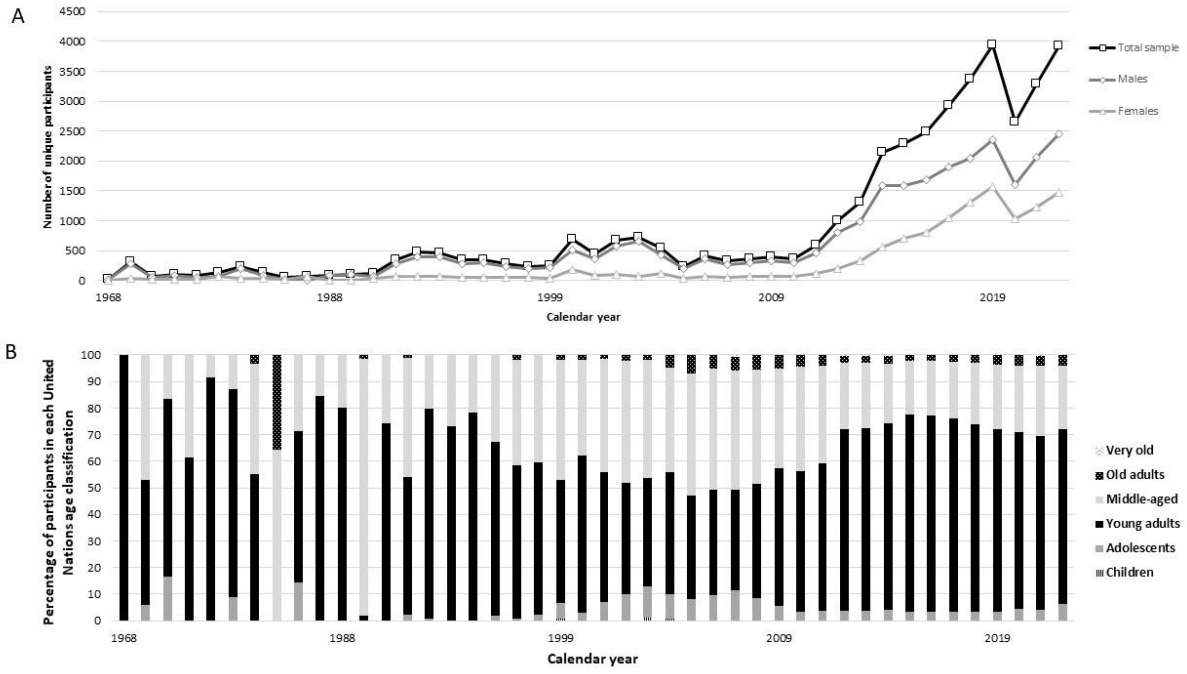

Figure 1: A. Number of unique participants in Australian powerlifting competitions by year (1968 -2022). Exponential growth over the period occurred overall, and third-order polynomial growth occurred for males and females, respectively. B. Percentage of competitors within each United Nations age classification in Australian powerlifting competitions by year (1968 - 2022) where age data were available.

In the total sample, athletes participated in 2.92 ± 4.33 powerlifting competitions over an average of 1.82 ± 1.69 years [range: 1 – 30 years]. For males, the mean number of competition participations was 2.93 ± 4.62 events over a mean duration of 1.85 ± 1.79 years [range: 1 – 30 years]. For females, the mean number of competition participations was 2.89 ± 3.63 events over a mean duration of 1.78 ± 1.46 years [range: 1 – 26 years]. In the total sample, 52.2% of participants competed only once, 63.9% of all participants competed only in a single calendar year (Table S1), and 96.2% of all participants competed in ≤5 calendar years (Table S2). When exploring the number and period of participation by sex, 53.6% of males and 49.1% of females competed only once. For males, 95.8% participated in 1 – 5 calendar years. For females, 97.0% participated in 1 – 5 calendar years. Table 2 shows trends for competition entries based on age classification at first participation.

Table 1. The mean number of powerlifting competitions participated in; stratified according to United Nations age classification at first recorded competition participation.

United Nations Age Classification	n	Number of times participated Mean ± SD	Range of number of competition participations	Number of calendar years participated
Total sample				
Children	21	1.57 ± 1.25	1 – 5	1.24 ± 0.54
Adolescents	912	3.14 ± 3.81 #	1 – 42	1.83 ± 1.49 #
Young adults	10,971	3.03 ± 3.71 *	1 – 100	1.92 ± 1.61*
Middle-aged adults	2,695	3.61 ± 5.79 #*	1 – 163	2.05 ± 1.94 # *
Older adults	246	3.63 ± 4.27	1 – 32	2.00 ± 1.72
Very old adults	2	3.00 ± 1.41	2 - 4	1.50 ± 0.71
Missing	6,670	2.39 ± 4.60	1 – 103	1.58 ± 1.74

Males				
Children	9	1.67 ± 1.41	1 – 5	1.33 ± 0.71
Adolescents	670	3.17 ± 4.05	1 – 42	1.85 ± 1.57
Young adults	7117	3.12 ± 3.99 #	1 – 100	1.99 ± 1.73
Middle-aged adults	1470	3.68 ± 6.87 #	1 – 163	2.09 ± 2.17
Older adults	150	3.41 ± 4.36	1 – 32	1.91 ± 1.72
Very old adults	2	3.00 ± 1.41	2 – 4	1.50 ± 0.71
Missing	5299	2.29 ± 4.38	1 – 63	1.59 ± 1.65
Females				
Children	12	1.50 ± 1.17	1 – 5	1.17 ± 0.39
Adolescents	242	3.03 ± 3.06	1 – 19	1.76 ± 1.26
Young adults	3854	2.87 ± 3.11 #*	1 – 51	1.79 ± 1.33 #
Middle-aged adults	1225	3.53 ± 4.14 #	1 – 34	2.00 ± 1.63 #
Older adults	96	3.97 ± 4.12 *	1 – 17	2.14 ± 1.73
Missing	1371	2.29 ± 4.38	1 - 63	1.54 ± 1.65
# Significantly different to classifications within the same group sharing this symbol * Significantly different to classifications within the same group sharing this symbol				

In the total sample, across all years, age data was missing for an average of 55.5 ± 30.4% [2.4 – 93.7%] of competition entries per year. Since 2012, the number of competition entries missing participant age data has decreased to 10.4 ± 10.4%. Across the period 1968 – 2022, most participants were young adults (61.1 ± 17.3%) in each calendar year. The first record of a competitor from the "very old aged" category occurred in 2007. In the same year, entries within the very old age category accounted for less than 0.5% of all competition entries. A detailed presentation of the percentage of competitors with available age data within each age classification in each calendar year is presented in Figure 1B.

The number of competitions hosted in each calendar year increased over the analysis period (1968 – 2022) with a trend similar to the number of unique participants. The number of

competitions hosted in each calendar year is presented in Figure S1. Peak competition density occurred in 2019 (171 competitions). Since 2012, there has been an average of 117 ± 37.49 [55 – 171] powerlifting competitions each year.

Strength comparisons to community norms

Bench press strength comparisons between powerlifters and available general population norms are shown in Figure 2A-D (females), and 3A-D (males). For females, bench press strength exceeded the 90th percentile across all years for young adults (18-35 years) and middle-aged adults (36-59 years) when compared to similar age groups. For older adults (60-79 years) bench press strength exceeded the 90th percentile in 11/15 years where data was available. No specific general population norms were available for the very old category, with only those aged 60+ available [21]. For adolescents (12-17 years), bench press strength exceeded the 70th percentile in most years for the closest comparison group. For males, bench press strength exceeded the 90th percentile across all years for middle aged adults (36-59 years), and in most instances for young adults (18-35 years) and older adults (60-79 years). For adolescents (12-17 years), less clear differences were observed to the closest comparison group.

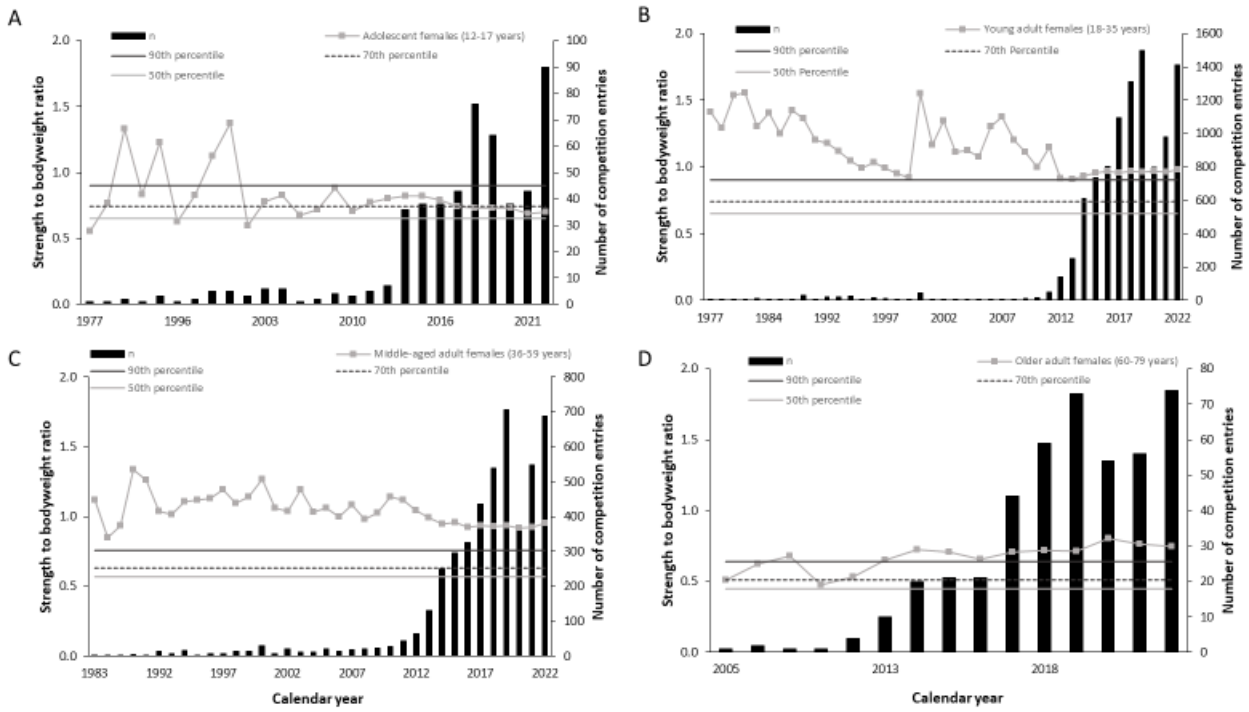

Figure 2: A) Relative bench press strength for adolescent females (12-17 years) compared to norms for females aged 20-29 years. B) Relative bench press strength for young adult females (19 - 35 years) compared to norms for females aged 20-29 years. C) Relative bench press strength for middle-aged adult females (36-59 years) compared to norms for females aged 30-39 years. D) Relative bench press strength for older adult females (60-79 years) compared to norms for females aged 60+ years.

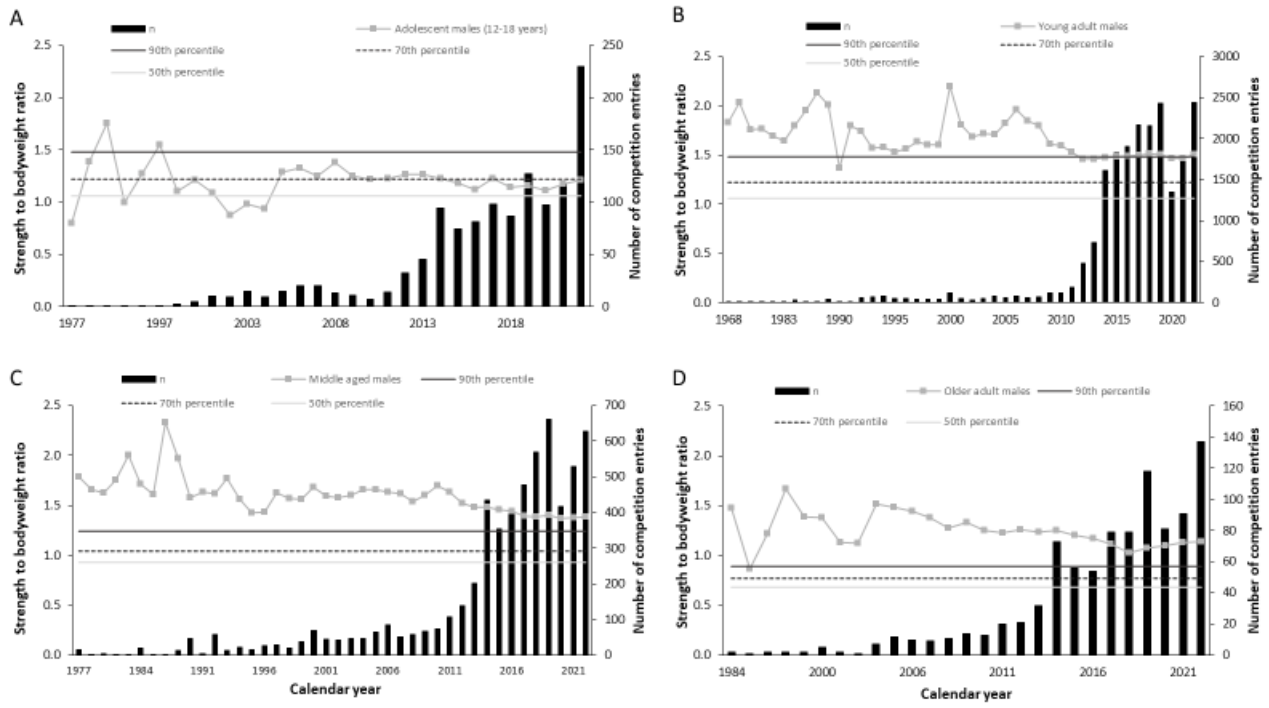

Figure 3: A) Relative bench press strength for adolescent males (12-17 years) compared to norms for males aged 20-29 years. B) Relative bench press strength for young adult males (19 - 35 years) compared to norms for males aged 20-29 years. C) Relative bench press strength for middle-aged adult males (36-59 years) compared to norms for males aged 30-39 years. D) Relative bench press strength for older adult males (60-79 years) compared to norms for males aged 60+ years.

Squat strength comparisons between powerlifters and available general population norms are shown in Figure 4A-D (females), and 5A-D (males). For females, squat strength exceeded the

excellent category in all years for middle-aged adults (36-59 years), and most years for young adults (18-35 years). Squat strength exceeded the excellent category in 9/15 years for older adults (60-79 years). As with bench press comparisons, less clear differences were observed for adolescents (12-17 years) compared to the closest comparison group. For males, squat strength exceeded the excellent category in all but one year for young adults (18-35 years), and in all years for middle-aged adults (36-59 years). Squat strength exceeded the average category in all but 3 years for older adults. Again, squat strength comparisons for adolescent males were less clear when compared to the closest comparison group.

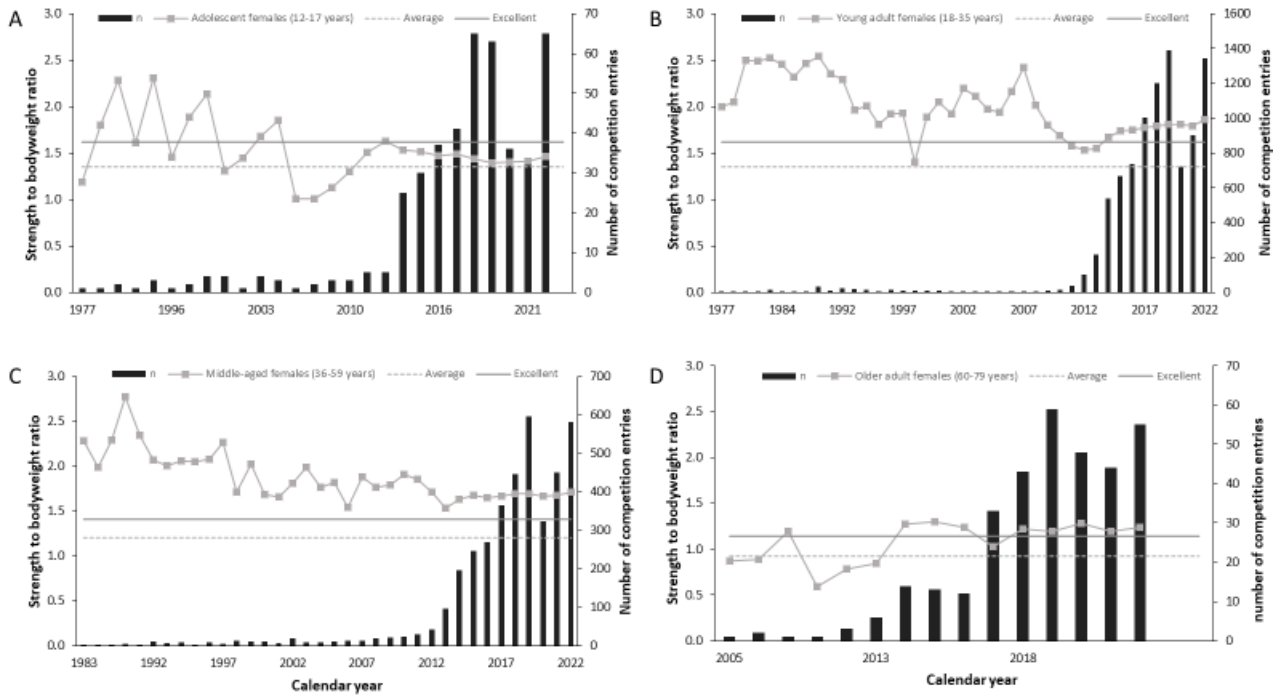

Figure 4: A) Relative squat strength for adolescent females (12-17 years) compared to norms for females aged 20-29 years. B) Relative squat strength for young adult females (19 - 35 years) compared to closest matching group of community norms comprising females aged 20-29 years. C) Relative squat strength for middle-aged adult females (36-59 years) compared to norms for females aged 30-39 years. D) Relative squat strength for older adult females (60-79 years) compared to norms for females aged 60+ years.

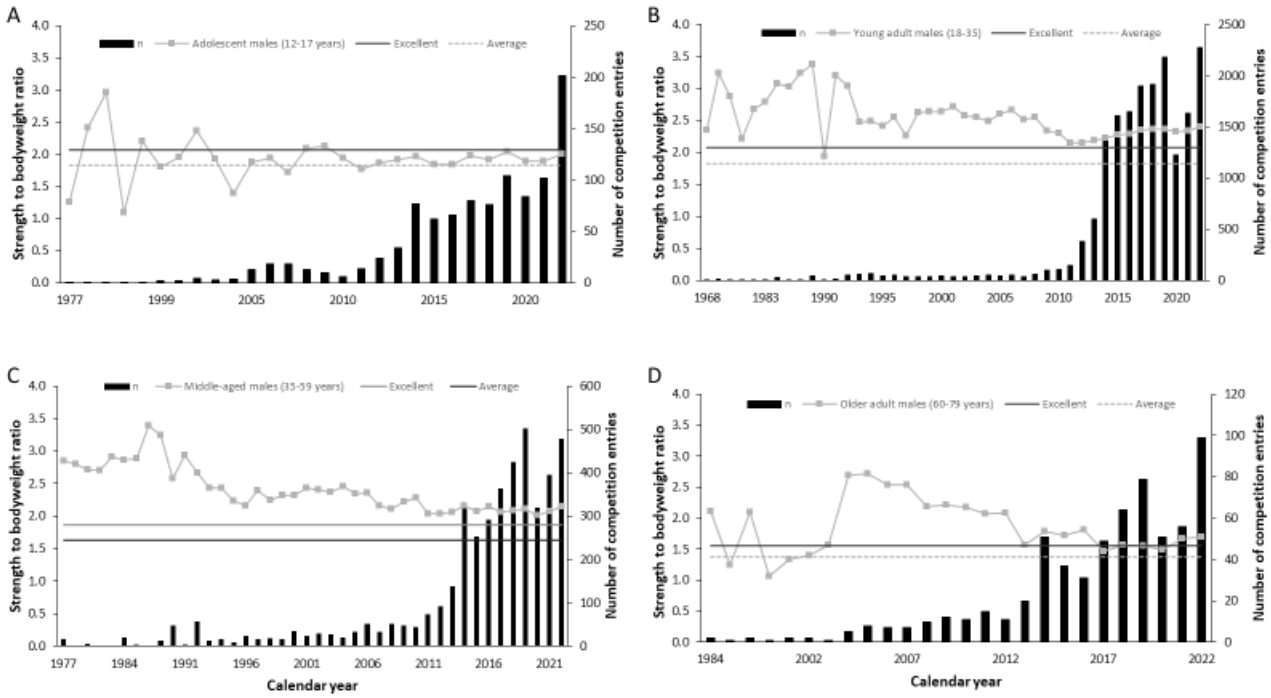

Figure 5: A) Relative squat strength for adolescent males (12-17 years) compared to norms for males aged 20-29 years. B) Relative squat strength for young adult males (19 - 35 years) compared to norms for males aged 20-29 years. C) Relative squat strength for middle-aged

adult males (36-59 years) compared to norms for males aged 30-39 years. D) Relative squat strength for older adult males (60-79 years) compared to norms for males aged 60+ years.

DISCUSSION

We explored Australian powerlifting participation trends, and compared strength levels to available general population strength norms to better understand the growth of this sport and the potential contribution powerlifting could make towards improving population health. Our data demonstrates the substantial, exponential growth of participation in powerlifting events in Australia between 1968 to 2022 and similar non-linear growth between sexes. Further, for the first time to our knowledge, we also demonstrate the superior upper- and lower-body strength of powerlifters across all age categories. Although not surprising given the focus of the sport, it advocates for powerlifting as an already established and viable community tool to encourage physical health and capacity. We contend that public health, national and regional sporting organisations, and related entities should seek to emphasise, support, and endorse community participation in powerlifting and other strength-related sports in the future.

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Powerlifting event participation has grown substantially in Australia since its introduction in 1968. From 2011 onwards, there was a marked increase in event participation by both sexes (unique competitors per year = 29.4% increase). This participation peaked in 2019 before a sharp 1-year decline in 2020 (-32.4%), with the latter likely related to the global pandemic (COVID-19) and the subsequent restrictions that were placed on recreational activity, exercise and sporting competitions within Australia [22]. These effects are reflected by the total number of competitions hosted in 2020 being limited to 55, with 3,630 total entries, compared to 171 competitions with 6,188 entries in 2019. Indeed, there was a return to similar numbers of unique participants in 2022 (n=3928) compared to 2019 (n=3940). Indeed, 2022 resulted in record total participation (154 competitions and 6,803 competition entries), noting that the average number of competitions participants entered each year also trended upwards (2019: 1.57 competitions per entrant, 2022: 1.73 competitions per entrant).

The average participation span and the number of competitions related to the athlete's United Nations age classification at their first competition entry (refer to Table 2). Athletes who commenced competition between 36 – 59 years partake in more competitions (3.61 ± 5.79 events) than those who begin as a young adult (18 – 35 years; 3.03 ± 3.71 events) or adolescent (12 – 17 years; 3.14 ± 3.81 events). For males, middle-aged adults participate in more events (3.68 ± 6.87) than their young adult counterparts (3.12 ± 3.99), but there is no difference in the

number of calendar years they participate. For females, older adults (60 – 79 years) participate in more events (3.97 ± 4.12) than their young adult counterparts (2.87 ± 3.11) over an equivalent period (~two calendar years). Middle-aged adults participate in more events (3.53 ± 4.14) and for a longer period (2.00 ± 1.63 years) than their young adult counterparts (2.87 ± 3.11 events and 1.79 ± 1.33 years, respectively). These trends suggest that those who commence participation at middle to older age are more likely to compete for longer periods and in more competitions. The reasons for commencement or cessation of the involvement across age classifications may be related to life events and their impact on leisure time physical activity (LTPA) [23]. For example, the commencement of work is associated with a decrease in LTPA for both sexes. Meanwhile, reduced income and changing work conditions are associated with decreased LTPA in young women but increased LTPA in middle-aged women. In addition, retirement is associated with increased LTPA and less chance of a decline in LTPA [23]. Whilst these examples are not exhaustive, they demonstrate that LTPA participation is likely affected by life stages/events and aids in understanding Australian powerlifting participation patterns observed here. Of course, one limitation is that the data set analysed has a most recent cut-off (i.e., 2022). Hence, this might not accurately reflect whether younger adults have stopped competing or will continue to compete in upcoming years. Additionally, given the time span of the data collected it is also likely that some athletes progressed into different age categories over this period (e.g., began competing at 17 years of age [adolescent], and after no longer than 12 months would progress to young adult [18-35 years]).

Nonetheless, the analysis shows that powerlifting participation occurred across all age classifications. Given the inherent benefits of participation in regular strengthening activities across the lifespan, it is vital for powerlifting federations, health professionals and governing bodies to identify and understand the opportunity at hand properly. Indeed, although there are unique performance requirements for strength sports such as powerlifting [24], and training, personal and competition equipment requirements for registered competitions [25], plus the appropriate periodisation of training and competition preparation [26], local-level competitions are held by many registered community powerlifting gyms across the county that provide accessibility and opportunity for many people to get involved. Support for the growing uptake of powerlifting comes from data in some of Australia's most popular sports (Australian Rules Football, tennis, hockey, cricket, basketball, lawn bowls, and tennis), where athletes aged 35 years and over represent only 16.2% of all participants [27]. In contrast, in the same calendar year (2011), 36 years and over, athletes represented 40.8% of all powerlifting participants (see Figure 1B). In the period 2011 – 2022, athletes aged 36 - 59 years represented an average of 24.75 ± 4.3% in any calendar year. Additionally, older adults (aged 60-79 years) represented and average of 3.2 ± 0.67% of participants per year (with age data available) during this time. These data suggest that middle-aged and older adults participate in powerlifting more than invasion and bat and ball sports in Australia compared to their younger counterparts. In part, the decision to participate in powerlifting may be due to the lower injury rates (1.0 – 4.4 injuries per 1000 hours

[28]) when compared to sports like soccer (15 injuries per 1000 hours [29]) and CrossFit (9.5 injuries per 1000 hours [30]). Whilst the 'competitive' powerlifting lifespan appears limited, it is plausible that these middle-aged and older adults continue powerlifting-style training without continuing in competition and/or that considerable time may be spent training before deciding to take the next step in competing. Hence, efforts should be made to engage middle-aged and older adults in strength-based training such as powerlifting, support the growing popularity of community level participation and identify regions across the nation where accessibility and opportunity is limited (e.g., location or otherwise) [19].

Along with the benefit to older adults, research in school-aged youths have shown that resistance training can improve cognitive function, academic performance, and on-task behaviours [19]. Resistance training may result in changes in coping and self− regulation skills which can lead to improvements in executive function. In the school setting, on− task behaviour is seen as synonymous with self− regulation. Robinson et al. report, improved mathematics and languages were shown to have the strongest relationships to muscular fitness. Educational settings can, therefore, provide an avenue to target school− aged youth where sedentary behaviours are prevalent. For example, the promotion of, and education around resistance training regardless of whether activities are embedded directy into curricular or extra-curricular activites, or emphasised in other ways appear warranted. Indeed, these efforts may result in

physical health benefits, lifetime adoption of resistance training and have a positive effect on learning.

Strength comparisons to community norms and proposed benefits

Importantly, upper- and lower-body strength of powerlifters exceeded available community norms when matched for the most similar age group(s). Although this may seem unsurprising given the focus of the sport, it provides important supportive information, which to our knowledge has not yet been extrapolated. Indeed, greater muscular strength is associated lower risk of mortality across the adult lifespan [5], and poor strength is becoming recognised as a risk factor in young adult mortality [18]. To further emphasise the importance of muscular strength development during adolescence and young adulthood Karelis (2012) reports that high strength levels (knee extension and handgrip) were associated with a 20% lower mortality risk, 35% reduction in cardiovascular disease and 20-30% reduction in suicide, and it seems likely that these effects would extend to bench press and squat strength metrics. Further evidence suggests team sport participation reduces psychological stress in senior high school girls (Guddal et al. 2019). That being said, although powerlifting is rightly classified as an individual performance sport, the club training environment and competition support can offer a sense of community, facilitate regular social interaction and support emotional wellbeing (Latella & Haff 2020).

As previously highlighted, poor muscle strength in older adults is a major contributor to healthcare financial burden [16, 17]. Muscular strength combats weakness and frailty, preserves bone density, independence and reduces the risk of many chronic lifestyle diseases (for further details see: Seguin & Nelson 2003; Fragala et al.2019). Specifically, greater muscular strength observed in powerlifters compared to the general older adult community may act as a 'strength reserve' to combat age related decline into late adulthood. Our prior work (Latella et al. 2022), demonstrates that even Master's category male and female powerlifters can continue to improve strength, or show attenuated age-related reductions compared to known rates of decline (e.g., only 0.35% strength loss per year in oldest male category). Further, we support the idea that this strength reserve maintains physiological resilience, reduces vulnerability to potentially catastrophic health events, and keeps older adults above clinically relevant muscle weakness threshold (Fragala et al.2019). Although clinically relevant muscle weakness is often based on handgrip values (e.g., normal strength, intermediate and weak scores [Alley et al. 2014]), it is possible that similar meaningful norms identifying at risk individuals could be developed from squat and bench press community data [21] with additional prospective work that includes health data. Lastly, and similar to adolescents, strength sport participation has benefits beyond physical health. For example, Huebner et al. (2022) recently showed that older adults participating the sport of weightlifting reported mental health benefits, reduced stress and improved community connections, further emphasising the important role of muscular strength and strength sport participation in older adults.

Collectively, we demonstrate a continued and growing uptake in powerlifting events by both sexes across all age groups (except 'very old age' females). With poor population-level participation rates in strengthening activities, powerlifting offers an opportunity for many individuals, including the general population, to become involved in goal-orientated strength training, regardless of being for competitive or personal health benefits. Further, strength training may offer mental, besides just physical health benefits [31], which is important in a society where the prevalence of clinically significant depression nears 1 in 10 people with estimates of major depressive disorder at ~1.2% [32]. Therefore, we advocate that powerlifting should be supported by health professionals, sporting organisations, and governing health bodies to increase resistance training uptake, adherence, and overall levels in the Australian population. Increased promotion, awareness, and endorsement of powerlifting (both organisations and opportunities for participation) should be a focus and requires a collaborative effort between those involved in leadership of the sport and health organisations across the nation.

Limitations

Whilst this investigation has several strengths, it must be acknowledged that the retrospective nature of the records, and subsequent analyses and results are subject to some limitations. Because the recording of athlete age at competition entry was not provided for all entries, the

trends in participation by athlete age group must be interpreted with caution. However, given the number of years and sample size, we do not think this has significantly affected the identified trends. Instead, this is likely to have provided a more conservative estimate if anything. Second, this investigation only explores data from Australian competition entries and does not account for international competitions where Australians may have participated or more global powerlifting trends. Lastly, as discussed above, athlete information about reasons for beginning or ceasing competitive powerlifting was unavailable.

Conclusion

Powerlifting in Australia has undergone exponential growth in participation since its inception in 1968. Whilst there is substantial growth in participation rates, the number of competitions undertaken by individuals remains limited. It is unclear why this issue exists, but it is plausible that individuals cease competitive participation due to competitive training requirements, major life events, or a desire to continue training without competition demands. Because demographic data reports that Australians continue to perform less than the recommended amount of strength training, and our analyses shows superior upper- and lower-body strength of powerlifters across all ages, we suggest that powerlifting is a viable recreational sport to be used to increase participation in strength training across the lifespan. Further prospective investigations are required to understand how powerlifting participation (training and/or

competition) impacts physical and mental health outcomes between recreational and more advanced participants.

Practical implications

- Participation in strength sports or activities such as powerlifting should be encouraged across the lifespan to attenuate age-related health decline(s) and to mitigate the known effects of low muscle strength on mortality risk.
- Health professionals and governing bodies should encourage long-term participation in strengthening exercise, whether for competitive or health-related reasons and work with strength sports organisations to improve public health messaging and opportunity awareness.
- Powerlifting federations should develop targeted interventions and strategies to improve community engagement and participant retention continually.

Contributions

Contributed to conception and design: DVH, CL
Contributed to acquisition of data: DVH, CL
Contributed to analysis and interpretation of data: DVH, CL, JS, PB, JMG, JP
Drafted and/or revised the article: All authors
Approved the submitted version for publication: All authors

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Data and Supplementary Material Accessibility

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