Niğde Ömer Halisdemir Üniversitesi
Spor Bilimleri Fakültesi
BEDEN EĞİTİMİ VE SPOR BİLİMLERİ DERGİSİ

Araştırma Makalesi

GENÇ VE BÜYÜK HALTERCİLERDE KUVVETİN ALLOMETRİK ANALİZİ

ALLOMETRIC ANALYSIS OF STRENGHT OF THE YOUTH AND SENIOR WEIGHT LIFTERS

Gönderilen Tarih: 08/11/2024
Kabul Edilen Tarih:18/12/2024

Ayşegül YAPICI
Pamukkale Üniversitesi Spor Bilimleri Fakültesi, Denizli, Türkiye
Orcid: 0000-0003-4243-5507

* Sorumlu Yazar: Ayşegül YAPICI, Pamukkale Üniversitesi Spor Bilimleri Fakültesi, E mail: ayapici@msn.com

Genç ve Büyük Haltercilerde Kuvvetin Allometrik Analizi

ÖZ

Halter, kuvvet ve güç sporu olarak tanımlanır. Halterde iyi bir bir fizyolojik profil için; kas kuvveti, esneklik, kas gücü ve kaldırış tekniğinin kombinasyonu önemlidir. Bu çalışmanın amacı, dünya halter şampiyonasına katılan haltercilerin gençler ve büyükler kategorisinde elde edecekleri toplam reytinglerdeki derecelerinin allometrik analiziyle karşılaştırılmasıdır. 86. Erkekler Avrupa Büyükler Şampiyonası ve 5. Erkekler Avrupa Gençler Şampiyonası verileri kullanıldı. Veriler Avrupa Halter Federasyonunun resmi internet sitesinden (http://www.ewf.sm) alınmıştır. Büyük erkekler Avrupa şampiyonası için 8 vücut ağırlığı sınıfı (56, 62, 69, 77, 85, 94, 105, +105 kg) ve genç erkekler Avrupa şampiyonası için 8 vücut ağırlığı sınıfı (50, 56, 62, 69, 77, 85, 94, +105 kg). Kaldırılan iki ağırlığın toplamı (koparma ve silkme) dikkate alındı. Her Avrupa şampiyonasında her sıklet kategorisinden en iyi 5 derece seçildi. Yaş (40 genç halterci) ve (40 büyük halterci) arasında istatistiksel olarak anlamlı farkı vardı (p<0.05). Büyük halterci ile genç halterci arasında vücut kütlesine bağlı olarak kaldırılan iki ağırlık değerinin toplamı açısından da anlamlı kuvvet farklılıkları bulundu (p<0.05). Büyük ve genç haltercilerde vücut kütlesi ile kaldırılan iki ağırlığın bağıl toplamı arasında negatif anlamlı korelasyonlar bulundu (p<0.05). Sonuç olarak, sportif performansta vücut büyüklüğü ölçümleri ile vücut kütlesi başına düşen oran arasındaki ilişkinin doğru şekilde tanımlanamadığı düşünülmektedir. Bu nedenle bu çalışmada vücut kütle etkilerini ortadan kaldırmak için, allometrik ölçeklendirme yöntemi kullanılmıştır.

Anahtar Kelimeler: Halter, allometrik analiz, performans

Allometric Analysis of The Strength of Youth and Senior Weightlifters

ABSTRACT

Weightlifting is defined as a sport of strength and power. For a good physiological profile in weightlifting, muscle strength, flexibility, muscle power, and lift combination of techniques is important. This study aimed to compare the allometric analysis of degrees of weightlifters in the total rating to obtain in the category of youth and seniors who participated in the world weightlifting championship. Data from the 86th Men's European Senior Championships and 5th Men's European Youth Championships were employed. Data was obtained from the official website of the European Weightlifting Federation (http://www.ewf.sm). There were 8 body-weight classes for senior men European championships (56, 62, 69, 77, 85, 94, 105, +105 kg) and 8 body-weight classes for youth men European championships (50, 56, 62, 69, 77, 85, 94, +105 kg). The sum of two weights lifted (snatch, clean, and jerk) were considered. At each European Championships, the best 5 degrees from each weight category were selected. There was significant age (40 youth weightlifters) and (40 senior weightlifters), mean age differences were found (p<0.05). Significant strength differences were also found between the senior weightlifter and the youth weightlifter for the sum of two weights lifted values related to body mass (p<0.05). Negative significant correlations were found between body mass and the relative sum of two weights lifted values for senior and youth weightlifters (p<0.05). As a result, it is thought that the relationship between body size measurements and the ratio per body mass in athletic performance cannot be accurately defined. For this reason, the allometric scaling method was used to remove the body mass effects.

Keywords: Weightlifting, allometric analysis, performance

INTRODUCTION

Weightlifting performance is determined as the most important feature of the athlete’s physical and physiological parameters such as power and muscular strength. Olympic weightlifting and powerlifting are competitions of muscular strength and power wherein lifters are in different weight categories to ensure equal competition[1]. Olympic weightlifting gives to the total weight lifted in the snatch and clean and jerk events, this then determines the athletes’ lifting weights and ranking[2]. Weightlifting is a branch where the highest weight lifted in the snatch and clean and jerk category is calculated. Weightlifting movement types should be designed in a way that preserves and improves the athlete's force-speed balance. Coaches may use specific weightlifting movements according to their biomechanics and motoric properties during specific training phases. A combination of weightlifting variants can be applied to improve the athlete's force-velocity profile[3]. Weightlifting can achieve much greater mechanical power outputs[4]. Therefore, weightlifters can produce more force and power than other athletes with similar training experience[5]. Power as in many branches the combination of strength and speed is important in increasing performance in weightlifting. Therefore, to produce force and other associated motor characteristics, the force development rate is integral to power production. Therefore, it is a key component in determining athletic success[6,7].

The strength applied in two different lifting techniques in weightlifting is related to body weight. Age and weight differences in athletes, and therefore the differences in power produced, are linked to the relationship between muscle cross-sectional area and muscle strength. Athletes with a higher body surface area have a larger muscle cross-sectional area than athletes with a smaller body surface area, and the force produced is greater[8]. Athletes with less body surface area will generate higher levels of maximum force per kilogram (strength/body mass) than larger athletes, provided the balance of proportions in the body is likely to remain stable. Comparing the performances of weightlifters, competing in different weight classes is important for organizing training programs, especially strength training. In weightlifting, multiple resistance training programs based on strength and power are applied for large muscle groups of the lower and upper extremities. It depends on the athlete's leg and hip strength to generate a large ground reaction force in a short time. Additionally, power-load and power-velocity curves can be used as distinguishing factors for skilled weightlifters. In measurements made on professional weightlifters, compared to beginners; differences depending on body size are more pronounced[9,10]. It is important to determine the performances of weightlifters competing at different body weights in different techniques. Different scaling methods are used to determine whether body weight affects athletic performance. One of the scaling methods is to divide the score obtained by the athlete's body weight. This method gives the athlete's body weight ratio and compares the amount of force per kilogram. In allometric modeling, the ratio of the athlete's lifting performance (y) to body mass (x) is determined and the formula is; $y = a\ x\ b$, a and b in the formula are constants[1]. This scaling system is calculated with logarithmically transformed dependent and independent variables; the least squares regression method is used in the formula ($\ln y = \ln a + b \ln x + \ln e$). This method has been applied to three sets of data involving adults and children[11-14].

MATERIAL AND METHODS

Subject

Data from 86th Men's European Senior Championships (14-22 Apr. 2007, FRANCE / STRASBOURG) and 5th Men's European Youth Championships (26 Aug. – 2 Sep. 2007, ITALIA / PAVIA) were employed. Data obtained from the official website of the European Weightlifting Federation (http://www.ewf.sm)[15]. There were 8 body-weight classes for senior men European championships (56, 62, 69, 77, 85, 94, 105, +105 kg) and 8 body-weight classes for youth men European championships (50, 56, 62, 69, 77, 85, 94, +105 kg). The sum of two weights lifted (snatch, clean, and jerk) were considered. At each European Championships, the best 5 degrees from each weight category were selected. The possible risks of the study were explained to the subjects and the volunteer consent form was signed. For the research, ethics committee permission was received from the Non-Interventional Clinical Research Ethics Committee within Pamukkale University to conduct the study (24.10.2024, Decision No: 8).

Statistical Analyses

SPSS 22.0 for Windows program was used for data analysis. Allometric analyses were used for this study. The allometric relationship between body surface area and the sum of two weights lifted is based on the allometric equation below.

- $y = a x^{b}$
- using this equation, we took log-transformed to dependent and independent variables.
- $\ln w = \ln a + b \ln m + \ln \epsilon$

Where w is the sum of two weights lifted (kg), m is body mass, b is the exponent, a is the proportionality coefficient, and є is multiplicative error data. An allometric model was built up for independent variables which to become common b exponent for each group. Firstly, the allometric model was linearized by taking the natural logarithms of each side. After this, we added group variables (G) (for senior weightlifters (0) code and youth weightlifters (1) code) and the group interaction term (G x ln m) on this model.

- $\ln w = \ln a + d (G \times \ln m) + c G + b \ln m + \ln \epsilon$

RESULTS

According to the independent-samples t-test, there were significant ages (40 youth weightlifters, mean age 16,45 ± 0,81 years old, and 40 senior weightlifters, mean age 25,67 ± 4,20 years old) differences were found ($p<0.05$). Significant strength differences were also found between the senior weightlifter and the youth weightlifter for the sum of two weights lifted values related to body mass ($p<0.05$; Table 1).

Table 1. Body Mass-Related Differences in Strength Values

Variables	Senior Weightlifters	Youth Weightlifters	t
Age (year)	25,67 ± 4,20	16,45 ± 0,81	13,61*
Sum of two weights lifted / Body Mass (kg)	4,25 ± 0,50	3,73 ± 0,39	5,14*

Table 2. Relationships Between Relative Strength Values and Body Mass for Weightlifters

Variable	Senior Weightlifters	Youth Weightlifters
	Body Mass (kg)	Body Mass (kg)
Lifting Weight / Body Mass	-0,93*	-0,86*

In this study, according to the Pearson Product Moment Correlation, Negative significant correlations were found between body mass and the relative sum of two weights lifted values for senior and youth weightlifters ($p<0.05$; Table 2).

Table 3. Differences in Allometric Scaling Strength Values Between Senior and Youth Weightlifters

Variable	Senior Weightlifters	Youth Weightlifters	t
Allometric scaling sum of two weightslifted (kg)	23,57 ± 1,38	19,78 ± 1,36	12,35*

Significant allometric scaling strength differences were also found between the senior weightlifters ($p<0.05$; Table 3).

DISCUSSION

This study investigated strength differences between senior and youth weightlifters within an allometric framework. 8 weight categories from senior and youth weightlifters of whom the best 5 degrees from each weight category in the European Weight-Lifting Championships were considered in this study. It is shown that significant strength differences were found between the senior weightlifter and the youth weightlifter for the sum of two weights lifted values related to body weight ($p<0.05$; Table 1). Weber et al. (2006)[16] reported that ratio scaling caused the absolute power data to be overcorrected for body mass. Thus, lighter participants have some advantages for higher power values. On the contrary heavier participants have some disadvantages for lower power values. The athlete's performance during development; It is thought that the weight lifted per body weight does not accurately reflect the ratio between body surface area measurements[17,18]. When strength values (sum of two weights lifted) related to body mass and correlated with body mass, we found a significant negative relationship (-0,93 for senior weightlifters; -0,86 for youth weightlifters) between relative strength characteristics and body mass for weight lifters (Table 2). For this reason, we used an allometric scaling method to remove the body mass effects. Some researchers investigated the allometric scaling method in detail and found that the allometric scaling method provides a more appropriate model when performance variables are related to body mass[16,17,19,20]. Batterham and George (1997)[21] applied this model for men and women weight lifters and their model included the sum of the weights lifted by the athletes who qualified in the "snatch" and "clean and jerk" branches of the men's and women's world weightlifting championships. Firstly, these researchers used allometric relationships between the sum of the “snatch” and “clean and jerk” lifts and body weight was obtained with logarithmic values of absolute data and investigated normality of the log-transformed variables with the Kolmogorov-Smirnov one-sample test.

As we revealed log-transformed dependent and independent variables and allometric model residuals via Kolmogorov-Smirnov one-sample test, we found that all the variables were normally distributed. The allometric scaling method was derived from common b exponents for independent variables of each group. When the data was analyzed, we found the separate allometric model for senior weightlifters is: T = 22,64 W ^{0,61} and for youth weightlifters is: T = 19,10 W ^{0,61}, respectively. Welsman and Armstrong (2000b)[18] reported that the body size exponents produced for performance values, depending to mostly depend on factors such as sample variables. When strength values were scaled allometrically, there were significant strength differences found between senior (23,57 ± 1,38 kg) and youth (19,78 ± 1,36 kg) weightlifters (Table 4).

CONCLUSION

As a result, the true relationship between simple ratios per unit body mass and the athlete's performance may not always be appropriately defined. It may affect athletes' body mass measurements and performance parameters. Therefore, in this study, the allometric scaling method was used to eliminate body mass effects.

REFERENCES

1. Cleather DJ. (2006). Adjusting powerlifting performances for differences in body mass. Journal of Strength and Conditioning Research. 20(2), 412-421.
2. McGuiagan MR., Kane MK. (2004). Reliability of performance of elite olympic weightlifters. Journal of Strength and Conditioning Research. 18(3), 650-653.
3. Chiu L., Schilling B. (2005). A primer on weightlifting: From sport to sports training. The Journal of Strength & Conditioning Research. 27(1), 42-48.
4. Funato K., Kanehisa H., Fukunaga T. (2001). Differences in muscle cross-sectional area and strength between elite senior and college Olympic weight lifters. The Journal of Sports Medicine and Physical Fitness. 40(4), 312-318.
5. McBride J., Triplett-McBride T., Davie A., Newton R. (1999). A comparison of strength and power characteristics between power lifters, Olympic lifters, and sprinters. The Journal of Strength & Conditioning Research. 13(1), 58-66.
6. Stone MH., O'Bryant HS., McCoy L., Coglianese R., Lehmkuhl M., Schilling B. (2003). Power and maximum strength relationships during performance of dynamic and static weighted jumps. The Journal of Strength & Conditioning Research. 1, 140-147.
7. Stone M., Pierce K., Sands W., Stone M. (2006). Weightlifting: a brief overview. National Strength and Conditioning Association. 28(1), 50-66.
8. Ford LE., Detterline JA., Kevin KHO., Wenyuan CA. (2000). Gender- and height-related limits of muscle strength in world weightlifting champions. Journal of Applied Physiology. 89, 1061-1064.
9. Darveau CA., Suarez RK., Andrews RD., Hochachka PW. (2002). Allometric cascade as a unifying principle of body mass effects on metabolism. Nature. 417(6885), 166-170.
10. West GB., Savage VM., Gillooly J., Enquist BJ., Woodruff WH., Brown JH. (2003). Why does metabolic rate scale with body size? Nature. 713.
11. Batterham AM., Tolfrey K., George KP. (1997). Nevill’s explanation of Kleiber’s 0.75 mass exponent: an artifact of collinearity problems in least squares models? Journal of Applied Physiology. 82, 693-697.
12. Kabitsis C., Nevill AM. (1992). Power output during arm cycling and its relationship to body size and throwing performance. Journal of Sports Science. 10, 568-569.

13. Nevill AM. (1994). Evidence of an increasing proportion of leg muscle mass to body mass in male adolescents and its implication on performance. Journal of Sports Science. 12, 163-164.
14. Welsman JR, Armstrong N, Nevill AM, Winter EM, and Kirby BJ. (1996). Scaling peak VO2 for differences in body size. Medicine Science and Sports Exercise. 28, 259-265.
15. http://www.ewf.sm [Erişim tarihi 09.09.2024].
16. Weber CL., Chia M., Inbar O. (2006). Gender differences in anaerobic power of the arms and legs-a scaling issue. Medicine Science and Sports Exercise. 38(1), 129-137.
17. Welsman JR, Armstrong N. (2000). Longitudinal changes in submaximal oxygen uptake in 11- to 13-year-olds. Journal of Sports Sciences. 18, 183-189.
18. Welsman JR, Armstrong N. (2000). Longitudinal changes in young people's short-term power output. Medicine Science and Sports Exercise. 32(6), 1140-1145.
19. Nevill A., Tsiotra G., Tsimeas P., Koutedakis Y. (2009). Allometric associations between body size, shape, and physical performance of Greek children. Pediatric Exercise Science. 21(2), 220-232.
20. Nevill AM., Holder RL., Jones AB., Round JM., Jones DA. (1998). Modeling developmental changes in strength and aerobic power in children. Journal of Applied Physiology. 84, 963-970.
21. Batterham AM., George KP. (1997). Allometric modeling does not determine a dimensionless power function ratio for maximal muscular function. Journal of Applied Physiology. 83, 2158-2166.