Short Communication

Regional body composition and its relationship to performance in powerlifters with physical disabilities: A pilot study

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Total lean body mass (LBM) is related to the absolute load lifted in the bench press in powerlifters with physical disabilities, but the relationship between relative performance and regional LBM is unknown.

Objectives: The purpose of this pilot study was to 1) examine the regional body composition characteristics of competitive powerlifters with physical disabilities and 2) to determine the relationships between relative performance and regional LBM in these powerlifters.

Design: Cross-sectional, descriptive study.

Methods: Dual energy x-ray absorptiometry (DXA) scans were obtained on 11 powerlifters with physical disabilities along with competition performance on 9 athletes. Total and regional LBM values were indexed relative to height (kg/m^2).

Results: A strong, significant, relationship was observed between AH (Haleczko) bench press score and LBM index in the arm region (rho = 0.787; p = 0.015) but not in the trunk (rho = 0.583; p = 0.108), legs (rho = 0.042; p = 0.922), or total body (rho = 0.617; p = 0.086).

Conclusions: These results suggest LBM accretion in the arms may be most beneficial for powerlifting performance for those with physical disabilities.

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Key words: Body fat ■ lean body mass ■ strength ■ bench press

INTRODUCTION

Para Powerlifting is a sport in which athlete's performance is determined by the maximum load that can be lifted in the bench press. Athletes eligible for Para Powerlifting competition include those with one or multiple physical impairments including impaired muscle power, impaired passive range of motion, limb deficiency, leg length difference, short stature, hypertonia, ataxia, and athetosis.[1] In contrast to traditional powerlifting, which includes the sum of the lifter's best squat, bench press, and deadlift, Para Powerlifting involves only the bench press and the athlete's entire body is upon the bench preventing any use of the lower body (i.e. leg drive) to execute the movement. Previous work suggests lean body mass (LBM) accretion may affect traditional powerlifter performance as skeletal muscle mass has a strong relationship with the load lifted for each of the lifts involved in traditional powerlifting.[2,3] Performing the bench press with the feet off the floor compared to with the feet on the floor has been shown to cause greater the activation of both the prime movers (e.g. pectoralis major) and stabilizer muscles (e.g. obliques) when lifting submaximal loads.[4] Given the unique technical demands of the bench press and the physical impairments of Para Powerlifters, it is possible measures of regional LBM may be more strongly related to performance compared to whole body LBM.

In male lifters, Para Powerlifting performance, as measured by absolute load (kg) lifted in the bench press, is strongly related to arm circumference but weakly related to total body LBM estimated by bioelectrical impedance.[5] It is possible that LBM specifically in the arms is an important factor for performance but, to date, no study has looked at measures of regional body composition in relation to performance in this population. Additionally, since Para Powerlifting is a weight class sport, it is also important to know how body composition may relate to performance when it is normalized to body mass. In Para Powerlifting, performance between athletes of different weight classes is compared using the AH (Haleczko) formula which normalizes performance for body mass.[1]

Currently, it is unclear if regional (e.g. trunk, arms, legs) LBM may be of greater importance than total LBM for performance when normalized for body mass in these athletes. Determining these relationships may help athletes and coaches understand the impact of trunk (e.g. pectoralis major) and arm (e.g. deltoid and triceps brachii) muscular development on performance. Additionally, there is a paucity of data on the physical characteristics of powerlifters with physical disability currently. Previous work has shown national level Malaysian Para Powerlifters to have high levels of upper body strength measured as the ratio of bench press one-repetition maximum to body mass (1.78 ± 0.58)[6] but there are no other descriptive studies specifically on this population to our knowledge. As the number of participants in powerlifting

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events has been increasing,[7] it is important to provide more descriptive data on this population to provide more knowledge about the powerlifters with physical disabilities and to provide a basis for future research aimed at improving training practices and performance. Therefore, the primary purpose of this pilot study was to describe the regional body composition profile of powerlifters with physical disabilities and a secondary purpose was to investigate the relationships between performance normalized for body mass and total as well as regional measures of LBM in powerlifters with physical disabilities. We hypothesized that LBM in the arms and trunk region would show strong, positive relationships with normalized bench press performance whereas LBM in the legs and total body would show weaker relationships with normalized bench press performance.

METHODS

This pilot study used a cross-sectional research design to provide a body composition profile of powerlifters with disabilities and relate regional measures of body composition to powerlifting performance. Specifically, the body composition and performance data from those powerlifters with physical disabilities who took part in body composition testing and a sanctioned USA Para Powerlifting competition on the University's campus were included.

Participants

Data were included from a total of 11 (N = 11; age range 18-35 years) Para Powerlifters who voluntarily underwent a body composition assessment via dual-energy x-ray absorptiometry (DXA) between June 2018 and January 2020. The Para Powerlifters included: six (n = 6) athletes with spina bifida, two (n = 2) athletes with lower limb amputations, one (n = 1) athlete with short stature, and two (n = 2) athletes with spinal cord injury. Participant characteristics are presented in Table 1. Data from competition results were available from nine (n = 9) Para Powerlifters who achieved a successful competition result (at least one successful lift attempt in competition) during a sanctioned USA Para Powerlifting event during the same time frame. The DXA scans were conducted within 48 hours of the competition result. The University's Institutional Review Board (IRB) approved (control #RD0420200552) the use of the de-identified DXA data for this retrospective analysis and all athletes included in the analysis provided consent for use of their data in this analysis.

All participants underwent a full body DXA scan (software version 13.60.033, Lunar Prodigy Advance, Madison, WI) conducted by a trained technician who modified the scanning technique and position of each athlete based on their disability and body habitus as needed. From this scan, both whole body (total) and regional (arms, legs, and trunk) fat mass, body fat percentage, and LBM variables were recorded. Specifically, the region of interest (ROI) was defined for the trunk as the area including the chest, abdomen, and pelvic triangle. The ROI for the arms (right and left) was defined by a line through the shoulder joint of the right and left arm (including all tissue lateral to the shoulder joints). The legs ROI (right and left) was defined by a line through the hip joint aligned with the iliac crest and pubis (all tissue inferior to the hip joints). The regional LBM index and fat mass index were

Table 1 Participant Performance and Body Composition Characteristics.

	Mean	Standard deviation	Minimum	Maximum
Age (yrs)	27.0	6.3	18.8	35.6
Height (m)	1.62	0.19	1.37	1.98
Body mass (kg)	84.4	32.4	53.4	158.8
Bench press (kg)*	117.2	39.8	82.0	210.0
Bench press / body mass (kg/kg) *	1.61	0.50	0.92	2.21
AH (Haleczko) bench press (units)*	112.5	33.7	74.3	173.5
Total body fat (%)	37.1	17.3	11.3	62.3
Total lean body mass (kg)	48.4	13.9	27.5	77.3
Arms lean body mass (kg)	7.9	3.1	3.7	14.3
Legs lean body mass (kg)	11.9	4.9	2.4	7.6
Trunk lean body mass (kg)	25.5	6.5	15.8	39.4
Fat mass (kg)	32.6	21.7	6.5	70.3
Arms fat mass (kg)	2.8	1.9	0.6	7.0
Legs fat mass (kg)	10.3	7.2	2.2	28.9
Trunk fat mass (kg)	18.7	12.0	2.6	39.4
Lean body mass index (kg/m^2)	18.4	3.9	13.6	27.3
Arms lean body mass index (kg/m^2)	3.0	1.0	1.6	5.1
Legs lean body mass index (kg/m^2)	4.5	1.3	7.6	2.4
Trunk lean body mass index (kg/m^2)	9.7	1.8	7.8	14.1
Fat mass index (kg/m^2)	12.1	7.3	2.6	25.8

N = 11; Sex: n = 8 male, n = 3 female. *n = 9; Sex: n = 7 male, n = 2 female.

calculated as the ratio of LBM to height (kg/m^2) and the ratio of fat mass to height (kg/m^2), respectively. Each athlete was categorized by fat mass index according to gender specific reference values from the National Health and Nutrition Examination Survey (NHANES).[8] LBM index values for each athlete were also categorized according to age and gender specific percentiles from NHANES.[9]

Each athlete's highest successful bench press during competition was recorded in kilograms (kg). A successful bench press or "good lift" occurs when at least two of the three technical officials determine the athlete has been technically proficient all of the phases of the bench press (start sequence, press sequence and rack sequence)[10]. To normalize performance for body mass, the AH (Haleczko) formula was applied[1] and the normalized bench press scores were used for analysis. Relative bench press (bench press / body mass) strength for each athlete was also calculated and compared to age and gender norms for the one-repetition maximum bench press.[11]

Statistical Analysis

Means as well as standard deviation, minimum, and maximum values are reported for all descriptive variables. Relationships between relative bench press performance, fat mass index (kg/m^2) and both whole body as well as regional (arms, legs, trunk) LBM (kg) and LBM index (kg/m^2) were examined using Spearman's rho correlations and p-values were subjected to a Monte Carlo permutation test (9999 permutations). Statistical significance was set as $p < 0.05$ and data analysis was conducted using PAST version 4.04 (Paleontological Statistics software package).[12]

RESULTS

Table 1 presents the regional body composition values for all participants (N = 11) as well as the bench performance values for the nine (n = 9) Para Powerlifters who achieved a "good" lift during a competition. Table 2 presents the relationships between competition performance and body composition variables. The relative bench press scores for all athletes aged 20 and above (n = 8) were in the 90th percentile according to age- and gender-norms.[11] Gender-specific fat mass index classifications according to NHANES categorized the athletes (N = 11) as follows: mild fat deficit (n = 1), normal (n = 2), excess fat (n = 1), obese class I (n = 2), obese class II (n = 4), and obese class III (n = 1).[8] Age- and gender-specific total LBM index values according to NHANES categorized the athletes (N = 11) as follows: above the 10th percentile (n = 3), below the 50th percentile (n = 3), above 50th percentile (n = 2), above 97th percentile (n = 3).[9]

DISCUSSION

The primary finding of this study is that this group of athletes all exhibit above average level of upper body strength along with a diverse body composition profile in terms of relative fat mass and relative LBM. The second finding of the present study is that Para Powerlifting performance has a strong relationship with LBM in the arms region, a moderate relationship with total body LBM and LBM in the trunk region, and a very weak relationship to LBM in the leg region. While we cannot infer that increased LBM specifically in the arm region improves Para Powerlifting performance, these data suggest that those athletes with the highest relative amounts of LBM in the arms perform better in competition as determined by the AH (Haleczko) formula.[1]

The upper body strength of these athletes as measured by the bench press one-repetition maximum (1RM) to body mass ratio was very high (1.61 ± 0.50) which is agreement with previous work which observed a very similar strength to body mass ratio (1.78 ± 0.58) in eight national level powerlifters with disability.[6] This previous study also observed more variation in the isometric handgrip strength test with some participants having above average and some with below average scores relative to normative data.[6] Likewise, we observed more variance in indexes of LBM and fat mass relative to normative data within this group of athletes. This population appears to be homogeneous in respect to dynamic strength in

Table 2 Correlations between relative bench press performance and body composition variables.

		AH (Haleczko) Bench Press Score		
		Spearman's rho	p-value	permutation p-value*
Relative values (kg/m^2)	Total body mass	-0.067	0.880	0.880
	Total fat mass	-0.293	0.442	0.442
	Total lean body mass	0.617	0.086	0.087
	Arm lean body mass	0.787	0.015	0.017
	Trunk lean body mass	0.583	0.108	0.108
	Leg lean body mass	0.042	0.922	0.920
Absolute values (kg)	Total body mass	-0.180	0.644	0.645
	Total fat mass	-0.333	0.385	0.380
	Total lean body mass	0.333	0.372	0.375
	Arm lean body mass	0.678	0.051	0.051
	Trunk lean body mass	0.250	0.521	0.518
	Leg lean body mass	<0.001	> 0.999	> 0.999

*based on 9999 permutations

the upper body (e.g. bench press 1RM) whereas there is more variability in non-sport specific measures of fitness (e.g. handgrip strength and body composition).

In agreement with our findings, previous work has shown positive relationships between performance and arm circumference as well as total body LBM in Malaysian Para Powerlifters.[5] Compared to the relationships observed between absolute bench press performance and total body LBM (r = 0.389) and tensed arm circumference (r = 0.648) reported previously, we observed an even stronger relationship between relative performance and LBM in the arms (r = 0.787). Our study adds to the knowledge of these relationships as we were able to assess regional measures of LBM via DXA and observe the site-specific relationship between LBM in the arms and performance. It should be noted that the arm measurement of LBM included both the elbow extensors and deltoid muscles based on our defined ROIs with the DXA analysis. These defined ROIs for the DXA analysis were similar to previous investigations of regional body composition in athletes.[13] Furthermore, while the previous study used absolute load lifted (kg) as their performance measure, we showed a significant relationship between LBM in the arms and a performance measure that allows comparison across individuals of different weight classes. Total body mass and total LBM both show weak relationships to relative performance values in these athletes which highlights the impact that regional LBM may have on performance. These findings suggest that measuring regional LBM in powerlifters with physical disabilities may be useful as a predictor of competition performance.

Our study is limited by a small sample size. To address the small sample size, the data were subjected to Monte Carlo permutation tests. P-values are similar between permutation tests and Spearman's rho, lending credence to the observed patterns. Additionally, other cross-sectional studies on athletes with disabilities have had similar samples sizes due to relatively small number of total athletes available.[6,14] We acknowledge that combining both men and women into one sample may be problematic due to gender differences in LBM. However, we felt this was the most appropriate approach given the small sample size and that fact that both performance and LBM were normalized. Furthermore, the relationships remained the same when looking at the men only in the analysis (data not shown). Para powerlifting is currently a small but growing sport and this is the first study to characterize regional body composition of Para Powerlifters which provides a foundation for further research. As this was a retrospective analysis, we did not have detailed training history for these participants but we recommend future studies collect this data in continuing to explore the relationships between performance, body composition, and anthropometric characteristics in this population and to further understand what factors may be most predictive of performance. Furthermore, intervention studies examining the effect of manipulation of body composition on performance are warranted to provide evidence-based recommendation on training practices to improve performance.

This data is the first to provide total and regional body composition values on powerlifters with physical disabilities. The relationships between body composition variables and performance suggest that LBM specifically in the arms may be the most important predictor for bench press performance. In contrast, total body mass is weakly related to performance and thus, strategies to improve performance may be best focused on regional LBM accretion as opposed to simply increasing overall body mass.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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