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Hand Grip Strength as a Marker of Physical Fitness and Its Association to Body Symmetry in Young Adults: An Anthropological Approach

Genç Yetişkinlerde Fiziksel Uygunluğun Bir Göstergesi Olan El Kavrama Kuvvetinin Bedensel Simetri ile İlişkisi: Antropolojik Bir Yaklaşım

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Abstract

Some research in the field of anthropology provides some evidence that higher hand grip strength and a symmetrical body are reliable indicators of health and fitness. In this study, we consider the relationship between these two indicators in healthy young individuals. In the study, 185 university students (87 males and 97 females) were examined. In addition to the weight and height of the students, eight bilateral traits were measured with an accuracy of 0.01 mm to evaluate their bodily symmetry, and their hand grip strength was determined with a hand dynamometer by applying the Southampton protocol. The composite fluctuating asymmetry formula was used to standardize the bodily symmetries of individuals. Analyzes show that women have a more symmetrical body structure and lower hand grip strength scores than men. When the effect of weight and body mass index was controlled, no correlation was observed between composite fluctuating asymmetry and hand grip strength in both sexes. As a conclusion, contrary to the literature results, it is seen that there is no significant relationship between hand grip strength and body symmetry, which are accepted as reliable indicators of health and physical fitness. In addition, our findings support the view that fluctuating asymmetry is not a reliable indicator to predict an individual's physical fitness and developmental quality.

Keywords: Developmental Instability, Body Symmetry, Physical Fitness, Hand Grip Strength.

Öz

Antropoloji alanında yürütülmüş bazı araştırmalar, yüksek el kavrama kuvvetinin simetrik bir vücudun, sağlık ve fiziksel uygunluğun güvenilir göstergeleri olduğuna dair bazı kanıtlar ortaya koymaktadır. Bu çalışmada sağlıklı genç bireylerde bu iki gösterge arasındaki ilişkiyi ele alıyoruz. Araştırmada 185 üniversite öğrencisi (87 erkek ve 97 kadın) incelenmiştir. Öğrencilerin vücut simetrilerini değerlendirmek için ağırlık ve boylarının yanı sıra 0.01 mm hassasiyetle sekiz bilateral karakter ölçülmüş ve Southampton protokolü uygulanarak el dinamometresi ile el kavrama kuvvetleri belirlenmiştir. Bireylerin vücut simetrilerini standardize etmek için bileşik dalgalı asimetri formülü kullanılmıştır. Analizler, kadınların erkeklere göre daha simetrik bir vücut yapısına ve daha düşük el kavrama kuvvetine sahip olduğunu göstermektedir. Ağırlık ve beden kitle indeksinin etkisi kontrol altına alındığında ise her iki cinsiyette de bileşik dalgalı asimetri ile el kavrama kuvveti arasında bir ilişki gözlenmemiştir. Sonuç olarak, alan yazın bulgularının aksine sağlık ve fiziksel uygunluğun güvenilir göstergeleri olarak kabul edilen el kavrama kuvveti ve vücut simetrisi arasında anlamlı bir ilişki olmadığı görülmektedir. Ayrıca bulgularımız, dalgalı asimetrinin bireyin fiziksel uygunluğunu ve gelişim kalitesini tahmin etmek için güvenilir bir gösterge olmadığı görüşünü de desteklemektedir.

Anahtar Kelimeler: Gelişimsel İstikrarsızlık, Beden Simetrisi, Fiziksel Uygunluk, El Kavrama Kuvveti.

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Hand Grip Strength as a Marker of Physical Fitness and Its Association to Body Symmetry in Young Adults: An Anthropological Approach

Hand grip strength [HGS], measured with a hand dynamometer, provides an easy and reliable measurement of muscle strength in humans. It is known that HGS, also known as upper body strength, is associated with many parameters such as early mortality (Soysal et al., 2021), cognitive decline in the elderly (Taekema et al., 2010) cardiovascular diseases (Laukkanen et al., 2020) and lengthier stay following hospitalization or surgery (Bohannon, 2008). In addition, it is claimed that individuals with low HGS scores are more prone to depression (Marconcin et al., 2020), anxiety (Gordon et al., 2019), and suicidal ideation (Cao et al., 2020).

The highest HGS scores are observed between the ages of 24-39, and a significant decrease in HGS with aging is noted (Mathiowetz et al., 1985). Although this decrease is more pronounced in men than in women, men have higher HGS scores than women at any age. Sexual dimorphism observed in HGS is quite high even when height and body mass are controlled in men. According to some experts, this condition is associated with high androgen levels in men. (Page et al., 2005). Although clinical studies on populations, diet and some hand exercises are known to have an effect on grip strength (Cima et al., 2013; Norman et al., 2011), grip strength has an average heritability of 65% even when the effects of some variables such as height, weight, age are excluded (Reed et al., 1991). Insomuch that, the effect of exercise on grip strength is negligible in the elderly (Tieland et al., 2015). The heritability estimate of HGS is also largely sexual dimorphic. Isen et al. (2014) showed that, the absolute genetic variance observed in HGS is approximately nine times higher in boys than in girls. This striking difference shows that the developmental processes that shape upper body growth differ between the sexes. Studies involving adolescents and young adults reveal that HGS can be a strong health indicator even at an early age. For this reason, HGS values detected at an early age can help predict the future health status of the individual (Cooper at al., 2010; Sasaki et al., 2007).

In addition to hand grip strength, bilateral symmetries observed in physical characteristics are considered as one of the reliable indicators of the general health status and genetic quality of the individual. Fluctuating asymmetry [FA] is random and small asymmetrical deviations in bilateral organs, and this pattern of asymmetry is thought to reflect an individual's developmental stability (Palmer & Strobeck, 2003). Developmental stability refers to an individual's capacity to produce a well-developed, symmetrical phenotype in the face of stresses such as diseases, parasites, and toxins. A review by Thornhill and Møller (1997) reveals that, fluctuating asymmetry on average across various biological taxa are related to measures of stress, fitness, health and quality (e.g. reproductive success). Studies in humans showed that symmetrical individuals are taller, healthier, and more physically attractive. However, increased asymmetries have been documented in some studies to be associated with consanguineous marriage, mental illnesses, increased aggression, low birth weight, autoimmune diseases, malnutrition, and parasitic diseases (Özener, 2022). Some studies show that older men with lower FA levels have higher intelligence and higher cognitive abilities (Penke et al., 2009).

The relationships between hand grip strength and fluctuating asymmetry have attracted the attention of some researchers for the reasons mentioned above (Fink et al., 2014; Sim, 2013; Van Dongen, 2014; Van Dongen & Sprengers 2012). However, the findings of these few studies, all of which were conducted on Western societies are inconsistent. In this study, the relationship between hand grip strength and fluctuating asymmetry is discussed in a non-Western sample. Our hypothesis is that individuals with more symmetrical bodies (especially males) should be physically stronger.

Material and Methods

Sample

The recommended minimum sample size for fluctuating asymmetry studies is 40 (Graham, 2021). This study was conducted on 185 students, 87 of whom were males (%47) and 97 were females (%53), studying at Istanbul University in Istanbul. The students who agreed to participate in the study were invited to the Department of Anthropology and the informed consent form was filled out. The weight and then the height of the students who filled out the information in the anthropometry questionnaire were measured according to the procedures recommended by the International Biological Program (Weiner & Lourie, 1969). All procedures used in this study were approved by the ethics committee of the İstanbul University.

Hand Grip Strength Measurements

Hand grip strength was measured using a CAMRY EH-101 digital dynamometer and the values were recorded in kilograms (Huang et al., 2022; Tai et al., 2022). Before the hand grip strength measurement, individuals were asked whether they had any discomfort in their upper extremities and whether they had any chronic diseases that could affect muscle strength. Participants with disorders thought to affect muscle strength were not included in the sample. Hand grip strength is higher in people who do some professional sports than those who do not (Cronin et al., 2017; Fallahi & Jadidan, 2011). Therefore, the data of the participants who were professionally involved in sports were excluded from the analysis.

Southampton protocol was applied for the measurement of grip strength (Roberts et al., 2011). In accordance with this protocol, participants were seated in a chair with a fixed armrest with back support, and their forearms were kept at a 90-degree angle relative to their upper body. Since it was aimed to maximize the score to be obtained, the grip part of the dynamometer was adjusted to the most comfortable position considering the size of the participant's hand. When the participant reported that he/she felt ready, he/she was asked to squeeze the device with his last strength. In this process, the participant was encouraged to verbally squeeze harder in order to get the maximum score from the participant (Jung & Hallbeck, 1999). When the increase in the indicator score of the device began to decrease, the measurement was terminated and the other hand was passed. The same procedure was performed three times for each hand, and the highest reading was recorded as the maximum grip force.

Bilateral Measurements

In order to determine the bodily symmetry of the individuals examined in this study, 8 bilateral traits were measured: hand length, hand width, second finger length, third finger length, fourth finger length, ear length, ear width and elbow width. A digital caliper measuring with an accuracy of 0.01 mm was used for the measurements. Bilateral data were obtained using the blind measurement technique. First, measurements from the right side of the body were taken in the order listed above. Then data were collected from the left side in the same manner. For the second set of measurements this exact procedure was repeated without referring to the prior data (Palmer & Strobeck, 2003).

Fluctuating Asymmetry Analysis

Before the fluctuating asymmetry analysis; measurement error analysis, directional asymmetry analysis and size dependence analysis were performed. Then, it was checked whether the sign asymmetries (i.e. R-L) were normally distributed.

For measurement error analysis, 80 (40 males, 40 females) individuals were measured twice and two-way mixed-model ANOVA was used (Palmer & Strobeck, 2003). In this test, individuals as random and sides were used as fixed factor. Mixed model ANOVA results showed that the measurement error variance was significantly lower than the asymmetry variance for all traits (Hand length: $F_{1,79} = 11.86$, $P < 0.0001$; hand width: $F_{1,79} = 13.58$, $P < 0.0001$; second digit length: $F_{1,79} = 12.13$, $P < 0.0001$; third digit length: $F_{1,79} = 14.94$, $P < 0.0001$; fourth digit length: $F_{1,79} = 13.37$, $P < 0.0001$; ear length: $F_{1,79} = 10.04$, $P < 0.0001$; ear width: $F_{1,79} = 9.46$, $P < 0.0001$; elbow width: $F_{1,79} = 3.39$, $P < 0.0001$).

Traits that do not exhibit directional asymmetry, antisymmetry, leptokurtosis and skewness were used in the fluctuating asymmetry analysis. For this reason, it was checked whether each trait examined exhibited directional asymmetry using the one sample T test. As seen in Table 1, hand width exhibits a significant directional asymmetry. However, the other 7 traits do not exhibit directional asymmetry.

It was checked whether the seven bilateral traits that did not show directional asymmetry were distributed symmetrically. Ear width was negatively skewed ($P < 0.05$) in males, and elbow width was positively skewed ($P < 0.01$) in females. Logarithmic transformation applied to the right and left traits by directional asymmetry did not normalize the distribution. For this reason, in line with the suggestion of Palmer and Strobeck (2003), the distribution of these two traits were visually inspected and Grubb's test was applied to possible outlier measures (Grubbs, 1950). As a result, when 12 outlier measurements were removed from the sample, a normal distribution was achieved.

Size dependence was controlled by Spearmans's rank correlation analysis and it was seen that there was no size dependence in seven traits exhibiting fluctuating asymmetry. For composite fluctuating asymmetry (CFA), we summed the standardized absolute asymmetries of the four traits (Leung et al., 2000); the asymmetry of each trait was standardized by its mean fluctuating asymmetry: $CFA = \sum_{i=1}^{k} \frac{|d|}{|\bar{d}_i|}$.

In fluctuating asymmetry analyzes, it is accepted that bilateral organs develop through identical pathways. However, the organizational and activational effects of prenatal sex hormones play an important role in the development of second and fourth finger lengths. Therefore, some researchers find it inconvenient to use these two traits in FA analyses. From this point of view, the composite index was calculated in two different ways. While the second and fourth digits were included in the CFA1 index, these traits were not included in the CFA2 index. The Statistical Package for Social Sciences (SPSS of version 21.0) was used for all statistical analysis.

Table 1

Right and Left Measurements and Sign Asymmetries of Bilateral Traits (mm)

Traits	Right	Left	Sign Asymmetry[1]	T
Hand length	181.95	182.23	-0.28	1.66
Hand width[2]	81.19	80.25	-1.00	8.18***
Second digit	72.07	71.94	+0.13	1.03
Third digit	78.50	78.71	-0.28	1.46
Fourth digit	72.61	72.54	+0.08	0.58
Ear length	62.80	62.88	+0.09	0.66
Ear width	35.55	35.81	-0.26	1.91
Elbow width	63.82	63.73	+0.09	1.20

Note. 1 = Right - Left, 2 = Directional asymmetric trait, ***$P < 0.001$

Results

Males and females do not differ in terms of average age (Table 2). As expected, male's average height and BMI were significantly higher than females. When bilateral traits which showed fluctuating asymmetry are examined, it is seen that the third digit FA and ear width FA are higher in males. In terms of Composite FA1 and Composite FA2, the high values of males reveal that they are more asymmetrical than females. Consistent with the literature findings, males show higher values than females in terms of hand grip strength. Males are about 60% stronger than females in terms of both hand grip strengths.

Hand grip strength is closely related to the body structure of the individual. Tall and large bodied individuals have greater hand grip strength (Morlino et al., 2021). There are also significant relationships between age and HGS (Massy-Westropp et al., 2011). For this reason, the effects of height, BMI and age on HGS were controlled using multiple regression analysis. According to Tables 3 and 4, an expected relationship emerges between body structure and HGS in both sexes. Individuals who are taller and have a more massive body have higher upper body strength. However, there is no significant relationship between age and HGS in both sexes. The narrow age range of the sample may explain this situation. Relationships between composite FAs and HGS are not significant (Table 3-4, Fig 1).

Table 2

Means and Standard Deviations of Age (Year), Height (cm), BMI, Fluctuating Asymmetry (mm) and Hand Grip Strength (kg) Values

	Males		Females		
	M	*SD*	*M*	*SD*	*F*
Age	22.42	3.37	22.88	3.87	0.775
Height	177.15	6.84	161.64	5.31	290.53***
BMI	24.21	3.36	22.21	3.95	13.10***
Hand length FA	1.80	1.39	1.77	1.36	0.024
Second digit FA	1.24	1.00	1.32	0.96	0.321
Third digit FA	1.71	1.42	1.23	0.88	7.632**
Fourth digit FA	1.46	1.12	1.35	0.96	0.516
Ear length FA	1.39	1.23	1.38	1.10	0.000
Ear width FA	1.28	0.89	1.01	0.72	4.737*
Elbow width FA	0.93	0.74	0.83	0.69	0.895
Composite FA^1	1.42	0.55	1.25	0.44	5.61*
Composite FA^2	1.33	0.45	1.19	0.33	6.28*
Right HGS	42.06	7.14	24.95	4.67	371.47***
Left HGS	41.50	6.97	24.11	4.19	424.44**

Note. 1 = CFA without 2. and 4 digits; 2 = CFA with 2. and 4 digits, *P < 0.05, **P < 0.01, *** P < 0.001

Table 3.

Multiple Regression Analysis Results (Dependent Variable = Right HGS)

		Unstandardized Coefficients		Standardized Coefficients		
Sex		*B*	*SE*	*Beta*	*T*	*P*
Male	(Constant)	-39.156	20.330		-1.926	0.058
	Age (year)	0.236	0.223	0.110	1.058	0.294
	Height (cm)	0.360	0.109	0.345	3.315	**0.001**
	BMI	0.497	0.219	0.234	2.269	**0.026**
	CFA[1]	0.450	1.891	0.035	0.238	0.812
	CFA[2]	-0.402	2.368	-0.025	-0.170	0.865
Female	(Constant)	-37,606	15.432		-2.437	0.017
	Age (year)	-0.011	0.114	-0.009	-0.097	0,923
	Height (cm)	0.348	0.089	0.386	3.932	**0.000**
	BMI	0.284	0.147	0.193	1.932	0.057
	CFA[1]	0.444	1.175	0.043	0.378	0.706
	CFA[2]	-0.146	1.534	-0.011	-0.095	0.925

Note. 1 = CFA without 2. and 4 digits; 2 = CFA with 2. and 4 digits

Table 4

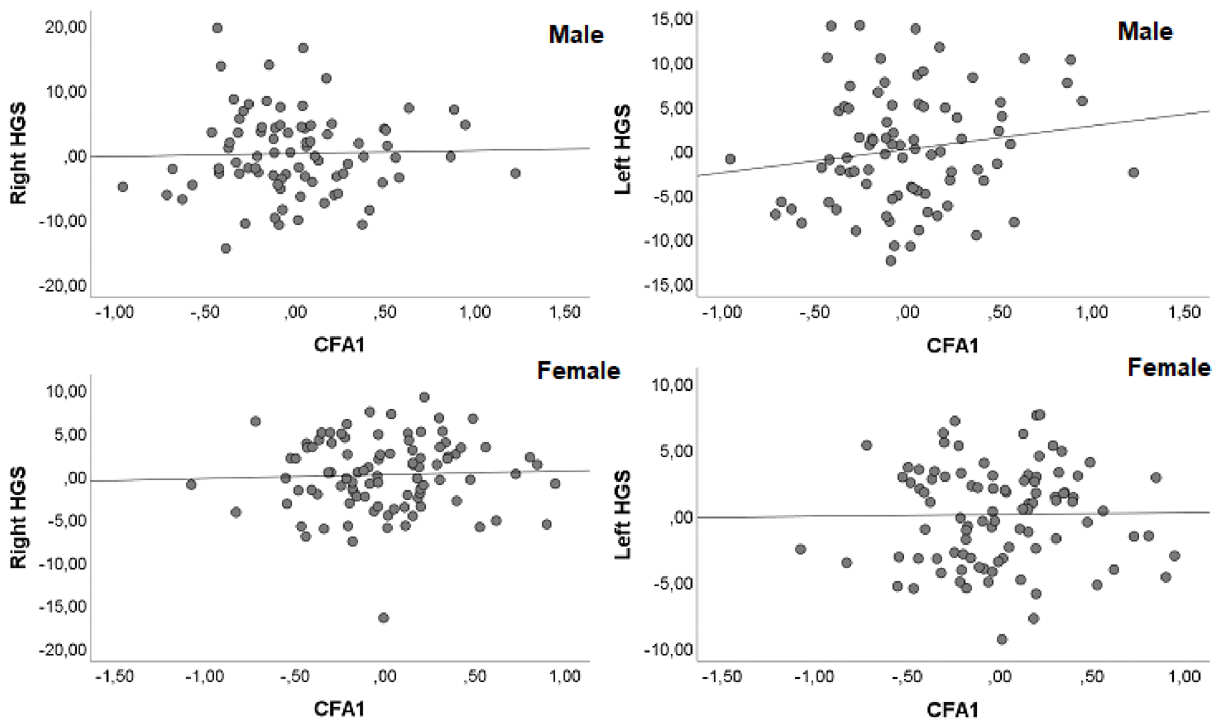
Multiple Regression Analysis Results (Dependent Variable = Left HGS)

		Unstandardized Coefficients		Standardized Coefficients		
Sex		*B*	*SE*	*Beta*	*T*	*P*
Male	(Constant)	-16.838	19.995		-0.842	0.402
	Age (year)	0.240	0.219	0.115	1.097	0.276
	Height (cm)	0.204	0.107	0.200	1.908	0.060
	BMI	0.621	0.216	0.299	2.880	**0.005**
	CFA[1]	2.630	1.859	0.209	1.414	0.161
	CFA[2]	-1.458	2.328	-0.094	-0.626	0.533
Female	(Constant)	-38.944	13.647		-2.854	0.005
	Age (year)	0.046	0.101	0.043	0.455	0.650
	Height (cm)	0.344	0.078	0.419	4.385	**0.000**
	BMI	0.320	0.130	0.239	2.462	**0.016**
	CFA[1]	0.136	1.039	0.015	0.131	0.896
	CFA[2]	-0.528	1.356	-0.043	-0.390	0.698

Note. 1 = CFA without 2. and 4 digits; 2 = CFA with 2. and 4 digits

Figure 1

Partial Regression Plots between Hand Grip Strenght (HGS) and Composite Fluctuating Asymmetry (CFA[1])



Discussion

This study shows that females have a more symmetrical body structure and lower HGS scores than males. According to literature findings, males physically have higher fluctuating levels of asymmetry than females. Females are considered more resistant to environmental and genetic stresses as they have two X chromosomes. Therefore, females show a more stable development in most cases. However, in some traditional patriarchal societies, women's living conditions are worse than men's, which may explain the increased bodily asymmetry in women (Gray & Marlow, 2002).

In this study, the relationships between composite FA1 and composite FA2 and right and left HGS were not significant. This finding means that there is no significant relationship between upper body strength and body symmetry. In recent years, a large anthropology literature has emerged that independently deals with the relationships between both HGS and FA and health and quality of life. For this reason, the relationship between FA and HGS in terms of being an indicator of health and fitness has attracted the attention of some anthropologists. However, as it was emphasized in the previous lines, the findings of these studies conducted on healthy individuals are contradictory. In a study by Sim (2013) in which six bilateral traits were examined on 243 college students studying at the University at Albany, it was found that women with higher HGS scores had more symmetrical bodies, while no significant relationship was found in men. In another study examining 12 bilateral traits on men, it was seen that symmetrical individuals had higher HGS scores (Fink et al., 2014). In two separate studies conducted by Van Dongen (2014) and Van Dongen & Sprengers (2012), it is seen that there is no relationship between FA and HGS in both sexes.

According to Fink et al. (2014), the positive relationship between physical strength and developmental stability in men can be explained by the fact that healthy men are more resistant to the possible immunosuppressive effects of testosterone. For this reason, masculine traits are associated with high androgens. High sexual dimorphism in terms of HGS is due to testosterone, as in other masculine traits. Therefore, possible associations between HGS and FA are more likely to be observed in males. Some studies reveal that men have a more symmetrical body as their body masculinity levels increase. Gangestad and Thornhill (2003) showed that in a sample of 141 men and 154 women, body FA was negatively associated with facial masculinity in men. According to Ekrami et al. (2021), on the other hand, could not find a relationship between FA and facial masculinity score in men in a large sample of 630 males and 630 females. However, in this study, it is seen that feminine faces have a higher level of fluctuating asymmetry on average, and there is a weak but significant relationship between the mean fluctuating asymmetry score in women and facial masculinity.

As can be seen, results of studies conducted between masculinity, fitness and FA are contradictory (as in studies of HGS and FA). According to some experts, the reason for this discrepancy may be related to the measurement methods of bilateral traits. According to Manning et al. (2006), direct measurements of bilateral traits used in FA analyzes are more reliable than indirect measurements. In the study of Van Dongen and Sprengers (2012), bilateral measurements were obtained from scanner images. For this reason, Fink et al. (2014) in the study of Van Dongen and Sprengers (2012) attributed the absence of the expected relationship between FA and HGS to the indirect measurements. However, in this study, bilateral traits were measured directly, and despite this, no relationship was found between FA and HGS.

Another problem is that the physical strength measured by the HGS is likely to be affected by sporting activities and hobbies as well. It is known that HGS is higher in professional athletes and that there is a relationship between athletic performance and HGS (e.g. Cronin et al., 2017; Fallahi & Jadidan, 2011). Therefore, the data of the participants engaged in sports were excluded from the analysis in this study. However, in previous studies (Fink et al., 2014; Sim, 2013; Van Dongen, 2014; Van Dongen & Sprengers 2012), all conducted on Western populations, there is no information on how the sample was selected. Obviously, the hypothesis that HGS is a reliable indicator of general health and fitness should be based on studies of sedentary individuals.

The lack of a relationship between HGS and FA may also be due to the structure of the sample examined. The group examined in this study (like studies in Western countries) consists of healthy university students. The fact that the examined group consists of healthy individuals may make it difficult to detect signals related to FA. A study of populations exposed to environmental stresses or clinical populations may shed more light on the relationships between the two variables. In conclusion, although HGS and FA are accepted as reliable indicators of health and fitness, it is seen that there is no significant relationship between the two indicators in both sexes in this study. In addition, findings of this study support the view that fluctuating asymmetry is not a reliable indicator to predict an individual's health and developmental quality.

Compliance with Ethical Standards

Ethical Approval

This study was approved by the Board of Ethics for Social and Humanities Research of İstanbul University (approval no. 17.01.2022-01/11). Institutional and/or national research committee ethical standards and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards were followed in all study procedures involving human participants.

Author Contributions

Both authors B.E. and M.F.A made equal contributions in various stages of the study, including investigation, methodology, writing original draft, and writing - review and editing. In addition to these shared responsibilities, B.E. took the lead in conceptualization.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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