2024, Retos, 61, 495-500

Determining the respiratory functions and isometric strength differences among recreational athletes and non-athletes: a cross-sectional analysis

Determinación de la función respiratoria y las diferencias de fuerza isométrica entre atletas recreativos y no atletas: un análisis transversal

Hussain Al Khowaildi, Mohammad Ahsan, Hadi Al Khalaf, Nasser Busaleh, Ammar Alabdullah, Yousif Al Ghamdi, Mohammed Al Omani, Mohammed AlSowaimel
Imam Abdulrahman Bin Faisal University (Kingdom of Saudi Arabia)

Abstract. Understanding the differences in respiratory functions and isometric strength between recreational athletes and non-athletes has a significant importance in the fields of Sports science, exercise physiology, and performance enhancement. The purpose of this study was to determine the respiratory functions and isometric strength differences among recreational athletes and non-athletes. A cross-sectional design was selected for this research with 16 recreational athletes and 16 non-athletes. Respiratory functions were assessed using spirometry tests, measuring parameters such as forced vital capacity (FVC), peak expiratory flow rate (PEFR), and forced expiratory volume in one second (FEV1). Isometric strength was measured by a handheld dynamometer for dominant and non-dominant hands. The results of the study showed a significant difference between recreational athletes and non-athletes for respiratory function parameters (FVC = t-3.00, p-.006 & FEV1= t-2.221, p-.011), whereas PEFR is insignificant (t-218, p-.219). The isometric strength is also significant between recreational athletes and non-athletes (Dominant arm = t—3.039, p-.005 & non-dominant arm= t-.255, p-.001). The study findings revealed significant differences in respiratory functions and isometric strength between recreational athletes and non-athletes, and there was a significant relationship between parameters. Athletes typically exhibit remarkable isometric strength due to their consistent engagement in activities designed to enhance muscle function. Future research should give priority to conducting long term studies that directly compare the effects of different sports disciplines on respiratory functions and isometric strength.
Keywords: Isometric Strength, Pulmonary Functions, Forced Vital Capacity, Peak Expiratory Flow Rate, FEV1, Recreational Athletes.

Resumen. Comprender las diferencias en la función respiratoria y la fuerza isométrica entre atletas recreativos y no atletas es de gran importancia en el campo de las ciencias del deporte, la fisiología del ejercicio y la mejora del rendimiento. El propósito de este estudio fue determinar las funciones respiratorias y las diferencias de fuerza isométrica entre atletas recreativos y no atletas. Para esta investigación se seleccionó un diseño transversal, con 16 deportistas recreativos y 16 deportistas no. Las funciónrespiratoria se evaluó mediante pruebas de espirometría, midiendo parámetros como la capacidad vital forzada (FVC), la tasa de flujo espiratorio máximo (PEFR) y el volumen espiratorio forzado en el primer segundo (FEV1). La fuerza isométrica se midió con un dinamómetro de mano para manos dominantes y no dominantes. Los resultados del estudio mostraron una diferencia significativa entre los atletas recreativos y los no atletas en los parámetros de la función respiratoria (FVC = t-3,00, p-0,006 y FEV1 = t-2,221, p-0,011), mientras que la PEFR es insignificante (t -218, pág-.219). La fuerza isométrica también es significativa entre deportistas recreativos y no deportistas (brazo dominante = t—3.039, p-.005 y brazo no dominante= t-.255, p-.001). Los hallazgos del estudio revelaron diferencias significativas en las funciones respiratorias y la fuerza isométrica entre los atletas recreativos y los no atletas, y hubo una relación significativa entre los parámetros. Los atletas suelen exhibir una fuerza isométrica notable debido a su participación constante en actividades diseñadas para mejorar la función muscular. Las investigaciones futuras deberían priorizar la realización de estudios a largo plazo que comparen directamente los efectos de diferentes disciplinas deportivas sobre las funciones respiratorias y la fuerza isométrica.
Palabras clave: Fuerza isométrica, Funciones pulmonares, Capacidad vital forzada, Tasa de flujo espiratorio máximo, FEV1, Deportistas recreativos.

Fecha recepción: 09-06-24. Fecha de aceptación: 10-09-24
Mohammad Ahsan
mahsan@iau.edu.sa

Introduction

The respiratory functions determine general health status and are an important physical fitness parameter. Studies showed that respiratory functions influence daily life activities and sports performance (Prieske et al., 2016). It is widely recognized that elite athletes and individuals who regularly participate in physical exercise generally have higher respiratory functions (Ganzit et al., 2019). The respiratory functions are affected by multiple factors, including metabolism, physiology (such as strength, power, speed, agility, and cardiovascular endurance), and anthropometry (Mazic et al., 2015). Respiratory functions are critical aspects when comparing recreational athletes and non-athletes. Ferreira et al., (2022) conducted research examining the effect of combined training on respiratory functions among adult non-athletes. The findings revealed that structured exercise programs could significantly improve respiratory function parameters, indicating that regular physical activity can enhance force vital capacity even in non-athlete individuals. Furthermore, research has demonstrated a correlation between respiratory functions and athletic performance (Boutellier et al., 1992; Ganzit et al., 2019). While it is well-acknowledged that skeletal muscles do not actively participate in respiration during regular breathing, it is believed that the muscles of the upper extremities assist in breathing as exercise intensity increases (Liu et al., 2019).

Isometric muscular strength is a vital component of physical fitness that has a significant impact on both everyday activities and athletic performance. Additionally, it plays a significant role in the prevention of sports injuries (Niemuth, 2007). Isometric strength differences between athletes and non-athletes, as well as within different groups of athletes based on the type of sport they participate in (such as endurance vs power sports), there is a general agreement that consistent and structured training improves muscular strength regardless of the specific sport being practiced (Abed et al., 2011; De Groot et al., 2012). Karatrantou et al., (2017) conducted a study comparing integrated and serial combined strength and aerobic training. The results showed that middle-aged females saw significant improvements in muscle strength and endurance, independent of the order in which the exercises were performed.

Prior research has examined the correlation between muscle strength and respiratory functioning. Several studies have indicated a correlation between muscle strength and respiratory functions (Bae et al., 2015; Kim, 2018; Liu et al., 2019). It is crucial in the field of sports science, exercise physiology, and performance enhancement to comprehend the differences in respiratory functions and isometric strength between recreational athletes and non-athletes. These parameters are important indicators of the general health status of both recreational athletes and non-athletes. However, the previous studies among these populations did not provide a clear understanding of the impact of recreational game participation or regular physical exercise compared to sedentary lives on these parameters. This study aimed to assess the respiratory functions and isometric strength differences between recreational athletes and non-athletes.

Methods

Study Design

This study adopted a cross-sectional study design, comparing the respiratory functions and isometric strength differences between recreational athletes and non-athletes. Both comparative and relationship study designs were included to provide a comprehensive understanding of the study.

Ethical Considerations

Prior to conducting the study, an ethical approval (IRB-UGS-2024-03-160) was obtained from the research review board of the Imam Abdulrahman Bin Faisal University. Prior to the data collection, written consent was obtained from all participants. This study was conducted according to Hilinski's principles.

Sample Size

The sample size was determined using G*Power software (Version 3.1.9.4) with the following parameters: Critical value = 2.00, Effect size = .80, α = .05, and 1-ß = .85. The allocation ratio was set at 1:1, resulting in a total sample size of 32, with 16 participants in each group.

Participants

All the participants in this study were male. They were classified into two groups, i.e. recreational athletes and non-athletes, with equal numbers in each group. Recreational athletes were selected from different sports disciplines, whereas non-athletes were chosen from the general population. Participants with a prior medical history of cardiovascular or respiratory problems or those who have taken medication that could potentially impact their performance during the test were excluded from the study.

Outcome measures

Respiratory Functions

Spirometry tests were conducted to evaluate respiratory functioning, measuring parameters including forced vital capacity (FVC), peak expiratory flow rate (PEFR), and forced expiratory volume in one second (FEV1).

Isometric Strength

The handheld dynamometer was used to assess isometric strength for both the dominant and non-dominant hands.

Procedure

Upon arrival at the physical therapy lab, participants were instructed to carefully read the aim, objectives, and associated risks and benefits of the study and sign the consent form if they agreed. After their written consent agreement, the collection procedure began. The data were collected individually for testing in a lab setting. First, the participants were instructed to wear the spirometry mask. They were then asked to inhale and exhale in a normal rhythm three times, followed by two rounds of maximum inhalation and exhalation. Once the test was completed, the results were displayed on the device. Next, the participants proceeded to the isometric strength test using a handheld dynamometer. This involved squeezing the grip with maximum force three times using their dominant hand, followed by three repetitions with their non-dominant hand. The average strength for each hand was recorded as a result. All the assessment tests were conducted under the supervision of a qualified researcher in a controlled environment to guarantee uniformity and reliability of measurements.

Statistical analysis

The collected data were statistically analyzed using SPSS (Version 23.0) for both descriptive and inferential analysis. The missing data, outliers, and normalcy were assessed, and it was determined that the data followed a normal distribution. Data analysis was conducted using parametric testing. The demographic data of both groups was compared using an independent t-test. An independent t-test was employed to ascertain the differences in respiratory functions and isometric strength between recreational athletes and non-athletes. The Pearson correlation coefficient test was also applied to determine the relationship between parameters. The statistical significance was established with a p-value of less than 0.05, and the confidence interval was set at 95%.

Results

Table 1.
Anthropometric characteristics of participants

	Participant Types	N	Mean (SD)	t	p
Age	Recreational Athlete	16	21.00 (1.41)	-.305	.763
	Non-Athlete	16	20.83 (1.40)		
Weight	Recreational Athlete	16	81.68 (19.29)	-.207	.838
	Non-Athlete	16	80.04 (21.80)		
Height	Recreational Athlete	16	176.50 (5.68)	.144	.696
	Non-Athlete	16	175.37 (8.52)		

* Significant at 0.05 level.

Table 1 shows that there is no significant difference between recreational athletes and non-athletes for their anthropometric characteristics.

Table 2.
Tests of Normality among recreational athletes and non-athletes.

Parameters	Participant Types	Shapiro-Wilk		
		Statistic	df	Sig.
FVC	Recreational Athlete	.923	15	.309
	Non-Athlete	.917	15	.172
FEV1	Recreational Athlete	.893	15	.130
	Non-Athlete	.959	15	.667
PEFR	Recreational Athlete	.891	15	.120
	Non-Athlete	.929	15	.264
Strength Dom	Recreational Athlete	.973	15	.940
	Non-Athlete	.951	15	.543
Strength non-Dom	Recreational Athlete	.970	15	.914
	Non-Athlete	.918	15	.183

The table showed that there is a normal distribution for all the parameters among athletes and non-athletes. Thus, parametric tests were applied for further analysis.

Table 3.
Descriptive and inferential statistics between recreational athletes and non-athletes for different parameters

	Sport Types	N	Mean	t	Sig. (2-tailed)
FVC	Recreational Athlete	16	4.12 (.58)	-3.007	.006*
	Non-Athlete	16	3.33 (.78)		
FEV1	Recreational Athlete	16	3.60 (.79)	2.221	.011*
	Non-Athlete	16	2.85 (.57)		
PEFR	Recreational Athlete	16	5.73 (2.43)	.218	.219
	Non-Athlete	16	4.61 (2.14)		
Strength Dom	Recreational Athlete	16	53.00 (9.96)	-3.039	.005*
	Non-Athlete	16	41.89 (8.73)		
Strength non-Dom	Recreational Athlete	16	52.71 (10.93)	3.255	.001*
	Non-Athlete	16	39.39 (6.70)		

* Significant at 0.05 level.

Table 3 shows that there is a significant difference between recreational athletes and non-athletes for respiratory function parameters (FVC = t-3.00, p-.006 & FEV1= t-2.221, p-.011), whereas PEFR is insignificant (t-218, p-.219). The isometric strength is also significant between recreational athletes and non-athletes (Dominant arm = t—3.039, p-.005 & non-dominant arm= t-.255, p-.001).

Table 4 showed that there is a significant positive relationship between respiratory parameters (FVC, FEV1, PEFR) and arm strength (Dominant and non-dominant) among players, except for the PEF parameter.

Table 4.
Relationship between respiratory parameters and arm strength among players.

		FVC	FEV1	FEV1FVC	PEF	Strength Dom
FEV1	Pearson Correlation	.755**				
	Sig. (2-tailed)	.000				
PEFR	Pearson Correlation	.298	.626**	.525**		
	Sig. (2-tailed)	.132	.000	.005		
Strength Dom	Pearson Correlation	.495**	.427*	.039	.236	
	Sig. (2-tailed)	.009	.026	.848	.236	
Strength non-Dom	Pearson Correlation	.561**	.540**	.055	.309	.860**
	Sig. (2-tailed)	.002	.004	.786	.117	.000

** Significant at 0.01 level, * Significant at 0.05 level.

Discussion

Understanding the differences in respiratory functions and isometric strength between recreational athletes and non-athletes is an essential aspect of exercise physiology, performance improvement, and success in sports. This study attempts to determine the respiratory functions and isometric strength differences between recreational athletes and non-athletes. The finding of the study revealed that there is a significant difference between recreational athletes and non-athletes for respiratory function parameters (FVC = t-3.00, p-.006 & FEV1= t-2.221, p-.011), whereas PEF is insignificant (t-218, p-.219). The isometric strength is also significant between recreation athletes and non-athletes. The current findings supported previous studies that have shown that athletes generally exhibit higher lung capacity in comparison to individuals who do not engage in athletic activities. Vedala et al., (2013) also demonstrated that the athletic group had higher mean values for FVC (88.0 ± 12.8%), FEV1 (86.8 ± 22.0%), FEV3 (86.5 ± 13.7%), PEFR (93.0 ± 12.8%), and FEV1/FVC ratio (92.1 ± 4.4%) compared to the non-athletic group. In the same direction, In the study conducted by Myrianthefs et al., (2014), which involved 276 athletes participating in different sports, the findings were similar to those found in our study. The authors revealed that the respiratory function parameters (VC, FVC, FEV1, and MVV) are better in athletes than in the general population and also the highest among athletes participating in water-based sports. Bernhardsen et al., (2023) found that swimmers and ball game athletes had greater average forced vital capacity and forced expiratory volume in one second when compared to the reference values estimated by the Global Lung Initiative equation. Rochat et al., (2022) conducted a review of the lung function characteristics of athletic swimmers. They discovered that these swimmers have superior expiratory flows and higher baseline lung volumes compared to individuals who are not athletes. Both genetic predisposition and adaptive reactions resulting from hard training contribute to this phenomenon. Regular participation in recreational physical sports activities can also enhance the synthesis of contractile proteins, such as actin and myosin. An athlete's respiratory function may be enhanced compared to that of non-athletes due to increased muscle contraction strength. This improvement is attributed to changes in lung muscle strength, expansion, elasticity, and balance (Vedala et al., 2013). Mahotra et al., (2017) reported that the force vital capacity in athletes was markedly greater compared to non-athletes. Engaging in muscular exercise enhances the frequency and intensity of breathing and enhances FVC, oxygen consumption, and the rate of diffusion. Gowhar & Jaan, (2019) demonstrated that athletes engaging in rigorous physical training experience enhanced respiratory function in comparison to individuals who do not participate in athletic activities. Multiple Indian research has demonstrated that the length of physical activity impacts respiratory function.

The analysis of isometric strength differences between recreational athletes and non-athletes provides valuable insights into the physiological changes brought about by consistent athletic training compared to a sedentary way of life. The result of this study showed that the isometric strength was significant (Dominant arm = t—3.039, p-.005 & non-dominant arm= t-.255, p-.001) between athletes and non-athletes. The findings are consistent with the findings of others, as Trajkov et al., (2018) investigate the isometric strength of hand muscles in older women who are physically active compared to those who are sedentary. Their research indicates that there were significant differences in maximal force between the two groups. However, it does emphasize that physically active individuals had a greater rate of force development and muscular strength. This implies that the maximum strength during static contractions may vary significantly between individuals who participate in sports and those who do not. Giles et al., (2006) present a thorough examination of the physiology of rock climbers, emphasizing that although the overall hand strength of climbers does differ significantly from that of the general population, top climbers have notably higher relative hand strength when corrected for body mass. This investigation emphasizes the significance of taking body composition into account when assessing hand strength measurements in athletes compared to non-athletes. Eastwood et al., (2001) showed that endurance athletes have higher inspiratory muscular endurance compared to inactive individuals. This is not due to stronger respiratory muscles but rather because they have a more beneficial breathing pattern during exercises that include breathing against resistance. This discovery emphasizes the importance of sensory conditioning in improving overall strength by optimizing respiratory mechanics. Zwolski et al., (2017) present indirect evidence indicating that engaging in structured physical activity improves muscular strength in individuals of different age groups. The study's results indicate that engaging in resistance training might enhance overall muscle fitness, including handgrip strength. This improvement in muscle strength may help explain the difference observed between athletes and non-athletes.

Much research has examined the relationship between isometric muscular strength and respiratory functions. A systematic review conducted by Mgbemena et al., (2022) revealed a significant positive relationship between hand grip strength and respiratory function measurements, such as forced expiratory volume in one second. It forced vital capacity in both healthy and unhealthy populations. Zhu et al., (2020) study examined Chinese people without cardiopulmonary disease and found significant positive correlations between handgrip muscle strength and vital capacity, as well as forced expiratory volume in one second. This suggests that increased muscle strength may improve respiratory efficiency. Zhao et al., (2023) employed Mendelian randomization to investigate the causal relationship between isometric muscle strength and respiratory function. They utilized genetic data from extensive cohorts for their analysis. The study demonstrated that there are positive causal relationships between genetically determined handgrip isometric muscle strength, and both forced vital capacity with an odds ratio of 1.519 and forced expiratory volume in one second with an odds ratio of 1.486. This finding supports the concept that muscle strength has a direct impact on respiratory capacity. The existing studies strongly confirm a significant correlation between respiratory function and hand isometric strength in different groups. There is a positive correlation between stronger handgrip isometric strength and better respiratory functions. This means that having a stronger handgrip is associated with higher FEV1 and FVC values, which indicate increased respiratory efficiency. This is likely because having stronger muscles overall, including the respiratory muscles, contributes to better respiratory health.

This study has some limitations due to the design of this cross-sectional study; it is not possible to establish causation, but the finding can be verified through prospective studies in the future. The data provided by recreational athletes and non-athletes was based on their reports, and we did not have any reliable source to verify the information. The sample size was small and limited to the types of sports population. Furthermore, we did not employ the grip strength measurement protocols endorsed by the American Society of Hand Therapists or the South Hampton group.

Conclusion

The result of the study demonstrates significant differences in respiratory function and isometric strength between recreational athletes and non-athletes, which might be due to differences in levels of participation in recreational sports activities, physical activity and specific training programs. Athletes usually demonstrate exceptional isometric strength as a result of regularly participating in exercises aimed at improving muscular function. However, those who are not involved in athletic activities might make substantial advancements by following well-organized resistance training regimens. Future research should prioritize doing longitudinal studies that compare the effects of various sports disciplines on isometric strength. This will help provide a clearer understanding of the links between these factors.

References

Abed, K., Rebai, H., Bloomer, R. J., Trabelsi, K., Masmoudi, L., Zbidi, A., Sahnoun, Z., Hakim, A., & Tabka, Z. (2011). Antioxidant status and oxidative stress at rest and in response to acute exercise in judokas and sedentary men. *Journal of Strength and Conditioning Research*, *25*(9). https://doi.org/10.1519/JSC.0b013e3181fc5c35

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). https://doi.org/10.1589/jpts.27.2687

Bernhardsen, G. P., Stang, J., Halvorsen, T., & Stensrud, T. (2023). Differences in lung function, bronchial hyperresponsiveness and respiratory health between elite athletes competing in different sports. *European Journal of Sport Science*, *23*(8). https://doi.org/10.1080/17461391.2022.2113144

Boutellier, U., Büchel, R., Kundert, A., & Spengler, C. (1992). The respiratory system as an exercise limiting factor in normal trained subjects. *European Journal of Applied Physiology and Occupational Physiology*, *65*(4). https://doi.org/10.1007/BF00868139

De Groot, S., Janssen, T. W. J., Evers, M., Van Der Luijt, P., Nienhuys, K. N. G., & Dallmeijer, A. J. (2012). Feasibility and reliability of measuring strength, sprint power, and aerobic capacity in athletes and non-athletes with cerebral palsy. *Developmental Medicine and Child Neurology*, *54*(7). https://doi.org/10.1111/j.1469-8749.2012.04261.x

Eastwood, P. R., Hillman, D. R., & Finucane, K. E. (2001). Inspiratory muscle performance in endurance athletes and sedentary subjects. *Respirology*, *6*(2). https://doi.org/10.1046/j.1440-1843.2001.00314.x

Ferreira, J. P., Duarte-Mendes, P., Teixeira, A. M., & Silva, F. M. (2022). Effects of combined training on metabolic profile, lung function, stress and quality of life in sedentary adults: A study protocol for a randomized controlled trial. *PLoS ONE*, *17*(2 February). https://doi.org/10.1371/journal.pone.0263455

Ganzit, G. P., Scarzella, F., Cravero, M., Tarozzo, C., & Beratto, L. (2019). Evaluation of the effects of respiratory training on functional aerobic capacity in young soccer players. *Medicina Dello Sport*, *72*(4). https://doi.org/10.23736/S0025-7826.19.03589-0

Giles, L. V., Rhodes, E. C., & Taunton, J. E. (2006). The physiology of rock climbing. In *Sports Medicine* (Vol. 36, Issue 6). https://doi.org/10.2165/00007256-200636060-00006

Gowhar, M., & Jaan, I. (2019). A Study on Effect of Acute Exercise on Pulmonary Function Tests of First Year M.B.B.S. Students. *International Journal of Physiology*, 7(4), 141. https://doi.org/10.5958/2320-608x.2019.00157.4

Karatrantou, K., Gerodimos, V., Häkkinen, K., & Zafeiridis, A. (2017). Health-Promoting Effects of Serial vsIntegrated Combined Strength and Aerobic Training. *International Journal of Sports Medicine*, *38*(1). https://doi.org/10.1055/s-0042-116495

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). https://doi.org/10.12965/jer.1836444.222

Liu, X., Li, P., Wang, Z., Lu, Y., Li, N., Xiao, L., Duan, H., Wang, Z., Li, J., Shan, C., & Wu, W. (2019). Evaluation of isokinetic muscle strength of upper limb and the relationship with pulmonary function and respiratory muscle strength in stable COPD patients. *International Journal of COPD*, *14*. https://doi.org/10.2147/COPD.S214737

Mahotra, N. B., Amatya, T. M., Rana, B. S., & Banstola, D. (2017). Effects of exercise on pulmonary function tests: A comparative study between athletes and non-athletes in Nepalese settings. *Journal of Chitwan Medical College*, 6(1). https://doi.org/10.3126/jcmc.v6i1.16575

Mazic, S., Lazovic, B., Djelic, M., Suzic-Lazic, J., Djordjevic-Saranovic, S., Durmic, T., Soldatovic, I., Zikic, D., Gluvic, Z., & Zugic, V. (2015). Respiratory parameters in elite athletes - does sport have an influence? *Revista Portuguesa de Pneumologia* , *21*(4). https://doi.org/10.1016/j.rppnen.2014.12.003

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). https://doi.org/10.1080/09593985.2021.1901323

Myrianthefs, P., Grammatopoulou, I., Katsoulas, T., & Baltopoulos, G. (2014). Spirometry may underestimate airway obstruction in professional Greek athletes. *Clinical Respiratory Journal*, *8*(2). https://doi.org/10.1111/crj.12066

Niemuth, P. E. (2007). The role of hip muscle weakness in lower extremity athletic injuries. In *International SportMed Journal* (Vol. 8, Issue 4).

Prieske, O., Muehlbauer, T., & Granacher, U. (2016). The Role of Trunk Muscle Strength for Physical Fitness and Athletic Performance in Trained Individuals: A Systematic Review and Meta-Analysis. In *Sports Medicine* (Vol. 46, Issue 3). https://doi.org/10.1007/s40279-015-0426-4

Rochat, I., Côté, A., & Boulet, L. P. (2022). Determinants of lung function changes in athletic swimmers. A review. In *Acta Paediatrica, International Journal of Paediatrics* (Vol. 111, Issue 2). https://doi.org/10.1111/apa.16095

Trajkov, M., Cuk, I., Eminovic, F., Kljajic, D., & Dopsaj, M. (2018). Relationship between hand grip strength and endurance and postural stability in active and sedentary older women. *Journal of Electromyography and Kinesiology*, *43*. https://doi.org/10.1016/j.jelekin.2018.09.006

Vedala, S. R., Paul, N., & Mane, A. B. (2013). Differences in pulmonary function test among the athletic and sedentary population. *National Journal of Physiology, Pharmacy and Pharmacology*, *3*(2). https://doi.org/10.5455/njppp.2013.3.109-114

Zhao, X., Xu, W., Gu, Y., Li, Z., & Sun, G. (2023). Causal associations between hand grip strength and pulmonary function: a two-sample Mendelian randomization study. *BMC Pulmonary Medicine*, *23*(1). https://doi.org/10.1186/s12890-023-02720-0

Zhu, R., Li, W., Xia, L., Yang, X., Zhang, B., Liu, F., Ma, J., Hu, Z., Li, Y., Li, D., Jiang, J., He, Y., & Shan, G. (2020). Hand grip strength is associated with cardiopulmonary function in Chinese adults: Results from a cross-sectional study. *Journal of Exercise Science and Fitness*, *18*(2). https://doi.org/10.1016/j.jesf.2019.12.001

Zwolski, C., Quatman-Yates, C., & Paterno, M. V. (2017). Resistance Training in Youth: Laying the Foundation for Injury Prevention and Physical Literacy. *Sports Health*, *9*(5). https://doi.org/10.1177/1941738117704153

Datos de los/as autores/as y traductor/a:

Hussain Al Khowaildi	2210000235@iau.edu.sa	Autor/a
Mohammad Ahsan	mahsan@iau.edu.sa	Autor/a
Hadi Al Khalaf	2210000631@iau.edu.sa	Autor/a
Nasser Busaleh	2210000732@iau.edu.sa	Autor/a
Ammar Alabdullah	2210000727@iau.edu.sa	Autor/a
Yousif Al Ghamdi	2210000286@iau.edu.sa	Autor/a
Mohammed Al Omani	2210000042@iau.edu.sa	Autor/a
Mohammed AlSowaimel	2210000070@iau.edu.sa	Autor/a
Mohammad Feroz Ali	ali.feroz@fnu.ac.fj	Traductor/a