Sports Science

Age and body stature, handgrip, and strength endurance analyses of elite weightlifters: boosting 1RM bench press

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Abstract - Aim: This study aims to characterize the body stature and age, handgrip, and endurance strength of elite male weightlifters, and ascertain the anthropometric features that can boost IRM bench press. **Methods:** Forty-four elite male weightlifters of different weight categories participated in this study. All participants were members of the Ebonyi state team in Nigeria. We assessed their body weight, height, arm span, arm girth, chest girth, hip girth, thigh girth, handgrip strength, 1RM, time for repetitions (TR), and the number of repetitions (NR) of bench press, using National Strength and Conditioning Association's guidelines. **Results:** 1RM bench press depends on waist and thigh girths, while the speed of bench press was associated with height and arm span of elite weightlifters. 1RM, NR, and TR of bench press depend on age, body weight, and BMI. Consistently, NR of bench press increase with age; range 18, 22 years, and body weight increases with age; range 28, 32 years, while handgrip strength reduces with age; range 38 years and above ($p < 0.05$). **Conclusion:** The strength of association of age, and BMI with strength endurance and 1RM bench press was robust and similar, but inconsistent with handgrip strength. It also suggests that enhancing the musculoskeletal structures of the thigh and waist could boost 1RM bench press while handgrip strength could not but reduces as age advances beyond 38 years.

Keywords: Biomechanics, BMI, age, body composition.

Introduction

The sport of weightlifting is one of the most powerful athletic activities that involve a complex interplay between muscle and skeletal framework. It is regarded as a sport that involves maximum strength as a major factor in determining performance[1]. Body physique contributes to success in sports by offering certain natural advantages and preventing injuries[2]. Power and strength games require coordination, balance, and flexibility for optimal performance in training and competitive settings. Understanding the relationship between strength and body stature is important in maximizing performance and training efficiency[3]. A weightlifting event incorporates some functional movements in different planes of the body that trigger the whole strength and physiological demands of the weightlifter[4]. Therefore, attempts to indicate the body parts that boost uplifting speed, strength endurance, and 1RM bench press are required.

A greater mechanical work is done on the first vertical lift of a barbell than on the second[5-7]. An effective utilization of the power-generating ability of the muscles and handgrip strength contributes to maximum performance in weightlifting and prevents injury[8-10]. Optimal vertical velocity is important for a weightlifter to lift maximal loads, and the duration of pull increases with load[11,12]. The trajectories of barbell propulsion are longer in heavy category weightlifters than in light category[13]. The extent to which age and body mass explain differences in muscular power and grip strength differs for sexes[14-16]: Men have higher grip strength than women across the adult life span. Age and body weight influence physical activities which remain stable in middle age but reduce at old age[17].

The importance of kinematic factors; muscular strength, anaerobic endurance, grip strength, physical stability, and technical mastery, in the snatch and the clean and jerk progression lifts has been the subject of most researches[18]. Other factors that might help weightlifters develop the power to succeed, such as speed and strength endurance analyses have received a little attention. The study aims to characterize the body stature, age, and handgrip strength of elite male weightlifters, and test the hypotheses of association of these features with strength endurance and IRM bench press. It could also explain in part the interplay between the musculoskeletal structures of upper and lower body parts in response to stress resulting from the weight of the barbell and dumbbell. Furthermore, the results of this study could serve as reference

values to characterize the weight class of weightlifters, as the study is the first of its kind in Nigeria.

Materials and methods

Subjects

Forty-four elite male weightlifters participated in this study (Age range; 19 to 51). The participants were members of the Ebonyi state team in Nigeria and belong to the following body weight categories; ≥ 60 kg (n = 7), ≥ 70 kg (n = 12), ≥ 80 kg (n = 15), ≥ 90 kg (n = 6), ≥ 100 kg (n = 4). Only male weightlifters were considered in the study since there was no female team available during the study and due to gender-specific patterns of handgrip and muscular strength. The participants were regular trainees that perform a 1RM bench press as part of a routine fitness test. Strictly, the study adhered to Helsinki's declaration (2013) on ethics of human research, the National Strength and Conditioning Association's guidelines, and training protocol. Alex Ekwueme Federal University Ndufu Alike Ethics committee approved this study with a reference number: AEFUNAI/VOL 2/2345. A written consent was obtained from the participants and those with psychological, congenital malformation, or physical challenges were excluded. The participants were advised to consume stable agricultural products and avoid steroid and hormone pills for bodybuilding.

Experimental procedure

The participants were trained, using a within-subjects design. First, the participants and their coaches were briefed on the objectives and expectations of the study. Second, their body weight, height, arm span, arm girth, chest girth, hip girth, and thigh girth were measured, using a direct standard anthropometric protocol with the aid of a health scale (model RGZ-160, England) and non-stretchable anthropometric tape. All measurements were repeated, with a technical error of measurements < 1%, according to the methods of Winwood et al.[19].

Determination of handgrip strength

The subjects performed a brief 10 min of warm-up exercise, consisting of light stretching, walking, and jogging interspersed with lifting light and a moderate amount of weight, according to the methods of Winwood et al.[19]. Each training session was carefully monitored by the investigators, coaches, and researchers, and the participants were advised to apply maximum effort in all tests. The grip strength of the active hand was measured using a standard adjustable digital handgrip dynamometer (Model: EH101, England) at a standing position with the shoulder adducted, elbow extended, and medially rotated. The subject held the dynamometer freely and put maximum force on it thrice without any support; the average was recorded, as adopted by Koley and Kaur[20].

Determination of the maximum number of repetitions of bench press (NR)

The participants were made to perform as many bench presses as possible using a fixed weight (50 kg); 20 kg weight (barbell) and 15 kg discs placed at the two extremes.

Determination of time for the maximum number of repetitions of bench press (TR)

The time taken for each participant to complete his maximum number of repetitions was measured using a stopwatch (UF0816, I sport, China).

Calculation of speed (m/s): Arm span (m) x No of repetitions/time for maximum number of repetitions (s).

Determination of 1RM bench press

The weight was progressively increased for each participant until the 1RM weight that he could lift was reached.

Calculation of BMI: Body weight (kg)/ Height $(m)^2$

Percentage body fat (%): BMI (1.20) + Age (0.23) - 10.8 - 5.4 Michelle et al.[21].

Statistical analyses

The descriptive statistics and analysis of variance of the anthropometric features, age, handgrip strength, NR, TR, Speed, and a 1RM bench press of the male elite weightlifters were performed in Tables 1 and 2. Furthermore, their age groups were correlated with the anthropo-

Table 1 - Descriptive Statistics of anthropometric, handgrip, and strength endurance characteristics of elite male weightlifters in Ebonyi State team, Nigeria.

Variables	Mean ± SD	Minimum	Maximum
Age (years)	29.94 ± 6.85	19.00	51.00
Body weight (kg)	81.30 ± 12.52	59.00	112.00
Height (m)	1.79 ± 0.07	1.62	1.90
BMI (kg/m^2)	25.41 ± 3.91	17.00	36.16
% Body fat	22.05 ± 5.88	10.41	36.60
Arm girth (m)	0.36 ± 0.04	0.30	0.48
Chest girth (m)	0.98 ± 0.10	0.69	1.22
Waist girth (m)	0.89 ± 0.10	0.69	1.77
Thigh girth (m)	0.62 ± 0.06	0.51	0.74
Handgrip (kg)	47.10 ± 9.55	47.00	57.10
Arm span (m)	1.53 ± 0.02	1.47	1.57
1RM weight (kg)	110.64 ± 30.17	70.00	170.00
Number of repetitions (Endurance)	19.30 ± 4.68	13.00	35.00
Time for repetitions (s)	22.55 ± 4.32	16.00	36.00
Speed (m/s)	1.30 ± 0.12	1.03	1.50

Table 2 - Pearson correlation analysis of anthropometric, handgrip, strength endurance, and 1RM bench press characteristics of elite male weightlifters in Ebonyi State team, Nigeria.

Variables	1RM (kg)		Number of repetitions		Time for repetitions (s)		Speed (m/s) $\frac{\text{arm span (m)} \times \text{number of repetitions}}{\text{Time of repetitions (s)}}$	
	r	p-value	r	p-value	r	p-value	r	p-value
Age (years)	0.568**	0.000	0.362*	0.013	0.337*	0.021	0.259	0.459
Body weight (kg)	0.700**	0.000	0.383**	0.008	0.346*	0.017	0.276	0.103
Height (m)	0.149	0.319	0.117	0.435	0.078	0.603	0.316*	0.908
BMI (kg/m^2)	0.635**	0.000	0.322**	0.023	0.316*	0.031	0.126	0.150
% Body fat	0.603**	0.000	0.311*	0.034	0.346*	0.017	0.061	0.374
Arm girth (m)	0.170	0.144	0.070	0.440	0.085	0.406	0.029	0.089
Chest girth (m)	0.172	0.191	0.130	0.381	0.119	0.454	0.083	0.325
Waist girth (m)	0.496**	0.000	0.219	0.162	0.247	0.108	0.049	0.055
Thigh girth (m)	0.295*	0.012	0.156	0.198	0.239	0.054	-0.103	0.626
Handgrip (kg)	0.055	0.712	0.039	0.793	-0.038	0.798	0.235	0.870
Arm span (m)	0.198	0.153	0.197	0.174	0.184	0.185	0.323*	0.652

* and **Correlation is significant $p < 0.05$ and 0.001 (2-tailed), respectively.

metric variables, handgrip strength, and bench press performance using Pearson correlation (Table 3). Scatter plots were constructed to show how age was related to 1RM, TR, and NR (Figures 1 and 2), and how BMI was related to 1RM, TR, and NR of bench press (Figures 3 and 4). The level of significance was considered at $p < 0.05$. Analyses were performed with the aid of SPSS version 23.0 (SPSS Inc. Chicago, IL)

Table 2 shows that 1RM, the maximum number and time for repetitions depend on age, body weight, BMI, and percentage of body fat. It also shows that the 1RM bench press depends on waist and thigh girths. Speed of bench press was associated with height and arm span of the weightlifter. The association of chest and arm girth and handgrip with 1RM and strength endurance bench press was inconsistent.

Table 3 shows that BMI, body fat, and the number of repetitions increase with age (18 to 22), and weight increases with age (28-32 years) while handgrip reduces with age (38 and above). Other variables failed to correlate with the age groups of the weightlifters.

Results

The descriptive statistics show that the mean age, BMI, 1RM, speed, and the maximum number of repeti-

Table 3 - Correlation of age categories with anthropometric variables, handgrip strength, and bench press performance of male elite weightlifters.

Variables	Weightlifters' age categories (years)				
	Group 1 (19-22) N = 7	Group 2 (23-27) N = 12	Group 3 (28-32) N = 15	Group 4 (33-37) N = 6	Group 5 (38 and above) N = 4
No of subjects					
Weight (kg)	0.858	-0.113	0.521*	-0.088	0.034
Height (cm)	0.646	0.314	0.275	-0.193	0.301
BMI (kg/m^2)	0.910*	-0.353	0.267	0.094	-0.090
% Body fat	0.934*	-0.411	0.307	0.163	0.123
Arm girth (m)	0.130	-0.110	0.025	0.215	-0.411
Chest girth (m)	-0.434	-0.008	0.278	0.554	0.707
Waist girth (m)	0.222	-0.252	0.255	0.144	0.482
Thigh girth (m)	0.490	-0.344	-0.023	0.056	-0.709
Arm span (cm)	0.761	0.302	0.256	-0.306	0.378
Handgrip (kg)	-0.374	0.353	0.167	-0.329	-0.908*
1RM weight (kg)	0.896	-0.252	0.369	-0.004	0.112
No of Repetitions(NR)	0.915*	0.033	0.188	0.008	-0.096
Time for NR (sec)	0.814	-0.059	0.108	-0.140	-0.023

*Correlation is significant $p < 0.05$.

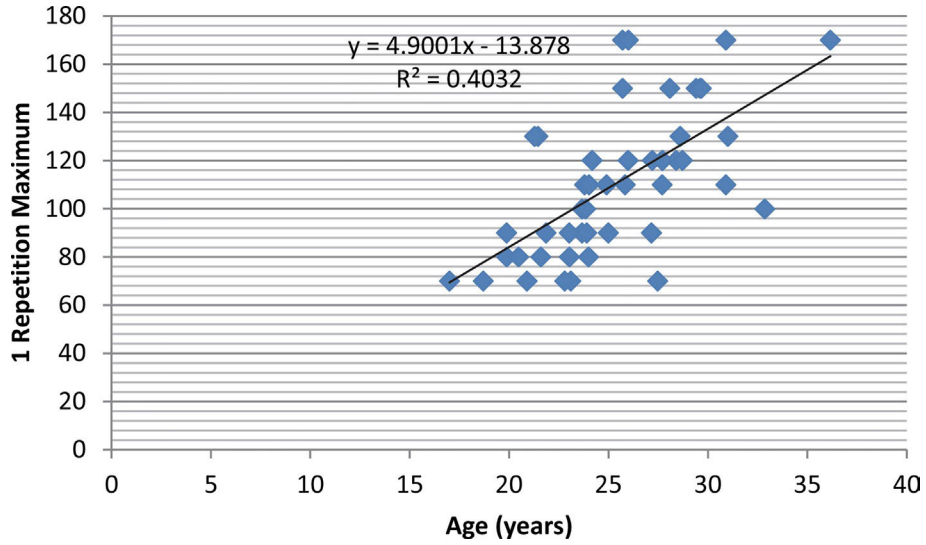

Figure 1 - correlation of I Repetition Maximum with the age of elite male weightlifters in Ebonyi State team, Nigeria, showing linear and positive relationships.

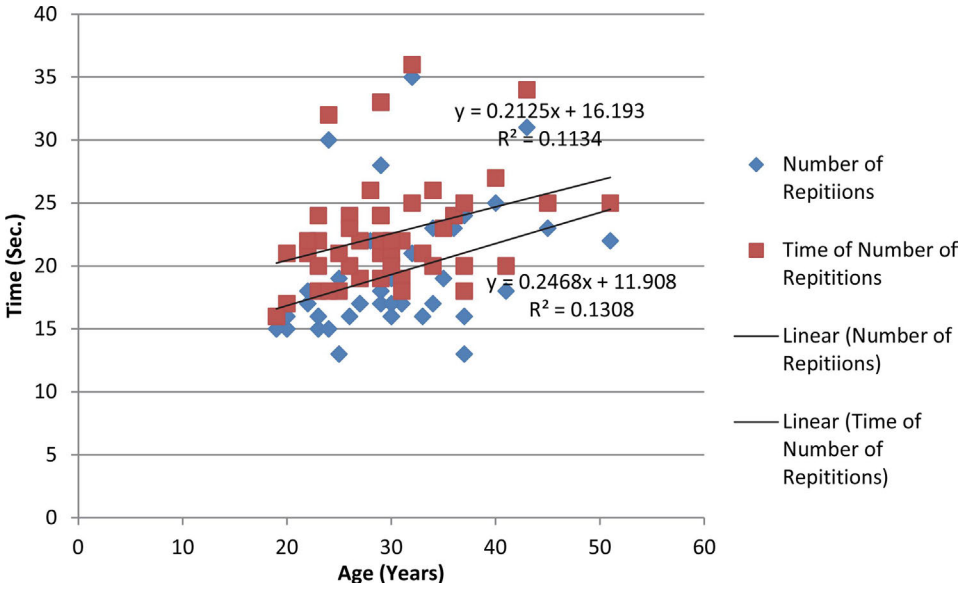

Figure 2 - correlations of number of repetitions and time of repetitions with the age of elite male weightlifters in Ebonyi State team, Nigeria, showing linear and positive relationships.

tions of bench press for the elite male weightlifters in Ebonyi State team Nigeria were 29.94 ± 6.85 years, 25.41 ± 3.91 kg/m^2, 110.64 ± 30.17 kg, 1.30 ± 0.12 m/s and 19.30 ± 4.68, respectively (Table 1). Table 2 shows that 1RM bench press depends on waist and thigh girths, and speed of bench press was associated with height and arm span of the weightlifter. Figures 1-4, and Table 2 show that 1RM and the maximum number or time for repetitions of bench press depend on age, body weight, BMI, and percentage of body fat. Table 3 shows that BMI, body fat, and the number of repetitions increase with age (range; 18, 22 years), and body weight increases with age (range; 28, 32 years) while handgrip reduces with age (38 years and above) ($p < 0.05$). It also shows that the 1RM bench press depends on waist and thigh girths. Speed of bench press was associated with height and arm span of the weightlifter. The association of chest and arm girth and handgrip with 1RM and strength endurance bench press was inconsistent. Table 3 shows that BMI, body fat, and the number of repetitions increase with age (18 to 22), and weight increases with age (28-32 years) while handgrip reduces with age (38 and above). Other variables failed to correlate with the age groups of the weightlifters. Figures 1-3 illustrate the data.

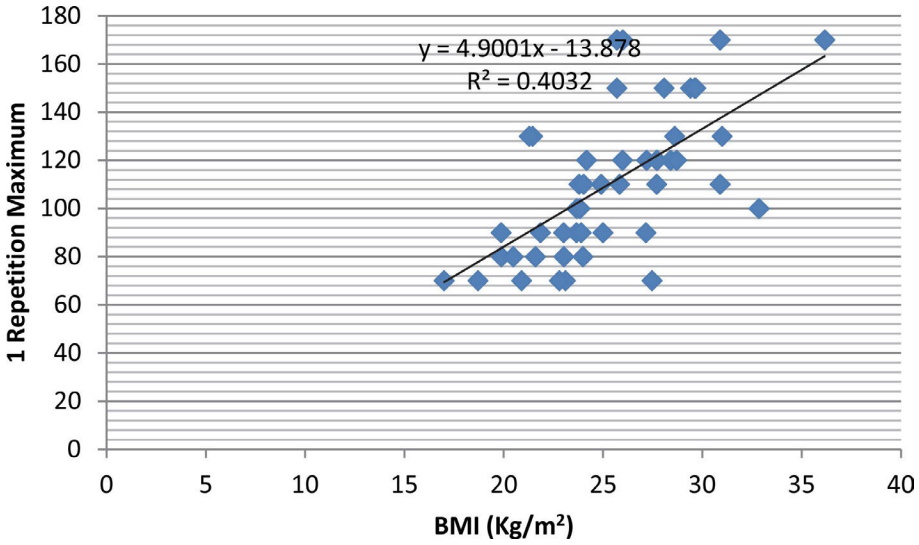

Figure 3 - correlation of I Repetition Maximum with BMI of elite male weightlifters in Ebonyi State team, Nigeria, showing linear and positive relationships.

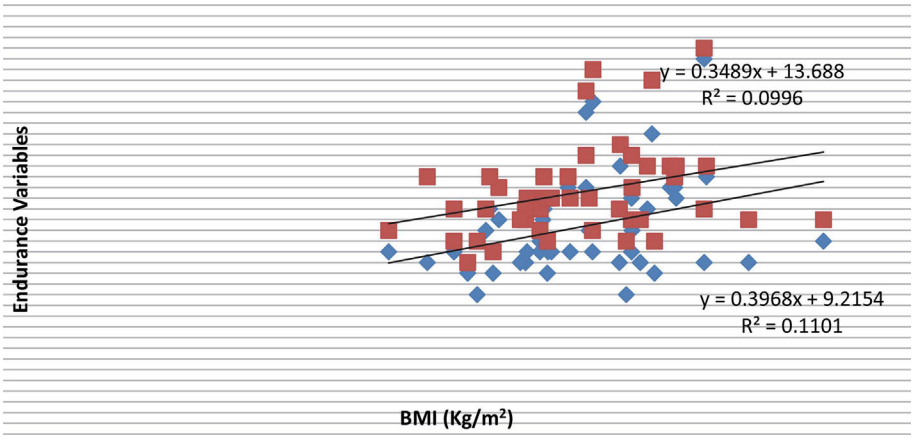

Figure 4 - correlations of the number of repetitions and time of repetitions with BMI of elite male weightlifters in Ebonyi State team, Nigeria, showing linear and positive relationships.

Discussion

Most likely, identifying the anthropometric feature that boosts up handgrip and endurance strength in power events could introduce a paradigm in training techniques and methods. Sacrificing proper technique in favor of lifting a large amount of weight, regardless of age and exact muscle that requires strength and enhancement can increase the risk of injury. Ebonyi State weightlifting team in Nigeria had an excellent performance in the just concluded 2021 National Sports Festival in Nigeria. Interestingly, one of the participants participated in the 2020 Olympic Games. In our locality, there is no standard protocol to boost uplifting speed, strength endurance, and a 1RM bench press for weightlifters. Specifically, we boost the muscle thickness of weightlifters through daily brief exercise interspersed with the lift of light to moderate load, followed by a 1RM bench press. One repetition maximum (1RM) has been a prime indicator of upper-body strength, and athletes desire to lift as much weight as possible, repeatedly[22]. Relying on the above proposal, muscle enhancing medications and exercise are used sometimes, targeting to boost the upper limb muscles of weightlifters[23-25].

Conversely, the anthropometries of the musculoskeletal structures of a lower-body region of elite weightlifters; waist girth, and thigh girth did correlate with 1RM bench press, but chest and arm girth did not. Moreover, the speed for repetitions of bench press was associated with the body height and arm span of the elite weightlifters. Similarly, Windwood et al.[19] suggested that tall individuals with long limbs require more muscular work and torque to lift a given load than individuals with short limbs. Likewise, Ford et al.[24] and Keogh et al.[25] suggested

that relatively short arm span and body height with an accumulation of muscular mass in the upper and lower limb, especially in the arm could enhance weightlifting. Therefore, it implies that enhanced muscle mass built especially, around the waist and thigh could reinforce and stabilize the upper body strength of weightlifters during the bench press.

Specifically, it implies that the lower limbs, trunk, and upper limbs regions serve as a medium for the flow of kinetic energy between the bench and barbell during the bench press. It also suggests that the lower body region contributes to 1RM and the muscular endurance of weightlifters during the bench press. Similar to the studies of Avela et al.[26]; Arnold et al.[27], it suggests that contraction of muscles of the lower limb and trunk could elicit stretch reflexes that transfer elastic energy to the joints and extensor muscles of upper limbs during the bench press. Therefore, a weightlifter should boost the musculoskeletal structures of the upper and lower body regions to overcome the inertia and downwards thrust of the barbell. The ability to withstand shear forces produced during weightlifting could depend on the amount of bone and muscle mass of the weightlifter[25,28-29].

Interestingly, Kim et al.[22] and Mayhew et al.[30], extensively illustrated the relationship between BMI and 1RM bench press. Similarly, an increase in age and BMI; body weight but not body height could boost 1RM bench press (Table 2, Figures 1 and 3) and strength endurance (Figures 2 and 4). The results also suggest that increments in BMI and number of repetitions of bench press at age 18 to 22 and that of body weight between age 28 and 32 years were consistent (Table 3). Like the result of Angst et al.[31]; Nahhas et al.[32]; Forest et al.[33], there was a significant reduction in handgrip strength with increasing age from 38 and above. Similarly, men have higher grip strength than women across the adult life span, which tends to peak around 30-40 years of age and then decreases with advancing age in both sexes[34-36]. Noteworthy, it takes 18 - 23 years for long bones of upper and lower limbs to ossify, completely. Considering the age, it is pertinent to emphasize proper technique capable of reducing the risk of injury to the growing bones and muscles and lifting a relatively large amount of weight[35].

According to Foo[37], Bohannon et al.[38], Sternang et al.[39], handgrip strength has been an indicator of the overall body strength of an individual. Contrarily, the association of handgrip strength and speed, 1RM, or several repetitions of bench press of the elite weightlifters was inconsistent. Although handgrip strength reduces as age advances (Table 3), its negative value of correlation coefficient with the time for and the number of repetitions of bench press suggests that it may enhance the speed of bench press (Table 2). Handgrip strength could be helpful in technical and tactical manipulations of the hands during lifting of barbell and transfer of energy to the barbell during bench press[18]. Most likely, it could require a biomechanical analysis of joints, intrinsic and extrinsic muscles of the hand, to determine the relationship between handgrip, strength endurance, and 1RM bench press.

Conclusion

The strength of association of age, and BMI with strength endurance and 1RM bench press was robust and similar but inconsistent with handgrip strength. The study also suggests that enhancing the musculoskeletal structures of the thigh and waist could boost 1RM bench press while handgrip strength could not but reduces as age advances beyond 38 years.

Limitation of the study

The study could not consider the biomechanics of the human body framework during the bench press. The sample was all-male, since there was no female team of elite weightlifters in Ebonyi State during the study, albeit hindering comparative analysis of gender-specific factors. The sample size was limited to male elite weightlifters in Ebonyi State.

Practical implication

This study basically explained how age, body physique, and handgrip strength affect lifting speed, strength endurance, and 1RM during the bench press. It revealed that Age, body weight, thigh and waist girths, and handgrip strength of an elite weightlifter could confer a competitive advantage during the bench press. Strength endurance and 1RM bench press are indicators of power to succeed and should be considered an effective push and proper training techniques for weightlifters. The above suggestions should be useful to strength and conditioning coaches for talent identification.

Conflict of interest

The authors declare no conflict of interest.

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