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Abstract

Kraemer, WJ, Caldwell, LK, Post, EM, DuPont, WH, Martini, ER, Ratamess, NA, Szivak, TK, Shurley, JP, Beeler, MK, Volek, JS, Maresh, CM, Todd, JS, Walrod, BJ, Hyde, PN, Fairman, C, and Best, TM. Body composition in elite strongman competitors. *J Strength Cond Res* 34(12): 3326–3330, 2020—The purpose of this descriptive investigation was to characterize a group of elite strongman competitors to document the body composition of this unique population of strength athletes. Data were collected from eligible competitors as part of a health screening program conducted over 5 consecutive years. Imaging was acquired using dual-energy x-ray absorptiometry (DXA), providing total body measures of fat mass, lean mass, and bone mineral content (BMC). Year to year, testing groups showed a homogenous grouping of anthropometric, body composition, and bone density metrics. Composite averages were calculated to provide an anthropometric profile of the elite strongman competitor ($N = 18$; mean $\pm$ SD): age, 33.0 $\pm$ 5.2 years; body height, 187.4 $\pm$ 7.1 cm; body mass, 152.9 $\pm$ 19.3 kg; body mass index, 43.5 $\pm$ 4.8 kg·m^{-2}; fat mass, 30.9 $\pm$ 11.1 kg; lean mass, 118.0 $\pm$ 11.7 kg, body fat, 18.7 $\pm$ 6.2%, total BMC, 5.23 $\pm$ 0.41 kg, and bone mineral density, 1.78 $\pm$ 0.14 g·cm^{-2}. These data demonstrate that elite strongman competitors are among the largest human male athletes, and in some cases, they are at the extreme limits reported for body size and structure. Elite strongman competitors undergo a high degree of mechanical stress, providing further insight into the potent role of physical training in mediating structural remodeling even into adulthood. Such data provide a glimpse into a unique group of competitive athletes pushing the limits not only of human performance but also of human physiology.

Key Words: strength, power, body size, elite competitors, body mass index, visceral fat, muscle

Introduction

The modern sport of strongman traces its inception to 1977, and the debut of the "*World's Strongest Man*" on CBS (33). Athletes in the first few contests hailed from diverse training and competitive backgrounds, including professional football, bodybuilding, powerlifting, arm wrestling, professional wrestling, Olympic weightlifting, and track and field. The show's creator, television producer Barry Frank, sought to test various aspects of the athletes' strength in ways that would be more distinctive than traditional barbell-based events and to create a spectacle that would be visually appealing for home audiences (23). To that end, the original contest included lifting barrels filled with lead shot and liquid overhead, bending metal bars, racing up an incline with a wheelbarrow holding 750 lbs, pulling an 8,000-lb tram, deadlifting the rear end of a car, and racing 40 yards with a refrigerator on a competitor's back. Where a casual viewer might have had trouble differentiating between the difficulty of a 400 or a 600-lb squat in a traditional powerlifting contest, anyone could understand the immense strength required to tow a tram or tote a refrigerator on one's back.

The *World's Strongest Man* TV show developed a devoted following. By the mid-2000s, it was estimated that more than 200 million people viewed it worldwide (9). The 2020 iteration of the World's Strongest Man will be broadcasted in more than 70 countries and reach 500 million households. The 2019 deadlift event from another strongman contest, the *Arnold Strongman Classic* (ASC) has been viewed more than 3 million times on YouTube and the 2019 video of The Wheel of Pain event at the ASC has amassed nearly 5 million views. The popularity of these televised and online events also gave birth to a new "sport" called strongman that operates at both amateur and professional levels. Strongman has become an international phenomenon in the past 2 decades, with an array of federations offering competitions for men, women, masters, and even team competitions. It has also resulted in great interest in the appropriate training practices and techniques to improve event performance (16,35–37).

Strongman events (i.e., deadlifts, stone lifting, various carries and farmer's walk, loading medleys, vehicle pulls, various throws, overhead pressing, squats, and many other physically challenging events) require movement in multiple planes with both bilateral

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and unilateral ground contact (19,20,24,29,35). To train for such events, competitors engage in both traditional, periodized resistance training programs as well as competition-specific modalities (37). The diversity in training not only promotes the development of maximal strength, power, and endurance but also improves functional movement and stability needed to maintain biomechanical integrity while enduring extreme loading patterns (16). As a result, the training practices of strongman have been adopted by some athletes and coaches from different sports, given the high degree of functionality of the competitive events to some sporting movements (16). Although the demands of each sport may vary considerably, the multiplanar loading with strongman exercises provides a novel stimulus for strength and power improvements. The adaptive potential of the human body—from structure to function—has continued to push the limits of expectation. The underlying structures needed to produce record performances can be attributed to complex interactions between genetic predispositions and environmental factors, such as training practices, nutrition, and hormonal characteristics (8,15,22).

The structural changes associated with training provide a rare glimpse into the human body's adaptive potential and are important to document from both a historical and anthropological perspective. Winwood et al. (38) examined body composition in novice strongman athletes and found moderate to large correlations between anthropometric size (body mass, fat free mass) and strongman performance. Interestingly, in one of the only studies examining body composition in strongman competitors, they reported the following characteristics: height of 184.5 ± 6.5 cm, body mass of 102 ± 10.8 kg, fat free mass of 88.1 ± 8.6 kg, muscle mass 51.4 ± 5.2 kg, and a percent body fat of 13.6 ± 4.7. Despite a growing field of strongman competitors, few reach the status of the elite strongman competitors who compete in such professional competitions as World's Strongest Man or Arnold Strongman Classic. Thus, more elite performances are likely to involve even greater anthropometric adaptation, including adaptation to the bone.

With the intense training loads used in contest preparations and the size, strength, and power needed for optimal performance, we endeavored to characterize this most unique group of men who are elite strongman athletes. The primary rationale for this descriptive study was the rare opportunity to gain scientific descriptive data on a unique group of men who represent some of the strongest and largest weight-trained athletes in the world. We hypothesized that professional strongman competitors would exhibit high levels of structural adaptation, potentially pushing the upper limits of body composition metrics reported in other groups of athletes. Thus, the primary purpose of this descriptive investigation was to examine anthropometric, body composition, and bone density metrics in elite strongman competitors.

Methods

Experimental Approach to the Problem

Working within the constructs and constraints of Institutional Board Review and approvals, we had the opportunity to assess selected biometric data from elite strongman competitors as part of an ongoing comprehensive health screening program that consisted of confidential physician examination and consultation that was independent of the institutional review board–approved variables used in this study. We used a descriptive study design to characterize the body composition of elite strongman competitors and construct an anthropometric profile for this unique group of athletes. The study design also allowed for analysis of longitudinal changes in athletes that completed multiple years of testing.

Subjects

Eighteen professional strongman competitors at the pinnacle of their careers (age, 33.0 ± 5.2 years, body height, 187.4 ± 7.1 cm; body mass, 152.9 ± 19.3 kg) volunteered to take part in the health screening program. All subjects had competed in at least one international championship during the previous 12-month period and thereby demonstrated their status as an elite strongman. All subjects were tested 1–2 days after a non-drug-tested elite international competition. Limited access was given to the athletes. Therefore, information on current training habits, supplements, and performance-enhancing drug use was not collected. The study was approved annually by The Ohio State University Institutional Review Board for the protection of human subjects in research. The risks and benefits of participation were discussed with each subject before confirming written informed consent. Consent was obtained each year a competitor volunteered to participate in the screening. Because the intent of this descriptive study was to provide body composition data of the most elite international strongman competitors, a control group was not included.

Procedures

Strongman competitors reported to the laboratory (07:00–10:00 hours) on a nontraining day after an overnight fast of at least 8 hours. All subjects were tested 1–2 days following an elite multiday strongman competition. They had just completed several weeks of precompetition training and tapering before the competition. Thus, we were able to assess these elite strongman competitors while in peak physical condition. Each subject was encouraged to drink at least 16 ounces of water the night before the visit and an additional 16 ounces before arriving at the laboratory. Upon arrival, hydration status was confirmed via the use of a high precision TS400 Clinical Refractometer (Reichert Inc., Buffalo, NY). Subjects were required to demonstrate a minimum level of hydration (urine specific gravity ≤1.020) before engaging in the evaluation. Upon check-in, body mass was determined using a clinical scale/stadiometer (Seca 763 scale/stadiometer, Seca, Inc., Chino, CA). Each subject then progressed through various examination sections, including total body imaging, to assess body composition, which was the focus of this investigation.

Body composition was quantified via dual-energy x-ray absorptiometry (DXA) using a Lunar iDXA system (GE, Madison, WI) with CoreScan software (GE, Lunar, encore software version 14.10). DXA uses 2-dimensional projection data created by low-energy, fan beam x-ray to create a 3-compartment model of body composition consisting of fat mass, lean mass, and bone mineral content (BMC). The DXA was quality assured every 2 days to provide the highest intrameasure accuracy. All measurements were conducted by a certified General X-ray Machine Operator. Subjects removed all metals and were carefully aligned on the DXA bed by the technician. Because of the large size of subjects, the shoulders were often broader than the width of the scanning area. To prevent tissue overlap, the left arm was placed outside the detection limits, and a half-scan analysis was performed assuming symmetry of the body (31). The average duration of a whole-body scan lasted 13 minutes and exposed the subjects to negligible radiation (<0.01 sV). Using our methodology, ICCR reliabilities for all body composition measures ranged from 0.93 to 0.94.

Table 1
Anthropometric, body composition, and bone density profile by year.*†

	Year 1 *N* = 8	Year 2 *N* = 7	Year 3 *N* = 8	Year 4 *N* = 9	Year 5 *N* = 8
Age (y)	33.6 ± 5.2	31.9 ± 6.2	33.7 ± 4.4	32.3 ± 5.6	33.7 ± 5.5
Height (cm)	189.1 ± 10.1	191.1 ± 8.8	188.0 ± 9.3	188.8 ± 8.5	190.9 ± 6.8
Body Mass (kg)	166.3 ± 14.0	168.8 ± 20.3	155.7 ± 31.2	157.3 ± 21.8	160.9 ± 25.8
BMI (kg·m^{-2})	45.9 ± 4.0	46.3 ± 5.1	43.9 ± 6.7	43.8 ± 4.3	43.0 ± 3.2
Body fat (%)	22.6 ± 5.2	22.0 ± 5.9	17.1 ± 7.9	19.2 ± 4.5	17.2 ± 5.0
Lean mass (kg)	123.2 ± 14.7	125.8 ± 12.7	120.7 ± 16.5	120.0 ± 14.0	122.2 ± 13.6
Fat mass (kg)	36.7 ± 8.7	37.77 ± 11.6	30.0 ± 14.9	31.1 ± 9.9	29.8 ± 9.8
Visceral fat (kg)	3.0 ± 1.2	3.1 ± 1.6	2.9 ± 3.0	2.8 ± 1.8	2.4 ± 1.3
BMD (g·cm^{-2})	1.79 ± 0.05	1.76 ± 0.09	1.78 ± 0.09	1.78 ± 0.08	1.81 ± 0.10
Deadlift (kg)	437.5 ± 73.1	433.0 ± 41.7	419.5 ± 27.8	436.6 ± 24.6	436.5 ± 28.8

*BMI = body mass index; BMD = bone mineral density.
†Data presented as means ± *SD*.

Statistical Analyses

Data were analyzed using SPSS version 25 (IBM, Armonk, NY). Means and *SD*s of all anthropometric variables were calculated for each annual cohort. Additionally, composite means were used to make qualitative comparisons with previous study findings involving large male athletes and normative values for age-matched controls. In the event, an athlete completed the health screening program in multiple testing years; mean values were used for each individual when constructing composite values and range data for the group as a whole.

Results

Data were collected from eligible strongman competitors over 5 years. Table 1 illustrates the profile of each annual cohort (mean ± *SD*). Publicly available, maximal deadlift performance is depicted because it was the only similar contested event each of the 5 years. The types of deadlift employed (e.g., standard deadlift with augmented bar, tire deadlift) varied over the 5-year period but gave a context for the maximal strength of these competitors. Top performances for the various deadlifts during competition ranged from 450.5 to 507.7 kg during the 5-year period. Composite averages were calculated for all strongman competitors (n = 18) across time and are displayed in Table 2. Range data are also displayed, providing insight into the upper limits exhibited by this unique population of athletes. A comparison of how these values equate to age-matched men is presented in Table 3. Although 67% of competitors participated in just 1 or 2 years of testing, 2 competitors completed all 5 years testing. Figure 1 illustrates how body composition and bone density changed for these subjects during consecutive years of training and competition.

Discussion

The primary findings in this study were that strongman competitors at the elite levels of competition exhibit both size and composition profiles representing the upper limits of human adaptation. Structural adaptations are attributed to complex interactions between genetic endowment and environmental factors such as strength and conditioning, nutrition, and possible use of ergogenics (8,15,22). Our data sought to provide a unique glimpse into the adaptive potential of the human organism by documenting the physiological architecture associated with years of maximal mechanical loading.

Body composition and to a lesser extent, bone mineral density (BMD) have been examined in various groups of large-sized male athletes including American football players (3,5,10,21,30), track and field throwers (11,32), boxers (13), rugby players (6,17,26), and heavyweight judo athletes (27). Among these athletes, National Football League (NFL) offensive linemen are reported to be the largest, with an average height of approximately 193 cm and a body mass of 140 kg (4,10,21). Although similar in stature, the average body mass for the elite strongman was 13 kg higher—the largest competitor weighing nearly 40% more than the average NFL lineman. Winwood et al. (38) reported significantly lower body mass in novice strongman athletes, reflecting the structural need for mass in elite competitive strongman performance.

A 2018 study of body composition in large male athletes (2) reported that above a body mass of 90 kg, fat mass appears to increase at a greater rate than lean mass, which places larger athletes at an increased risk of cardiovascular disease and metabolic disturbance. Abe et al. (1) hypothesized that hormonal factors and myostatin expression might contribute to this disparity. Fat mass for elite strongman competitors was similar to reported values for heavyweight judo athletes (27) as well as American football lineman in both Division I collegiate programs (5,30) and the NFL (4,10). Although BMI is known to falsely inflate the risk of obesity in athletic populations because of its inability to distinguish between lean mass and fat mass, it is possible that BF% may *underestimate* obesity risk. Therefore, researchers have begun to express adiposity using fat mass index,

Table 2
Composite profile of strongman competitors (n = 18).*†

	Mean ± *SD*	Range
Age (y)	33.0 ± 5.2	24.2–40.7
Height (cm)	187.4 ± 7.1	175.3–202.7
Body mass (kg)	152.9 ± 19.3	107.9–192.6
BMI (kg·m^{-2})	43.5 ± 4.8	32.6–51.7
Body fat (%)	18.7 ± 6.2	5.9–28.6
Lean mass (kg)	118.0 ± 11.7	97.2–144.1
Fat mass (kg)	30.9 ± 11.1	6.3–44.8
Visceral fat (kg)	2.6 ± 1.4	0.2–5.6
Total BMC (kg)	5.23 ± 0.41	4.31–6.01
BMD (g·cm^{-2})	1.78 ± 0.14	1.66–1.91
Deadlift (kg)	419.5 ± 40.04	325.9–485.7

*BMI = body mass index; BMC = bone mineral content; BMD = bone mineral density.
†Data presented as means ± *SD*s with range: minimum, maximum.

Table 3

Comparison of body composition metrics to normative values for age matched males.*†

	Elite strongman	Normative value*
Body fat (%)	18.7 ± 6.2	25.7 ± 6.25
Fat mass index ($kg \cdot m^{-2}$)	8.64 ± 3.25	6.78 ± 2.77
Lean mass index ($kg \cdot m^{-2}$)	33.40 ± 1.77	19.6 ± 2.54
Total body BMC (g)	5.23 ± 0.41	2.75 ± 0.43
Total body BMD ($g \cdot cm^{-2}$)	1.78 ± 0.14	1.20 ± 0.10

*BMC = bone mineral content; BMD = bone mineral density.

†Normative values were constructed from NHANES DXA data for white men aged 30–35 years (*n* = 241).

a metric which represents body fat as a function of height [fat mass index = fat mass (kg)·height ($m-^2$)]. In this study, strongman competitors exhibited a mean body fat percentage categorized as "fair to good" but presented a fat mass index indicative of obesity (28). The fat mass index was 35% higher than age-matched controls, despite presenting a lower body fat percentage (18). Visceral adipose tissue is another factor closely associated with increased disease risk. In contrast to overall fat mass, average visceral fat of elite strongman competitors was significantly lower than reference values for healthy men (25) but higher than values reported for other large athletes (4,5,27).

Following the trend of body mass, the elite strongman displayed significantly greater lean mass than other elite athletes. Average lean body mass was approximately 23% higher than NFL lineman (4,10), 51% higher than collegiate track and field throwers (11), and 44–57% higher than professional rugby players (6,17,26). Range data provided by a number of studies allowed for further comparison of maximal values. Lean mass of the largest reported lineman was 109 kg (10) compared with 141 kg for the largest strongman, an astonishing 32 kg difference. The degree of lean mass displayed in elite strongman is truly remarkable and emphasizes the dynamic role of environmental factors, such as heavy strength and power training, nutritional intake, and ergogenic supplement use in determining genetic potential. Again, although not part of this investigation and because there was no drug testing as part of the competitions, the influence of anabolic drugs may well influence the magnitude of body composition demographics presented in these profiles.

In the early 1990s, it was hypothesized that bone adapts in response to the forces placed upon it, known as the mechanostat theory (14). Physical training involving high weight-bearing activity provides mechanical stress, resulting in underlying adaptation. In 1993, evidence of resistance training as a potent osteogenic stimulus was reported by Conroy et al. (7). Junior weightlifters displayed dramatically higher BMD than age-matched young men with some locations (spine and femoral neck) even greater than corresponding adult reference ranges. Few measures of bone mineral density have been reported in the literature for high level strength and power athletes. However, in 2000, Dickerman et al. (12) reported the highest BMD to date in a powerlifter, who at the time held the world record in the back squat (469 kg; approximately 4.3 times his body mass of 109 kg). This individual had an average lumbar spine value of 1.859 ± 6.01 $g \cdot cm^{-2}$, which was 155% of the value for a typical 32-year-old man of 1.197 $g \cdot cm^{-2}$. Although regional bone density metrics were not reported in our study of elite strongman, overall BMD was 1.78 $g \cdot cm^{-2}$, leading one to speculate that anatomical locations such as the lumbar spine and femoral neck would likely be even higher. The overall BMD for this group of strongman competitors is the highest reported for male athletes. In comparison, NCAA linemen reported average BMD of 1.58–1.65 $g \cdot cm^{-2}$ (5,30) whereas a case study of an elite shot put athlete reported a maximal BMD of 1.53 $g \cdot cm^{-2}$ (32). A few additional studies report total BMC. Bone mineral content for elite strongman was similar to that reported for NFL lineman (10) and significantly higher than collegiate linemen (30), collegiate throwers (11), and professional rugby players (6,17).

The longitudinal case studies of the 2 athletes who completed all 5 years of testing provide a profound examination of the

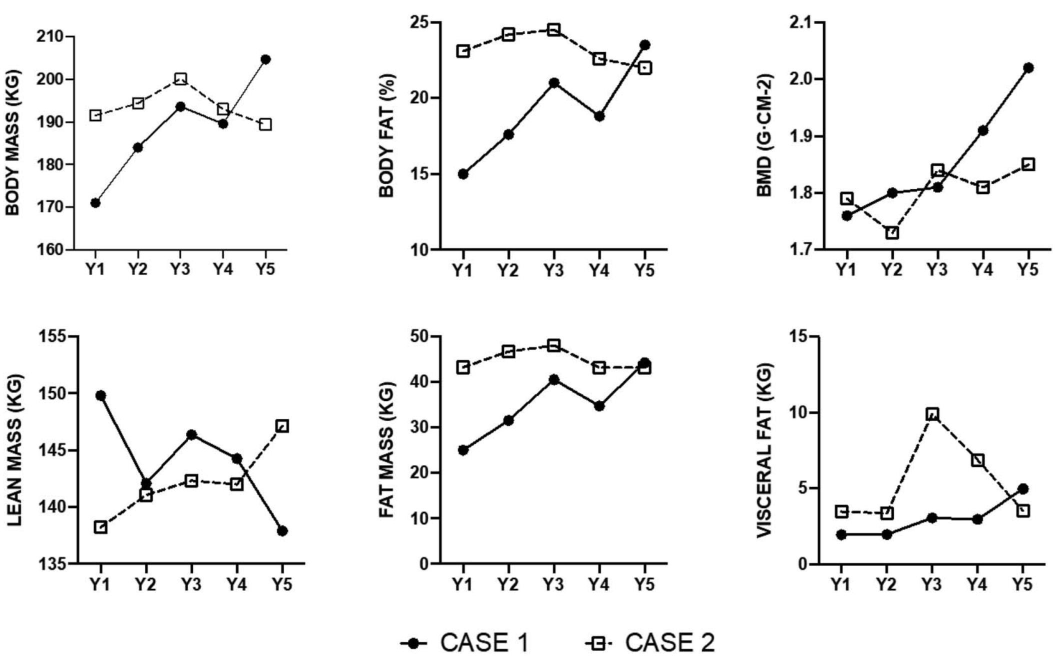

Figure 1. Individual case studies (*n* = 2) for body composition and bone density changes over 5 years of competition.

structural adaptation that occurs with this level of resistance training stimulus. Although peak BMD is expected to occur in late adolescence and decline after the age of 25 years (34), our case studies revealed increases over the 5-year period. Both subjects also showed increases in body mass but divergence with regard to lean mass. Case 1 displayed a 13% increase in body mass, 15% increase in BMD, and 8% decrease in lean mass. Case 2 displayed a 5% increase in body mass, 3% increase in BMD, and 6% increase in lean mass. It is unknown what the individual training goals were for each subject during this observational period and whether composition changes were directed toward improved performance in a particular strongman event. Furthermore, it is impossible to speculate upon the role nutrition, injury, or ergogenics played in the observed changes. It is abundantly clear, however, that even among the largest athletes, structural adaptation is possible.

Practical Applications

Our findings provide a rare glimpse into elite strongman competitors showing that they are among the largest human male athletes in the world and, in some cases, are at the upper limits reported for body size and structure. Such data reflect the enormous amount of lean mass needed to be successful in elite strongman competitions and caution the use of BMI and BF% in assessing obesity risk in highly weight-trained men. Although genetic endowment provides the basis for physiological structure, this unique group of highly strength-trained athletes emphasizes the power of adaptability, pushing the limits not only of human performance but also of human physiology.

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