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Does handgrip strength affect pulmonary function in healthy children?

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Abstract

The present study examined the relationship between handgrip strength (HGS) and pulmonary functions of healthy children and the aim was to use regression model and hand grip strength as a practical tool to predict pulmonary functions. The study was designed as cross-sectional and analytical. A total of 755 healthy children (age= 9.38±0.48) participated in the study voluntarily. Hand grip strength and respiratory function tests were applied to the children. In statistical analysis, pearson correlation and linear regression model were used. A significant correlation was found between right and left hand grip strength and FVC, FEV1 and PEF ($p<0.05$). In addition, while the left hand grip strength had a significant effect on the lung function parameters FVC, FEV and PEF ($p<0.05$), it was found that the right hand grip strength was not a significant predictor of the parameters ($p> 0.05$). As a result, it was concluded that there are correlations between HGS and functional respiratory parameters in children, just as in adults and patient groups. In order to analyse the correlations between HGS and respiratory functions more clearly, it is recommended to examine important factors such as different age, activity levels and gender together in new studies.

Keywords: Children, handgrip strength, respiratory function

Sağlıklı çocuklarda el kavrama kuvveti pulmoner fonksiyonu etkiler mi?

Öz

Araştırmada sağlıklı çocukların el kavrama kuvveti (EKK) ve pulmoner fonksiyonları arasındaki ilişki araştırılarak regresyon modeli ile el kavrama kuvvetinin pulmoner fonksiyonları tahmin etmede pratik bir araç olarak kullanılması amaçlandı. Çalışma kesitsel ve analitik olarak dizayn edildi. Araştırmaya 755 sağlıklı çocuk (yaş= 9.38±0.48) gönüllü olarak katıldı. Çocuklara el kavrama kuvveti ve solunum fonksiyonları testleri uygulandı. İstatistiksel analizde pearson korelasyonu ve doğrusal regresyon modeli kullanıldı. Sağ ve sol el kavrama kuvveti ile FVC, FEV1 ve PEF arasında anlamlı bir ilişki bulundu ($p<0,05$). Ayrıca sol el kavrama kuvveti akciğer fonksiyon parametreleri olan FVC, FEV ve PEF üzerinde anlamlı bir etkiye sahipken ($p<0,05$), sağ el kavrama kuvvetinin parametrelerin anlamlı bir yordayıcısı olmadığı görüldü ($p>0,05$). Sonuç olarak çocuklarda da tıpkı yetişkin ve hasta gruplarında olduğu gibi EKK ile fonksiyonel solunum parametreleri arasındaki ilişkilerin bulunduğu sonucu ortaya çıkmıştır. EKK ve solunum fonksiyonları arasındaki ilişkilerin daha net analiz edilebilmesi açısından yapılacak yeni çalışmalarda farklı yaş, aktivite düzeyleri ve cinsiyet gibi önemli faktörlerin bir arada incelenmesi önerilmektedir.

Anahtar Kelimeler: *Çocuk, el kavrama kuvveti, solunum fonkiyon*

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Genişletilmiş Türkçe Özet, makalenin sonunda yer almaktadır.

INTRODUCTION

Handgrip strength (HGS) is used to assess muscle strength of individuals as well as potential conditions related to overall health (Mcgrath et al., 2018). It is a functional and inexpensive method that provides results in a very short time with uncomplicated equipment in clinical settings (Ruiz et al., 2011; Da Silva et al., 2018; Smith et al., 2018; Porto et al., 2019). HGS has been associated with milder potential health indicators. However, although the use of handgrip strength as a tool to monitor progression of disease indices has not attracted much attention (Mgbemena et al., 2022), after controlling for puberty status, country of residence, body mass index, and waist circumference, it was reported that handgrip strength was negatively associated with fasting insulin (Jiménez-Pavón et al., 2012). In an important study conducted in Europe, it was stated that it is independently associated with metabolic risk (Artero et al., 2011). In a study conducted with young people in adolescence, low muscle strength (as measured by grip, knee extension, and elbow flexion) was shown to be one of the factors for major causes of death in young adulthood (Ortega et al., 2012). Besides being a general indicator of health for children, grip strength was reported to be correlated with better spirometric lung function (Smith et al., 2018) in some studies conducted on adults (Rożek-Piechura et al., 2014; Leong et al., 2015) and healthy children (Bae et al., 2015).

There are a large number of studies which show that handgrip strength is related to pulmonary functions and respiratory muscle strength (Rożek-Piechura et al., 2014; Sillanpää et al., 2014; Bae et al., 2015; Schweitzer et al., 2017; Smith et al., 2018; Zhu et al., 2020). In terms of athletes, adaptation of respiratory, circulatory and musculoskeletal systems to increasing loads is very important for cardiovascular health and exercise capacity (Wilson, 2016). In addition to this, mental exercises are quite important (Çankaya et al., 2020).

Aerobic performance of athletes is usually limited by respiratory muscle fatigue (Romer & Polkey, 2008). The diaphragm and other muscles that assist breathing become stronger through inhaling or exhaling against resistance during breathing (Illi et al., 2012). This situation leads to higher inspiratory and expiratory flow rates in both healthy (Illi et al., 2012) and diseased (Sahin et al., 2004) populations. An increasing number of epidemiological studies have established an association between HGS and a variety of harmful health outcomes among seniors. Having fewer skeletal muscles as a result of aging also leads to respiratory muscle mass and strength loss and therefore it is thought that it may lead to deterioration in lung functions (Son et al., 2018). Many studies have been conducted on the

relationship between HGS and pulmonary functions. These studies generally focused on the elderly and patient groups (Shah et al., 2013; Bae et al., 2015; Smith et al., 2018). Despite this, there is still no consensus on the mechanism of the relationship between HGS and pulmonary function in healthy children. This comprehensive study is among the first studies conducted on healthy children.

The present study examines how handgrip strength and pulmonary functions of healthy children are correlated and it was hypothesized that handgrip strength would be a practical tool to predict pulmonary functions.

METHOD

Study design and participants

This study was designed as a cross-sectional analytical study. A total of 755 healthy children aged 9-10 in Gaziantep and Kilis provinces participated in the study (Table 1). Subjects were excluded by following exclusion criteria: respiratory diseases, obesity, and chronic diseases. Age, gender, weight and height parameters were obtained by applying a short survey at the onset of the study, and BMI was calculated. Those with a history of disease were not included in the study. Before each measurement, the participants were explained the correct posture and the procedure. Afterwards, handgrip strength and pulmonary function tests were applied to the participants. Kilis 7 Aralik University Ethics Committee (2023/14) approved the study.

Handgrip strength

Handgrip strength was assessed by using a handgrip strength dynamometer (Takei, Japan) with a precision of 0.1 kg for both the right and left hands. After the participants performed the test twice, their best result was recorded (Aksoy, 2019).

Pulmonary function

After adequate explanation was given to the participants about how tools are used and about the method, the participants took the tests in sitting position with a nose clip attached. Pulmonary function was performed using forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV1/FVC and peak expiratory flow (PEF), measured with an electronic spirometer (Clement Clarke, Harlow, UK). The researchers carried out all pulmonary tests in accordance with American Thoracic Society/European Respiratory Society standards.

Data analysis

SPSS statistical package program (SPSS 21.0, IBM Chicago, Illinois, USA) was used for the analysis of data. Mean and standard deviation were used to present data. The relationship between HGS and pulmonary functions was examined with Pearson correlation test. Right and left handgrip strength were designed as independent variable, while each of the respiratory function parameters was designed as dependent variable, and four different multiple linear regression models were created. The multicollinearity between the independent variables was examined with variance increase factor (VIF) and tolerance value. P<0.05 significance level was used in analyses.

FINDINGS

Table 1. Characteristics of the study participants (N= 755)

Variables	Mean	Sd
Age (years)	9.38	0.48
Height (cm)	132.03	6.68
Weight (kg)	30.78	7.19
BMI (kg/m^2)	17.49	2.89
FVC (L)	1.72	0.43
FEV1 (L)	1.50	0.33
FEV1/FVC	0.89	0.16
PEF (L/sec)	170.29	61.28
Right hand grip (kg)	13.34	3.08
Left hand grip (kg)	12.89	2.95

BMI: body mass index; SD: standart deviation, FVC: forced vital capacity, FEV1: forced expiratory volume in one second, PEF: peak expiratory flow

Table 2. The correlation between HGS and pulmonary function

Variables		FVC	FEV	FEV1/FVC	PEF
Right hand grip (kg)	r	0.131*	0.137*	-0.007	0.134*
	p	0.000	0.000	0.853	0.000
Left hand grip (kg)	r	0.158*	0.158*	0.002	0.167*
	p	0.000	0.000	0.953	0.000

*p<0.05

Right and left handgrip strength and FVC, FEV1 and PEF were found to be significantly correlated low level (p<0.05). Right and left handgrip strength and FEV1/FVC were not significantly different (p>0.05).

Table 3. The effect of HGS on pulmonary function

Dependent Variable	Predictor Variables	B	Standart Error	β	p	R	R^2	Standart Error of Estimate
FVC (L)	Constant	1.402	0.075		0.000	0.161	0.026	0.42
	Right hand grip	0.006	0.007	0.043	0.377			
	Left hand grip	0.019	0.007	0.129	0.009			
FEV (L)	Constant	1.245	0.058		0.000	0.163	0.027	0.33
	Right hand grip	0.006	0.005	0.055	0.262			
	Left hand grip	0.014	0.006	0.120	0.014			
FEV1/FVC (%)	Constant	0.893	0.029		0.000	0.011	0.000	0.16
	Right hand grip	-0.001	0.003	-0.015	0.759			
	Left hand grip	0.001	0.003	0.013	0.801			
PEF (L/sec)	Constant	122.481	10.659		0.000	0.170	0.029	60.47
	Right hand grip	0.745	0.971	0.038	0.443			
	Left hand grip	2.937	1.014	0.142	0.004			

FVC: forced vital capacity, FEV1: forced expiratory volume in one second, PEF: peak expiratory flow

While left handgrip strength had a significant effect on the lung function parameters FVC, FEV and PEF ($p<0.05$), it was found that right handgrip strength was not a significant predictor of the parameters ($p>0.05$). According to standardized beta (β) coefficients, it was found that left handgrip strength explained 2.6% of the variance in the FVC value, 2.7% of the variance in the FEV value, and 2.9% of the variance in the PEF value. According to the results, it was found that left handgrip strength explained the variance on the PEF value at the highest rate (2.9%) and the variance on the FVC value at the lowest rate (2.6%). It can be seen that both right and left handgrip strength do not affect FEV1/FVC parameter significantly (Model 3, $p>0.05$).

DISCUSSION AND CONCLUSION

In this study, which was conducted to predict pulmonary function in healthy children by using HGS, right and left HGS, FVC, FEV1 and PEF were measured in 755 children (age= 9.38±0.48). As a general result, significant correlations were found between HGS and functional respiratory parameters in healthy children. Since HGS is among the determinants of pulmonary functions, a regression model was proposed in the study. As a result of the regression, it was found that while the left handgrip strength had a significant effect on the pulmonary function parameters FVC, FEV and PEF ($p<0.05$), right handgrip strength was not a significant predictor of the parameters ($p>0.05$).

While studies evaluating the relationships between HGS and functional respiratory parameters in patient and healthy adult groups are quite common in the literature, studies evaluating possible relationships in children are very limited (Bae et al., 2015). When the findings in our study were evaluated, positive significant correlations were found between

HGS in both hands and functional respiratory parameters FVC, FEV1 and PEF in children ($p<0.05$). In their study Bae et al. (2015) performed HGS, FVC and FEV1 measurements in 240 healthy subjects between the ages of 6 and 17, they found significant correlations between HGS and functional respiratory parameters. In this context, similar results were found between this study, which was carried out with a child subject group, and our current study. However, since sufficient number of studies were not found in the literature review on the relationship between HGS and functional respiratory parameters, especially in children, new studies on this subject are important in terms of obtaining more reliable results.

In a great majority of studies in the literature examining the relationships between HGS and functional respiratory parameters in healthy subject groups, significant relationships were found similar to our current study (Davies, 1992; Burchfiel et al., 1997; Hornby et al., 2005; Deary et al., 2006; Rożek-Piechura et al., 2014; Sillanpää et al., 2014; Schweitzer et al., 2017; Mgbemena et al., 2019; Zhu et al., 2020). HGS may represent overall skeletal muscle strength, which indirectly contributes to pulmonary function. The fact that skeletal muscle strength and diaphragm and other respiratory muscle strength are strongly correlated explains the physiological mechanism of the present study. The consistent results of our current study and many similar studies in the literature indicate a significant correlation between HGS and functional respiratory parameters. However, it is important to carry out studies with different parameters in order to understand the effects of HGS and lung functions more clearly.

Similar studies conducted were examined and in a study, conducted on individuals by Smith et al. (2018), handgrip strength was found to be positively correlated with lung volumes and flows corresponding to 250–300 mL FEV1 per standard deviation in a cohort of healthy adolescents who were not doing regular physical activity, spirometry was used to determine grip strength (Smith et al., 2018). A cross-sectional study conducted with elderly women in Korea on the relationship between handgrip strength and respiratory function and found handgrip strength to be positively and independently correlated with FVC in a dose-dependent manner (Son et al., 2018). In an acute medical service, 50 individuals older than 70 years of age were evaluated to find out the correlation between handgrip strength and respiratory function. Of the spirometry measurements such as FEV1, FVC, highest expiratory flow and highest cough flow, only the highest cough flow was associated with handgrip strength, and the correlation between handgrip strength and respiratory functions was low (Holmes et al., 2017).

In different studies conducted on healthy elderly individuals, handgrip strength and respiratory muscle strength, both of which depend on skeletal muscle tissue, were reported to be positively correlated (Shin et al., 2017). In a study conducted on individuals with three different COPD, handgrip strength and lung function were found to have significant correlations ranging from weak to moderate (r = 0.20-0.47) (Shah et al, 2013; Strandkvist et al., 2016; Martinez et al., 2017).

It has been reported that various factors such as age, gender, height, weight, body fat percentage, ethnicity, nutritional status and physical activity levels are important in both HGS and lung functions (Jung et al., 2010; Kubota & Demura, 2011; Ren et al., 2012; Bhatti et al., 2014; Koopman et al., 2015). In a large number of studies evaluating gender, which is one of these factors, it has been found that HGS is significantly higher in men compared to women (Moy et al., 2015; Ro et al., 2015; Vivas-Díaz et al., 2016; Holmes et al., 2017).

In conclusion, it can be said that there are relations between HGS and functional respiratory parameters in children, just as in adults and patient groups. Nevertheless, it is recommended to examine important factors such as different age, activity levels and gender together in new studies to be able to analyse the relations between HGS and respiratory functions more clearly.

Study limitations

This study several limitations. First, this study only included subjects belonging to the Gaziantep and Kilis population. Second, the spirometer could not calculate other pulmonary parameters.

GENİŞLETİLMİŞ ÖZET

GİRİŞ

El kavrama kuvveti (EKK) vücutta genel kas gücünün bir belirteci olarak kabul edilmiştir ve özellikle kolay uygulanabilirliği bakımından yaygınlık kazanmıştır (Ortega ve ark., 2011; Rantanen ve ark., 2012; Bohannon, 2015). Ayrıca EKK'nin kas gücünün yanı sıra genel sağlık sonuçlarının da potansiyel bir göstergesi olabileceği belirtilmiştir (Mcgrath ve ark., 2018). Bu nedenle araştırmacılar özellikle akciğer hastalığı, inme ve diyabet gibi çeşitli hastalıkları bulunan küçük örneklemli gruplarda EKK ile fonksiyonel solunum parametreleri arasındaki ilişkileri incelemişlerdir (Johansson-Strandkvist ve ark., 2016; Holmes ve ark., 2017; Lee ve ark., 2017; Jeong ve ark., 2017; Cichosz ve ark., 2018; Kim, 2018). Fakat sağlıklı çocuklarda bu ilişkinin mekanizması hala belirsizliğini korumaktadır. Sağlıklı çocuklar üzerinde bu kapsamlı yapılan ilk araştırmalar arasında yer almaktadır. Araştırmada sağlıklı çocukların el kavrama kuvveti ve pulmoner fonksiyonları arasındaki ilişki

araştırılarak el kavrama kuvvetinin pulmoner fonksiyonları tahmin etmede pratik bir araç olabileceği hipotezlenmiştir.

YÖNTEM

Çalışma kesitsel ve analitik olarak dizayn edilmiştir. Araştırmaya 9-10 yaş aralığındaki Gaziantep ve Kilis ilinde bulunan sağlıklı toplam 755 çocuk gönüllü olarak katılmıştır. Çalışmanın başlangıcında kısa bir anket uygulanarak yaş, cinsiyet, kilo ve boy parametreleri elde edilmiştir. Hastalık öyküsü bulunanlar araştırma dışı bırakılmıştır. Tüm katılımcılara doğru duruş ve her ölçümün prosedürü hakkında tam bir açıklama yapılarak el kavrama kuvveti ve solunum fonksiyon testleri uygulanmıştır. Araştırmanın etik kurul izni Kilis 7 Aralık Üniversitesi Etik Kurulundan alınmıştır (2023/14).

BULGULAR

Sağ ve sol el kavrama kuvveti ile FVC, FEV1 ve PEF arasında pozitif yönde düşük düzeyde anlamlı bir ilişki bulunmuştur ($p<0,05$). Sağ ve sol el kavrama kuvveti ile FEV1/FVC arasında ise anlamlı farklılık bulunamamıştır ($p>0,05$). Sol el kavrama kuvveti akciğer fonksiyon parametreleri olan FVC, FEV ve PEF üzerinde anlamlı bir etkiye sahipken ($p<0,05$), sağ el kavrama kuvvetinin parametrelerin anlamlı bir yordayıcısı olmadığı görülmektedir ($p>0,05$). Standardize edilmiş beta (β) katsayılarıma göre, sol el kavrama kuvvetinin FVC değerindeki varyansın %2,6'sını, FEV değerindeki varyansın %2,7'sini, PEF değerindeki varyansın %2,9'unu açıkladığı belirlenmiştir. Bulgulara göre, sol el kavrama kuvvetinin PEF değeri üzerindeki varyansı en yüksek oranda (%2,9), FVC değeri üzerindeki varyansı da en düşük oranda (%2,6) açıkladığı tespit edilmiştir.

TARTIŞMA VE SONUÇ

Literatürde hasta ve sağlıklı yetişkin gruplarda EKK ile fonksiyonel solunum parametreleri arasındaki ilişkilerin değerlendirildiği çalışmalar oldukça yaygınken çocuklardaki olası ilişkilerin değerlendirildiği çalışmalar oldukça kısıtlıdır (Bae ve ark., 2015). Bae ve arkadaşları (2015) yapmış oldukları çalışmada 6-17 yaş arasındaki 240 sağlıklı denek ile EKK, FVC ve FEV1 ölçümleri gerçekleştirmiş ve hem erkek hem de kadın gruplarda her iki elde de EKK ile fonksiyonel solunum parametreleri arasında anlamlı ilişki tespit etmişlerdir. Bu bağlamda çocuk denek grubuyla gerçekleştirilen bu çalışma ile mevcut çalışmamız arasında benzer sonuçlar ortaya çıkmıştır. Ancak literatürde özellikle çocuklarda EKK ile fonksiyonel solunum parametreleri arasındaki ilişkilerin incelendiği çalışmaların henüz yeterli sayıda olmamasından dolayı bu konuda yapılacak yeni çalışmalar daha güvenilir sonuçlar elde edilmesi bakımından önemlidir.

Literatürde EKK ile fonksiyonel solunum parametreleri arasındaki ilişkilerin sağlıklı denek gruplarında incelendiği birçok çalışmada mevcut çalışmalarımıza benzer olarak anlamlı ilişkiler tespit edilmiştir (Davies, 1992; Burchfiel ve ark., 1997; Hornby ve ark., 2005; Deary ve ark., 2006; Sillanpää ve ark., 2014; Rożek-Piechura ve ark., 2014; Schweitzer ve ark., 2017; Mgbemena ve ark., 2019; Zhu

ve ark., 2020). Bu sonucun fizyolojik mekanizması iskelet kas kuvveti ile diyafram ve diğer solunum kas kuvveti arasındaki güçlü ilişki ile açıklanmaktadır. Mevcut çalışmamız ve literatürde bulunan birçok benzer çalışmalar sonucu ortaya çıkan tutarlı sonuçlar EKK ile fonksiyonel solunum parametreleri arasında anlamlı ilişkinin varlığını göstermektedir. Ancak EKK ve akciğer fonksiyonlarının etkilerinin daha net anlaşılabilmesi için çalışmaların farklı parametrelerde gerçekleştirilmesi önemlidir.

Sonuç olarak, çocuklarda da tıpkı yetişkin ve hasta gruplarında olduğu gibi EKK ile fonksiyonel solunum parametreleri arasındaki ilişkilerin bulunduğu sonucu ortaya çıkmıştır. Yine de EKK ve solunum fonksiyonları arasındaki ilişkilerin daha net analiz edilebilmesi açısından yapılacak yeni çalışmalarda farklı yaş, aktivite düzeyleri ve cinsiyet gibi önemli faktörlerin bir arada incelenmesi önerilmektedir.

REFERENCES

Artero, E. G., Ruiz, J. R., Ortega, F. B., España-Romero, V., Vicente-Rodríguez, G., Molnar, D., ... et al. (2011). Muscular and cardiorespiratory fitness are independently associated with metabolic risk in adolescents: The HELENA study. *Pediatric Diabetes, 12*(8), 704-712.

Bae, J. Y., Jang, K. S., Kang, S., Han, D. H., Yang, W., & Shin, K. O. (2015). Correlation between basic physical fitness and pulmonary function in Korean children and adolescents: a cross-sectional survey. *Journal of Physical Therapy Science*, *27*(9), 2687–2692.

Bhatti, U., Rani, K., & Memon, M. Q. (2014). Variation in lung volumes and capacities among young males in relation to height. *Journal of Ayub Medical College, Abbottabad : JAMC*, *26*(2), 200–202.

Bohannon, R. W. (2015). Muscle strength. *Current Opinion in Clinical Nutrition and Metabolic Care*, *18*(5), 465–470.

Burchfiel, C. M., Enright, P. L., Sharp, D. S., Chyou, P.-H., Rodriguez, B. L., & Curb, J. D. (1997). Factors Associated With Variations in Pulmonary Function Among Elderly Japanese-American Men. *Chest*, *112*(1), 87–97.

Cichosz, S. L., Vestergaard, E. T., & Hejlesen, O. (2018). Muscle grip strength is associated to reduced pulmonary capacity in patients with diabetes. *Primary Care Diabetes*, *12*(1), 66–70.

Çankaya, S., Çakıcı, H. A., Yıldız, E., & Aksoy, Y. (2020). Analysis of athletes' mental training practices and self-confidence levels. *Turkish Studies - Social, 15*(4), 1805-1821.

Da Silva, T. K., Perry, I. D. S., Brauner, J. S., Wender, O. C. B., Souza, G. C., & Vieira, S. R. R. (2018). Performance evaluation of phase angle and handgrip strength in patients undergoing cardiac surgery: prospective cohort study. *Australian Critical Care*, *31*(5), 284-290.

Davies, G. J. (1992). *Compendium of isokinetics in clinical usage and rehabilitation techniques*. Simon & Schuster.

Deary, I. J., Whalley, L. J., Batty, G. D., & Starr, J. M. (2006). Physical fitness and lifetime cognitive change. *Neurology*, *67*(7), 1195–1200.

Holmes, S., Allen, S., & Roberts, H. (2017). Relationship between lung function and grip strength in older hospitalized patients: a pilot study. *International Journal of Chronic Obstructive Pulmonary Disease*, (12), 1207–1212.

Hornby, S. T., Nunes, Q. M., Hillman, T. E., Stanga, Z., Neal, K. R., Rowlands, B. J., … et al. (2005). Relationships between structural and functional measures of nutritional status in a normally nourished population. *Clinical Nutrition*, *24*(3), 421–426.

Illi, S. K., Held, U., Frank, I., & Spengler, C. M. (2012). Effect of respiratory muscle training on exercise performance in healthy individuals: a systematic review and meta-analysis. *Sports Medicine*, (42), 707-724.

Jeong, M., Kang, H. K., Song, P., Park, H. K., Jung, H., Lee, S.-S., … et al. (2017). Hand grip strength in patients with chronic obstructive pulmonary disease. *International Journal of Chronic Obstructive Pulmonary Disease*, (12), 2385–2390.

Jiménez-Pavón, D., Ortega, F. B., Valtueña, J., Castro-Piñero, J., Gómez-Martínez, S., Zaccaria, M., … et al. (2012). Muscular strength and markers of insulin resistance in European adolescents: the HELENA Study. *European journal of Applied Physiology*, (112), 2455-2465.

Johansson-Strandkvist, V., Backman, H., Roding, J., Stridsman, C., & Lindberg, A. (2016). Hand grip strength is associated with forced expiratory volume in 1 second among subjects with COPD: report from a population-based cohort study. *International Journal of Chronic Obstructive Pulmonary Disease*, (11), 2527–2534.

Jung, D. H., Shim, J. Y., Ahn, H. Y., Lee, H. R., Lee, J. H., & Lee, Y. J. (2010). Relationship of body composition and C-reactive protein with pulmonary function. *Respiratory Medicine*, *104*(8), 1197–1203.

Kim, N. S. (2018). Correlation between grip strength and pulmonary function and respiratory muscle strength in stroke patients over 50 years of age. *Journal of Exercise Rehabilitation*, *14*(6), 1017–1023.

Koopman, J. J. E., Van Bodegom, D., Van Heemst, D., & Westendorp, R. G. J. (2015). Handgrip strength, ageing and mortality in rural Africa. *Age and Ageing*, *44*(3), 465–470.

Kubota, H., & Demura, S. (2011). Gender differences and laterality in maximal handgrip strength and controlled force exertion in young adults. *Health*, *3*(11), 684–688.

Lee, S. H., Kim, S. J., Han, Y., Ryu, Y. J., Lee, J. H., & Chang, J. H. (2017). Hand grip strength and chronic obstructive pulmonary disease in Korea: an analysis in KNHANES VI. *International Journal of Chronic Obstructive Pulmonary Disease*, (12), 2313–2321.

Leong, D. P., Teo, K. K., Rangarajan, S., Lopez-Jaramillo, P., Avezum, A., Orlandini, A., … et al. (2015). Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. *The Lancet*, *386*(9990), 266-273.

Martinez, C. H., Diaz, A. A., Meldrum, C. A., McDonald, M. L. N., Murray, S., Kinney, G. L., ... et al. (2017). Handgrip strength in chronic obstructive pulmonary disease. Associations with acute exacerbations and body composition. *Annals of the American Thoracic Society*, *14*(11), 1638-1645.

Mgbemena, N., Jones, A., & Leicht, A. S. (2022). Relationship between handgrip strength and lung function in adults: A systematic review. *Physiotherapy Theory and Practice*, *38*(12), 1908-1927.

McGrath, R. P., Kraemer, W. J., Snih, S. Al, & Peterson, M. D. (2018). Handgrip strength and health in aging adults. *Sports Medicine*, *48*(9), 1993–2000.

Mgbemena, N. C., Aweto, H. A., Tella, B. A., Emeto, T. I., & Malau-Aduli, B. S. (2019). Prediction of lung function using handgrip strength in healthy young adults. *Physiological Reports*, *7*(1), e13960.

Moy, F. M., Darus, A., & Hairi, N. N. (2015). Predictors of Handgrip Strength Among Adults of a Rural Community in Malaysia. *Asia Pacific Journal of Public Health*, *27*(2), 176–184.

Ortega, F. B., Artero, E. G., Ruiz, J. R., Espana-Romero, V., Jimenez-Pavon, D., Vicente-Rodriguez, G., … et al. (2011). Physical fitness levels among European adolescents: the HELENA study. *British Journal of Sports Medicine*, *45*(1), 20–29.

Porto, J. M., Nakaishi, A. P. M., Cangussu-Oliveira, L. M., Júnior, R. C. F., Spilla, S. B., & de Abreu, D. C. C. (2019). Relationship between grip strength and global muscle strength in community-dwelling older people. *Archives of Gerontology and Geriatrics*, (82), 273-278.

Rantanen, T., Masaki, K., He, Q., Ross, G. W., Willcox, B. J., & White, L. (2012). Midlife muscle strength and human longevity up to age 100 years: a 44-year prospective study among a decedent cohort. *AGE*, *34*(3), 563–570.

Ren, W. Y., Li, L., Zhao, R. Y., & Zhu, L. (2012). Age-associated changes in pulmonary function: a comparison of pulmonary function parameters in healthy young adults and the elderly living in Shanghai. *Chinese Medical Journal*, *125*(17), 3064–3068. 2

Ro, H. J., Kim, D. K., Lee, S. Y., Seo, K. M., Kang, S. H., & Suh, H. C. (2015). Relationship between respiratory muscle strength and conventional sarcopenic ındices in young adults: A preliminary study. *Annals of Rehabilitation Medicine*, *39*(6), 880.

Romer, L. M., & Polkey, M. I. (2008). Exercise-induced respiratory muscle fatigue: implications for performance. *Journal of Applied Physiology*, *104*(3), 879-888.

Rożek-Piechura, K., Ignasiak, Z., Sławińska, T., Piechura, J., & Ignasiak, T. (2014). Respiratory function, physical activity and body composition in adult rural population. *Annals of Agricultural and Environmental Medicine*, *21*(2), 369–374.

Ruíz, J. R., España-Romero, V., Castro-Piñero, J., Artero, E. G., Ortega, F. B., Cuenca García, M., ... et al. (2011). Batería ALPHA-Fitness: test de campo para la evaluación de la condición física relacionada con la salud en niños y adolescentes. *Nutrición Hospitalaria*, *26*(6), 1210-1214.

Sahin, G., Ulubas, B., Calikoglu, M., & Erdogan, C. (2004). Handgrip strength, pulmonary function tests, and pulmonary muscle strength in fibromyalgia syndrome: is there any relationship?. *Southern Medical Journal*, *97*(1), 25-30.

Schweitzer, L., Geisler, C., Johannsen, M., Glüer, C. C., & Müller, M. J. (2017). Associations between body composition, physical capabilities and pulmonary function in healthy older adults. *European Journal of Clinical Nutrition*, *71*(3), 389–394.

Shah, S., Nahar, P., Vaidya, S., & Salvi, S. (2013). Upper limb muscle strength & endurance in chronic obstructive pulmonary disease. *The Indian Journal of Medical Research*, *138*(4), 492.

Shin, H., Kim, D. K., Seo, K. M., Kang, S. H., Lee, S. Y., & Son, S. (2017). Relation between respiratory muscle strength and skeletal muscle mass and hand grip strength in the healthy elderly. *Annals of Rehabilitation Medicine*, *41*(4), 686-692.

Sillanpää, E., Stenroth, L., Bijlsma, A. Y., Rantanen, T., McPhee, J. S., Maden-Wilkinson, T. M., … et al. (2014). Associations between muscle strength, spirometric pulmonary function and mobility in healthy older adults. *AGE, 36*(4), 9667.

Smith, M. P., Standl, M., Berdel, D., Von-Berg, A., Bauer, C. P., Schikowski, T., ... et al. (2018). Handgrip strength is associated with improved spirometry in adolescents. *PloS one, 13*(4), e0194560.

Son, D. H., Yoo, J. W., Cho, M. R., & Lee, Y. J. (2018). Relationship between handgrip strength and pulmonary function in apparently healthy older women. *Journal of the American Geriatrics Society*, *66*(7), 1367-1371.

Strandkvist, V. J., Backman, H., Röding, J., Stridsman, C., & Lindberg, A. (2016). Hand grip strength is associated with forced expiratory volume in 1 second among subjects with COPD: report from a population-based cohort study. *International Journal of Chronic Obstructive Pulmonary Disease*, 2527-2534.

Vivas-Díaz, J. A., Ramírez-Vélez, R., Correa-Bautista, J. E., & Izquierdo, M. (2016). Handgrip strength of Colombian university students. *Nutrición Hospitalaria*, *33*(2), 330–336.

Zhu, R., Li, W., Xia, L., Yang, X., Zhang, B., Liu, F., … et al. (2020). Hand grip strength is associated with cardiopulmonary function in Chinese adults: Results from a cross-sectional study. *Journal of Exercise Science & Fitness*, *18*(2), 57–61.

Wilson T. A. (2016). *Respiratory mechanics.* Springer International Publishing.

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Tasarım *Design*	Yöntem ve araştırma desenini tasarlamak *To design the method and research design.*	Serhat ERAİL
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Veri Toplama ve İşleme *Data Collecting and Processing*	Verileri toplamak, düzenlemek ve raporlaştırmak *Collecting, organizing and reporting data*	Serhat ERAİL
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