The role of body composition on cardio-respiratory fitness in futsal competitive athletes

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Abstract

Futsal is an intermittent high intensity sport which has become popular worldwide. Body composition and physical fitness have been studied in different sports disciplines. However, little is known regarding body composition and cardio-respiratory performance in competitive futsal players. Body composition parameters were analyzed by electrical impedance body composition analyzer in 31 competitive male futsal players. All participants performed spirometry, handgrip strength and cardiopulmonary exercise testing. Significant correlations were observed between muscle mass and spirometry parameters and peak VO2 ($p \leq 0.05$). Fat mass resulted inversely correlated with peak VO2% predicted and hand grip strength ($p \leq 0.05$). Regression analysis showed that muscle mass significantly predicts respiratory parameters ($p<0.01$) and reduced fat mass is associated with increased peak VO2 % predicted and handgrip strength ($p<0.01$). In futsal competitive athletes increased muscle mass is associated with higher spirometry parameters and fat mass is inversely associated with lower cardiorespiratory fitness.

Key Words: futsal; cardiopulmonary exercise testing; handgrip strength; fat mass; muscle mass.

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Futsal is a five-a-side indoor soccer officially authorized by International Association Football Federation (FIFA), which has been played for more than 80 years and has become popular worldwide.[1] Futsal is played within professional, semi-professional and amateur level in a 40 x 20 m court, with 3x2 m goal posts, 4 outfield players and 1 goalkeeper. A futsal match is organized in 2 halves of 20 minutes, separated by a 10-minute break. During match-play 1-minute time-out in each half may be requested by the teams. In competitions the squad consist of a maximum of 14 players and a number of unlimited substitutions are permitted. Futsal is an intermittent high intensity sport and the physiological demands during competitions are high: about 80% of maximum oxygen uptake (VO2 max) and more than 85% of maximal heart rate.[2] It has been reported that in elite futsal players mean values of VO2 uptake as measured by a portable gas analyzer reach up to 62.9 ml/kg/min. Compared to professional players, semi-professional futsal players have a significant lower VO2 max 55.2 vs 62.8 ml/kg/min, but with minimal difference in VO2 at the ventilatory threshold (VT) expressed as percentage of VO2 max.[3] High number of matches during a season and high intensity movements as sprinting and trackling activate the anaerobic component and may explain the above-mentioned findings. According to different studies,[4,5] futsal players do not display significant differences regarding body composition and anthropometric characteristics as compared to the competitive level. Indeed, similar fat mass has been described in elite and sub-elite futsal players, but with differences in lean mass between dominant and non-dominant legs. In contrast, compared to elite soccer players a higher body fat percentage has been described among futsal elite players.[6] It has been reported that respiratory parameters, measured by spirometry are significantly higher in elite athletes compared to general population regardless of age.[7,8] Forced vital capacity (FVC) resulted higher in all sports disciplines compared to references values and forced expiratory volume in the 1st second (FEV1) was higher among ball games athletes.[9] Another study reported that futsal players presented lower FEV1 and FVC compared to soccer athletes.[10] Furthermore, it has been suggested that muscle mass is positively associated with both FEV1 and FVC in athletes and body composition may be helpful in monitoring respiratory function.[11] However, little is known regarding body composition and cardio-respiratory performance in competitive futsal athletes.

In this study we aimed to describe the relationship between body composition parameters and cardiorespiratory performance in competitive futsal male athletes.

Materials and Methods

In this study competitive futsal athletes undergoing medical check-up and clinical evaluation in Exercise and Sports Medicine Unit “Antonio Cardarelli Hospital”, Department of Medicine and Health Sciences, University of Molise, Italy, from January 2019 to December 2020 were considered for enrollment. Competitive athletes are defined as individuals training at least 5 h per week being regularly involved in competitions.[12] The clinical evaluation of athletes consists on anamnestic information regarding cardiovascular risk factors, comorbidities and medications, body composition measurements, spirometry, exercise stress testing or cardiopulmonary exercise testing (CPET). Athletes participating in this study were included if the following inclusion criteria were met: a) age ≥ 16 years, b) no injuries in the three months prior to the clinical evaluation c) taking no dietary supplements for improving muscle mass, and d) the absence of medical conditions, or medications which could influence respiratory function. Data from athletes which performed treadmill exercise testing instead of CPET were not considered for this study. All participants or their legal representative in the case of athletes of age younger than 18 years, provided informed written consent for anonymous data collection prior to the study. All procedures were approved by the Institutional Review Board of Department of Medicine and Health Sciences, University of Molise, Italy and conducted in accordance with the declaration of Helsinki for studies on humans.

Height was measured with a stadiometer (Wunder SA. Bl. srl A 200), bare feet in standing upright position. Body mass, fat-free mass, muscle mass, percentage of muscle mass, fat mass, percentage of fat mass, and BMI were estimated via the electrical impedance body composition analyzer foot to foot TANITA BC-420MA (Tanita Corporation, Tokyo, Japan), as indicated by the manufacturer.

Lung function was measured by maximum flow- volume loops using a spirometer (Sensormedics Viasys Carefusion Vmax Encore 22). Spirometry was performed, with the subjects seated, wearing a nose clip, on the same after body composition measurements. All measurements and maneuvers were performed based on recommended standard.[13] Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and FEV1/FVC were measured and recorded as actual values and percent of predicted.

Hand grip strength was evaluated with handheld dynamometer DynX (MD Systems, Inc, Ohio, USA). Measurements were performed as described elsewhere.[14] In brief, the participant in a seating position performed a maximal effort for three times both in the right and left sides. Participants were asked to squeeze maximally for 5 seconds and the higher average of the two sides was assigned dominance. The mean result of three measurements from the dominant side was recorded in kilograms (Kg).

Respiratory gas exchange measurements and physical performance parameters were obtained by the use of a treadmill Cosmed T150med, a two-way breathing Hans Rudolph 7450 series V2 mask and headgear applied on the subject. The exercise stress on treadmill test started with 8 km/h speed and continuing with stepwise increases of 1 km/h every minute. After reaching a speed of 14 km/h, the treadmill inclination was increased by 1% every minute. For all subjects was required continuous electrocardiogram (ECG) monitoring using a 12 lead ECG recording system Quark T12X wireless12-lead and frequent arterial blood pressure measurements during exercise. All participants were encouraged to exercise until exhaustion. The test finished when one of the following conditions were met: Rate of Perceived Exertion > 8; Failure of oxygen uptake or heart rate (HR) due to additional increase in work rate. Peak respiratory exchange ratio (RER) ≥ 1.04.

Descriptive data are presented as mean and standard deviation (SD), or number and percentage. Shapiro-Wilk test was performed to evaluate the normality of data distribution. Population was divided in age tertiles and one-way ANOVA analysis was performed. Correlations between variables of interest were evaluated by Pearson’s correlation coefficient. For instance, correlation between body mass, muscle mass, fat free mass, fat mass, spirometry parameters and peak VO2, peak VO2 expressed as percentage predicted, first Ventilatory Threshold (VT) and maximal HR were explored. Pearson's correlation coefficient was calculated also for correlation between age, body composition and physical performance data. Regression analysis adjusted for age and height was performed to evaluate the association between variables which presented significant correlation as evaluated by Pearson's coefficient. Data were analyzed by STATA SE 16.1 (StataCorp LLC, College Station, TX, USA). The statistical significance was set at $p \leq 0.05$.

Results

A total of 31 non-professional men's futsal athletes were evaluated during the mid-season. All athletes trained regularly 5 sessions per week for 1.5 h and a weekend game, mean years of training 7.32 ± 3.50. Mean age was 24.35 ± 4.69 years and mean body mass index (BMI) 23.69 ± 2.02 kg/m2. Mean fat mass in kilogram was 8.97 ± 3.06 kg and expressed as percentage of body mass: 12.24 ± 3.61. Mean FVC resulted 5.18 ± 0.57; and mean FEV1: 4.46 ± 0.61 l. Physical performance parameters were as follows: mean hand grip strength 43.45 ± 7.41 kg and mean peak VO2 expressed as percentage predicted: 106.45 ± 16.25 %. No significant differences resulted across age tertiles, except for muscle mass (MM) (p=0.03). Table 1 shows, in details measurements of body composition, spirometry and CPET in our study population and stratification in age tertiles. Pearson's correlation coefficient revealed a significant correlation between muscle mass and FEV1 and FVC; fat free mass and FEV1 and FVC. Significant correlations were also observed between body mass, muscle mass, fat free mass and peak VO2. Fat mass and fat mass percentage resulted inversely correlated with peak VO2% predicted; and 1st ventilatory threshold (VT). In addition, fat mass percentage inversely correlated with hand grip strength. Table 2 and Table 3 report the correlations between the above-mentioned parameters. Correlation analysis regarding age, years of training and body composition, spirometry and physical performance characteristics are reported in Supplementary Material Table 1. Finally, regression analysis showed that muscle mass and fat free mass significantly predicted respiratory parameters as

***Table 1**. Characteristics of futsal athletes stratified by age tertiles.*

Characteristics	Overall Population (n= 31)	Tertile I (n=11)	Tertile II (n=10)	Tertile III (n=10)	p-value
Age, Mean SD	24.35 ± 4.69	19.54 ± 1.97	24.4 ± 0.97	29.6 ± 3.02	0.008
Gender Male, n (%)	31 (100)	-	-	-	-
Years of training, Mean, SD	7.32 ± 3.50	4.81 ± 1.40	6.20 ± 1.22	11.2 ± 3.35	≤0.0001
Body Mass kg, Mean, SD	72.78 ± 8.13	71.01± 6.85	71.38 ± 4.74	76.13 ± 11.2	0.29
Height m, Mean, SD	1.75 ± 0.06	1.73 ± 0.05	1.77 ± 0.05	1.76 ± 0.08	0.33
BMI kg/m2, Mean, SD	23.69 ± 2.02	23.73 ± 2.10	22.81± 1.26	24.52 ± 2.36	0.17
FFM kg, Mean, SD	63.95 ± 7.01	61.73 ± 6.18	62.17 ± 2.90	68.17 ± 9.13	0.07
MM kg, Mean SD	60.26 ± 6.61	58.08 ± 4.59	58.08 ± 3.45	64.85 ± 8.72	0.03
MM %, Mean SD	83.05 ± 6.35	81.99 ± 4.40	81.78 ± 8.33	85.46 ± 5.83	0.35
FM kg, Mean SD	8.97 ± 3.06	8.40 ± 3.35	9.18 ± 2.47	9.39 ±3.46	0.75
FM%, Mean SD	12.24 ± 3.61	11.68 ± 3.97	12.92 ± 3.64	12.17± 3.42	0.74
FVC l, Mean SD	5.18 ± 0.57	4.95 ± 0.56	5.07 ± 0.57	5.55 ± 0.45	0.16
FVC % predicted, Mean SD	99.74 ± 11.32	97.36 ± 10.95	99.20 ± 10.68	102.90 ±12.71	0.54
FEV1 l, Mean SD	4.46 ± 0.61	4.33 ± 0.39	4.22 ± 0.61	4.84 ± 0.68	0.06
FEV1 % predicted, Mean SD	102.23 ± 11.91	101.27 ± 8.33	97.70 ± 12.02	107.80 ± 13.88	0.16
FEV1/FVC % predicted, Mean SD	102.30 ± 10.89	102.34± 10.59	99.4 ± 13.98	105.14 ± 7.49	0.51
Handgrip Strength Kg, Mean SD	43.45 ± 7.41	41.42 ± 4.97	43.79± 8.24	45.34 ± 8.87	0.49
HR rest bpm, Mean SD	60.97 ± 11.61	60.82 ± 15.57	62.80 ± 8.70	59.30 ± 9.88	0.81
VO2 rest ml/kg/min, Mean SD	4.95 ± 1.18	4.87 ± 1.11	5.13 ± 1.30	4.85 ± 1.21	0.84
VCO2 rest ml/min, Mean SD	0.28 ± 0.10	0.27 ± 0.98	0.32 ± 0.13	0.25 ± 0.07	0.32
peak VO2 ml/min, Mean SD	3372.17 ± 539.69	3433.51± 440.77	3282.33 ±706.73	3394.53 ± 491.34	0.81
peak VO2 ml/min/kg, Mean SD	46.53 ± 7.03	48.34 ± 4.04	46.13 ± 10.17	44.95 ± 6.03	0.55
peak VO2 % predicted, Mean SD	106.45 ± 16.25	109.91± 9.32	104.7 ± 23.00	104.4 ± 15.22	0.69
1st VT % peak VO2 predicted, Mean SD	75.11 ± 6.38	75.35 ± 7.95	75.53 ± 5.09	74.41 ± 6.02	0.92
peak HR bpm, Mean SD	164.65 ± 0.08	165.54 ± 10.75	165.90 ± 16.55	162.40 ± 9.26	0.79
peak O2 pulse ml/beat, Mean SD	21.50 ± 3.84	21.93 ± 3.91	20.87 ± 3.76	21.67 ± 4.15	0.82
peak RER	1.05 ± 0.08	1.04 ± 0.08	1.1 ± 0.07	1.01± 0.08	0.14
peak BR %, Mean SD	40.82 ± 7.38	42.83 ± 6.27	43.02 ± 8.38	36.4 ± 5.95	0.07
VE/VCO2 slope, Mean SD	29.08 ± 2.72	28.42 ± 3.2	28.45 ± 1.74	30.43 ± 2.73	0.17

BMI: body mass index; BR: breathing reserve; FFM: fat free mass; FM: fat mass; FEV1: forced expiratory volume in 1st second; FVC: forced vital capacity; HR: heart rate; MM: muscle mass; RER: respiratory exchange ratio; VCO2: carbon dioxide uptake; VE: ventilation; VO2: oxygen uptake; VT: ventilatory threshold.

***Table 2**. Correlations between body composition and spirometry measurements.*

	FEV1	FEV1 % predicted	FVC	FVC % predicted	FEV1/FVC % predicted
Body Mass	0.24	-0.02	0.28	-0.09	0.06
MM	0.47*	-0.01	0.53*	-0.14	0.10
MM%	0.33	0.01	0.36*	-0.06	0.06
FFM	0.46*	-0.02	0.51*	-0.15	0.12
FM	-0.04	-0.17	0.18	-0.03	-0.18
FM%	-0.14	-0.20	0.10	-0.01	-0.23

*FEV1: forced expiratory volume in 1st second; FFM: fat free mass; FM: fat mass; FVC: forced vital capacity; MM: muscle mass. *Significant coefficient (p≤0.05).*

FVC and FEV1 and fat mass and fat mass percentage predicted peak VO2 expressed as percentage of predicted VO2 max and handgrip strength. Regression analysis is summarized in Table 4.

Discussion

The present study showed that in a population of competitive futsal male athletes body composition parameters are significantly correlated with spirometry measurements and predict physical performance. De Mura et al.[15] reported that body fat percentage in futsal players ranged from 10 to 13%. In our study we found a mean fat mass expressed as percentage of body mass of about 12%. Our results are in agreement with this previous report. Despite different studies have described anthropometric measures in futsal players of different competitive levels or playing positions, it should be highlighted that description of muscle mass was lacking.[1,2,16] A previous study, focused on description of body mass components in soccer players,[17] reported a mean muscle mass of about 40 kg. However, in this study a wide range of age groups were included, and in football players under 20 years there was a lower absolute muscle mass compared to older age groups. In line with this study, our results also report a lower absolute muscle mass among younger futsal athletes. The mean muscle mass in our study resulted around 60 kg, and this may be explained by training programs and high intensity activities which characterize futsal match. Indeed, greater percentage of muscle mass contributes to higher energy production.[18] As expected, muscle mass and respiratory

***Table 3**. Correlations between body composition and physical performance measurements.*

	Hand grip strength	peak VO2 ml/min	peak VO2 % predicted	1st VT% predicted	Peak HR
Body Mass	0.03	0.4*	-0.28	-0.31	-0.18
MM	0.05	0.36*	-0.15	-0.29	-0.29
MM %	0.01	-0.10	0.16	0.01	-0.17
FFM	0.07	0.39 *	-0.18	-0.23	-0.33
FM	-0.28	-0.16	-0.51*	-0.52*	-0.17
FM%	-0.38*	-0.37*	-0.55*	-0.47*	-0.13

*FFM: fat free mass; HR: heart rate; MM: muscle mass; peak VO2: peak oxygen uptake; VT: ventilatory threshold. *Significant coefficient (p≤0.05).*

***Table 4**. Regression analysis of FVC, FEV1, peak VO2% predicted and hand grip strength.*

Variable	R2	Coefficient Beta	p-value
		FVC	
MM	0.32	0.04	0.02
FFM	0.31	0.04	0.03
		FEV1	
MM	0.26	0.04	0.03
FFM	0.27	0.04	0.03
		peak VO2% predicted	
FM	0.32	-2.10	0.001
FM%	0.30	-2.47	0.002
		1st VT	
FM	0.27	-1.08	0.003
FM%	0.22	-0.82	0.009
		Hand Grip Strength	
FM%	0.25	-0.76	0.032

1st VT: first ventilatory threshold; FFM: fat free mass; MM: muscle mass; FEV1: forced expiratory volume in 1st second; FVC: forced vital capacity; peak VO2: peak oxygen uptake predicted.

parameters resulted significantly correlated. Physical activity has a direct influence on modification of body composition by reducing fat mass and increasing muscle mass, and ameliorates respiratory performance.[19-21] However, description of respiratory and musculoskeletal relationship in futsal athletes is not well established and our result is of interest considering also future studies which may explore respiratory adaptation in relationship to training programs and body composition modification in this population. Handgrip strength is a powerful indicator of muscle strength, and a significant relationship between muscle mass and handgrip strength has been described.[22] Furthermore, loss of skeletal muscle mass is an important contributor to the age-related reduction in anaerobic power, even among master athletes.[23] In our population hand grip strength did not result significantly associated to muscle mass probably because of the limited number of participants and the young age of our participants. Of interest, higher fat mass was associated with lower handgrip strength. Most of the studies focus on muscle mass- handgrip strength relationship, and only a recent study focused on the relationship of muscle mass, fat mass and muscle strength among adolescents described a significant relationship of fat mass index with hand grip strength independently of muscle mass.[24] Our population was characterized by a mean peak VO2 of about 46 ml/kg/min and the first ventilatory threshold was reached at about 70% of the peak VO2. Our results are similar to another study, which described that peak VO2 of among futsal athletes ranged between 40 to 46 ml/kg/min.[15] Other studies have shown higher peak VO2 levels, however these studies included professional or elite futsal players.[25-27] Our results indicate that reduced fat mass is characterized by increased hand grip strength and peak VO2 consumption. A previous study concluded that fat mass does not influence maximal VO2, and excess in adipose tissue does not necessarily imply reduction of VO2 consumption during exercise.[28] However, this study included pediatric population. In contrast, another study observed that increased fat mass percentage was associated with reduction of VO2 max in health young adults of age 18-25 years.[29] Of note, a recent study described that higher fat mass negatively affected aerobic power, and phase angel was positively associated to VO2 max.[30] Another study also reported that increased fat mass percentage reduces exercise capacity but VT was not effected by fat mass.[31] In our study, fat mass negatively influenced VT, indicating that anaerobic threshold is influenced by body composition and the level of cardiorespiratory fitness in futsal players depends also on adipose tissue. Furthermore, monitoring of fat mass variations in futsal athletes may indicate modifications in their physical performance status. In addition, training program and nutritional lifestyle should be also targeted to fat mass distribution. CPET is the gold standard for the evaluation of physical capacity and peak VO2 is a well-established parameter of physical performance status. In the context of sports medicine, identification of body composition parameters associated with physical performance is of great importance. Assessment of body composition characteristics as fat mass and muscle mass which predict physical capacity parameters in competitive futsal athletes is useful to establish what modifications may be adapted to ameliorate physical capacity. In addition, fat mass estimation through bioelectrical impedance analysis (BIA) may represent a support for screening of physical capacity and monitoring of training programs. Over the past years, different methods have been applied for the measurements of body composition. Despite dual-energy x-ray absorptiometry is still the gold standard of body composition evaluation, bioelectrical impedance analysis (BIA) is a safe, easy to use method which allows valid, reliable and replicable estimation of body composition.[32,33] It should be mentioned that estimation of fat mass by BIA is based on predictive equations developed for not physical active or general athletic population.[33] Of interest a recent study reported that anthropometry based generalized equations overestimated fat mass percentage, while BIA based generalized equations underestimated this parameter in futsal athletes.[34] Furthermore, this study demonstrated that a futsal-specific equation allows a more accurate and precise fat mass percentage estimation by using BIA or anthropometric measures interchangeably. Limitations of study are that it is a single center observational study including a limited number of participants. Other characteristics of body composition may be better explored including a larger number of participants, and other methods as magnetic resonance and dual-energy x-ray absorptiometry may give a more accurate estimation of muscle mass. Furthermore, the effects of different types of training among futsal athletes may influence the results. Caution is necessary when interpreting body composition data estimated from equations which derive from general athletic population and not specific to sports discipline. We could not include female participants and our results cannot be generalized also to female population. In conclusion, in futsal competitive athletes body composition influence the cardio-respiratory fitness. Increased muscle mass is associated with higher spirometry parameters and fat mass is inversely associated to lower cardiorespiratory fitness. Future studies should explore if targeting fat mass would ameliorate the physical performance in this population.

List of acronyms

1st VT - first ventilatory threshold
BMI - body mass index
BR - breathing reserve
CPET - cardio-pulmonary exercise testing
FEV1 - forced expiratory volume in 1st second
FFM - fat free mass
FIFA - International Association Football Federation
FM - fat mass
FVC - forced vital capacity
HR - heart rate
MM - muscle mass
Peak VO2: peak oxygen uptake
Peak VO2 predicted: peak oxygen uptake predicted
RER - respiratory exchange ratio
VCO2: carbon dioxide uptake
VE.- ventilation
VO2 - oxygen uptake
VT- ventilatory threshold

Contributions of Authors

Conceptualization, KK and GG; methodology, SV, FD, AP, and LP; data collection, SV, LP and AP; formal analysis, KK, and GG; writing, KK, SV and GG.
All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare they have no financial, personal, or other conflicts of interest.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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References

1. Naser N, Ali A, Macadam P. Physical and physiological demands of futsal. J Exerc Sci Fit. 2017;15(2):76-80. Epub 2018/03/16. doi: 10.1016/j.jesf.2017.09.001. PMID: 29541136
2. Spyrou K, Freitas TT, Marin-Cascales E, Alcaraz PE. Physical and Physiological Match-Play Demands and Player Characteristics in Futsal: A Systematic Review. Front Psychol. 2020;11:569897. Epub 2020/11/27. doi: 10.3389/fpsyg.2020.569897. PMID: 33240157
3. Alvarez JC, D'Ottavio S, Vera JG, Castagna C. Aerobic fitness in futsal players of different competitive level. J Strength Cond Res.

2009;23(7):2163-6. Epub 2009/10/27. doi: 10.1519/JSC.0b013e3181b7f8ad. PMID: 19855347.
4. Pedro RE, Milanez VF, Boullosa DA, Nakamura FY. Running speeds at ventilatory threshold and maximal oxygen consumption discriminate futsal competitive level. J Strength Cond Res. 2013;27(2):514-8. Epub 2012/04/03. doi: 10.1519/JSC.0b013e3182542661. PMID: 22465986.
5. Lopez-Fernandez J, Garcia-Unanue J, Sanchez-Sanchez J, Colino E, Hernando E, Gallardo L. Bilateral Asymmetries Assessment in Elite and Sub-Elite Male Futsal Players. Int J Environ Res Public Health. 2020;17(9). Epub 2020/05/07. doi: 10.3390/ijerph17093169. PMID: 32370138; PMCID: PMC7246711.
6. Gorostiaga EM, Llodio I, Ibanez J, Granados C, Navarro I, Ruesta M, Bonnabau H, Izquierdo M. Differences in physical fitness among indoor and outdoor elite male soccer players. Eur J Appl Physiol. 2009;106(4):483-91. Epub 2009/03/27. doi: 10.1007/s00421-009-1040-7. PMID: 19322582.
7. Durmic T, Lazovic Popovic B, Zlatkovic Svenda M, Djelic M, Zugic V, Gavrilovic T, Mihailovic Z, Zdravkovic M, Leischik R. The training type influence on male elite athletes' ventilatory function. BMJ Open Sport Exerc Med. 2017;3(1):e000240. Epub 2017/10/13. doi: 10.1136/bmjsem-2017-000240. PMID: 29021910; PMCID: PMC5633737.
8. Durmic T, Lazovic B, Djelic M, Lazic JS, Zikic D, Zugic V, Dekleva M, Mazic S. Sport-specific influences on respiratory patterns in elite athletes. J Bras Pneumol. 2015;41(6):516-22. Epub 2016/01/21. doi: 10.1590/S1806-37562015000000050. PMID: 26785960
9. Bernhardsen GP, Stang J, Halvorsen T, Stensrud T. Differences in lung function, bronchial hyperresponsiveness and respiratory health between elite athletes competing in different sports. Eur J Sport Sci. 2022:1-10. Epub 2022/08/18. doi: 10.1080/17461391.2022.2113144. PMID: 35975407.
10. Zeyad Tareq Abdul Razzaq ZA-M, Ghassan Thabet Saeed. The Effect of Training and Sport Type on Pulmonary Function Parameters among Iraqi Soccer and Futsal Players. Journal of Sports and Physical Education. 2016;3(5):27-30. doi: 10.9790/6737-03052730.
11. Komici K, D'Amico F, Verderosa S, Piomboni I, D'Addona C, Picerno V, Bianco A, Caiazzo A, Bencivenga L, Rengo G, Guerra G. Impact of Body Composition Parameters on Lung Function in Athletes. Nutrients. 2022;14(18). Epub 2022/09/24. doi: 10.3390/nu14183844. PMID: 36145219.
12. D'Ascenzi F, Anselmi F, Mondillo S, Finocchiaro G, Caselli S, Garza MS, Schmied C, Adami PE, Galderisi M, Adler Y, Pantazis A, Niebauer J, Heidbuchel H, Papadakis M, Dendale P. The use of cardiac imaging in the evaluation of athletes in the clinical practice: A survey by the Sports Cardiology and Exercise Section of the European Association of Preventive Cardiology and University of Siena, in collaboration with the European Association of Cardiovascular Imaging, the European Heart Rhythm Association and the ESC Working Group on Myocardial and Pericardial Diseases. Eur J Prev Cardiol. 2021;28(10):1071-7. Epub 2021/08/24. doi: 10.1177/2047487320932018. PMID: 34425587.
13. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, Hallstrand TS, Kaminsky DA, McCarthy K, McCormack MC, Oropez CE, Rosenfeld M, Stanojevic S, Swanney MP, Thompson BR. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. Am J Respir Crit Care Med. 2019;200(8):e70-e88. Epub 2019/10/16. doi: 10.1164/rccm.201908-1590ST. PMID: 31613151.
14. Shechtman O, Gestewitz L, Kimble C. Reliability and validity of the DynEx dynamometer. J Hand Ther. 2005;18(3):339-47. Epub 2005/08/02. doi: 10.1197/j.jht.2005.04.002. PMID: 16059855.
15. de Moura NR, Borges LS, Santos VC, Joel GB, Bortolon JR, Hirabara SM, Cury-Boaventura MF, Pithon-Curi TC, Curi R, Hatanaka E. Muscle lesions and inflammation in futsal players according to their tactical positions. J Strength Cond Res. 2013;27(9):2612-8. Epub 2012/12/20. doi: 10.1519/JSC.0b013e31827fd835. PMID: 23249823.
16. Ramos-Campo DJ, Martínez Sánchez, F, García P. E., Rubio Arias JÁ, Cerezal AB., Clemente-Suarez VJ, Jiménez Díaz JF. Body composition features in different playing position of professional team indoor players: basketball, handball and futsal [Características Antropométricas en Función del Puesto en Jugadores Profesionales de Equipo: Baloncesto, Balonmano y Fútbol Sala]. Int J Morphol. 2014; 32: 1316–24. doi: 10.4067/S0717-95022014000400032.
17. Nikolic S, Todorovska L, Maleska V, Dejanova B, Efremova L, Zivkovic V, Pluncevic-Gligoroska J. Analysis of body mass components in national club football players in republic of macedonia. Med Arch. 2014;68(3):191-4. Epub 2015/01/09. doi: 10.5455/medarh.2014.68.191-194. PMID: 25568532.
18. Vila H, Manchado C, Rodriguez N, Abraldes JA, Alcaraz PE, Ferragut C. Anthropometric profile, vertical jump, and throwing velocity in elite female handball players by playing positions. J Strength

Cond Res. 2012;26(8):2146-55. Epub 2011/10/15. doi: 10.1519/JSC.0b013e31823b0a46. PMID: 21997459.
19. Santana H, Zoico E, Turcato E, Tosoni P, Bissoli L, Olivieri M, Bosello O, Zamboni M. Relation between body composition, fat distribution, and lung function in elderly men. Am J Clin Nutr. 2001;73(4):827-31. Epub 2001/03/29. doi: 10.1093/ajcn/73.4.827. PMID: 11273860.
20. Peralta GP, Marcon A, Carsin AE, Abramson MJ, Accordini S, Amaral AF, Anto JM, Bowatte G, Burney P, Corsico A, Demoly P, Dharmage S, Forsberg B, Fuertes E, Garcia-Larsen V, Gislason T, Gullon JA, Heinrich J, Holm M, Jarvis DL, Janson C, Jogi R, Johannessen A, Leynaert B, Rovira JM, Nowak D, Probst-Hensch N, Raherison C, Sanchez-Ramos JL, Sigsgaard T, Siroux V, Squillacioti G, Urrutia I, Weyler J, Zock JP, Garcia-Aymerich J. Body mass index and weight change are associated with adult lung function trajectories: the prospective ECRHS study. Thorax. 2020;75(4):313-20. Epub 2020/02/27. doi: 10.1136/thoraxjnl-2019-213880. PMID: 32098862.
21. Mohamed EI, Maiolo C, Iacopino L, Pepe M, Di Daniele N, De Lorenzo A. The impact of body-weight components on forced spirometry in healthy italians. Lung. 2002;180(3):149-59. Epub 2002/08/15. doi: 10.1007/s004080000089. PMID: 12177729.
22. Wang YC, Bohannon RW, Li X, Sindhu B, Kapellusch J. Hand-Grip Strength: Normative Reference Values and Equations for Individuals 18 to 85 Years of Age Residing in the United States. J Orthop Sports Phys Ther. 2018;48(9):685-93. Epub 2018/05/25. doi: 10.2519/jospt.2018.7851. PMID: 29792107.
23. Alvero-Cruz JR, Brikis M, Chilibeck P, Frings-Meuthen P, Vico Guzman JF, Mittag U, Michely S, Mulder E, Tanaka H, Tank J, Rittweger J. Age-Related Decline in Vertical Jumping Performance in Masters Track and Field Athletes: Concomitant Influence of Body Composition. Front Physiol. 2021;12:643649. Epub 2021/04/20. doi: 10.3389/fphys.2021.643649. PMID: 33868010.
24. Confortin SC, Aristizabal LYG, Braganca M, Cavalcante LC, Alves JDA, Batista RFL, Simoes VMF, Viola P, Barbosa AR, Silva A. Are Fat Mass and Lean Mass Associated with Grip Strength in Adolescents? Nutrients. 2022;14(16). Epub 2022/08/27. doi: 10.3390/nu14163259. PMID: 36014765.
25. Morcillo JA, Jimenez-Reyes P, Cuadrado-Penafiel V, Lozano E, Ortega-Becerra M, Parraga J. Relationships between repeated sprint ability, mechanical parameters, and blood metabolites in professional soccer players. J Strength Cond Res. 2015;29(6):1673-82. Epub 2014/12/03. doi: 10.1519/JSC.0000000000000782. PMID: 25463691.
26. Charlot K, Zongo P, Leicht AS, Hue O, Galy O. Intensity, recovery kinetics and well-being indices are not altered during an official FIFA futsal tournament in Oceanian players. J Sports Sci. 2016;34(4):379-88. Epub 2015/06/13. doi: 10.1080/02640414.2015.1056822. PMID: 26067492.
27. Bekris E, Gioldasis A, Gissis I, Katis A, Mitrousis I, Mylonis E. Effects of a Futsal Game on Metabolic, Hormonal, and Muscle Damage Indicators of Male Futsal Players. J Strength Cond Res. 2022;36(2):545-50. Epub 2020/02/08. doi: 10.1519/JSC.0000000000003466. PMID: 32032230.
28. Goran M, Fields DA, Hunter GR, Herd SL, Weinsier RL. Total body fat does not influence maximal aerobic capacity. Int J Obes Relat Metab Disord. 2000;24(7):841-8. Epub 2000/08/05. doi: 10.1038/sj.ijo.0801241. PMID: 10918530.
29. Mondal H, Mishra SP. Effect of BMI, Body Fat Percentage and Fat Free Mass on Maximal Oxygen Consumption in Healthy Young Adults. J Clin Diagn Res. 2017;11(6):CC17-CC20. Epub 2017/08/03. doi: 10.7860/JCDR/2017/25465.10039. PMID: 28764152; PMCID: PMC5535345.
30. Matias CN, Campa F, Cerullo G, D'Antona G, Giro R, Faleiro J, Reis JF, Monteiro CP, Valamatos MJ, Teixeira FJ. Bioelectrical Impedance Vector Analysis Discriminates Aerobic Power in Futsal Players: The Role of Body Composition. Biology (Basel). 2022;11(4). Epub 2022/04/24. doi: 10.3390/biology11040505. PMID: 35453705.
31. Hulens M, Vansant G, Lysens R, Claessens AL, Muls E. Exercise capacity in lean versus obese women. Scand J Med Sci Sports. 2001;11(5):305-9. Epub 2001/11/07. doi: 10.1034/j.1600-0838.2001.110509.x. PMID: 11696216.
32. Ackland TR, Lohman TG, Sundgot-Borgen J, Maughan RJ, Meyer NL, Stewart AD, Muller W. Current status of body composition assessment in sport: review and position statement on behalf of the ad hoc research working group on body composition health and performance, under the auspices of the I.O.C. Medical Commission. Sports Med. 2012;42(3):227-49. Epub 2012/02/07. doi: 10.2165/11597140-000000000-00000. PMID: 22303996.
33. Campa F, Gobbo LA, Stagi S, Cyrino LT, Toselli S, Marini E, Coratella G. Bioelectrical impedance analysis versus reference methods in the assessment of body composition in athletes. Eur J Appl Physiol. 2022;122(3):561-89. Epub 2022/01/25. doi: 10.1007/s00421-021-04879-y. PMID: 35067750.
34. Campa F, Matias CN, Moro T, Cerullo G, Casolo A, Teixeira FJ, Paoli A. Methods over Materials:

The Need for Sport-Specific Equations to Accurately Predict Fat Mass Using Bioimpedance Analysis or Anthropometry. Nutrients. 2023;15(2). Epub 2023/01/22. doi: 10.3390/nu15020278. PMID: 36678150.

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Supplementary Material Table 1*. Correlation analysis for age and years of training with body composition, spirometry parameters and physical performance measurements.*

	Age	Years of training
BMI	0.09	0.01
FFM	0.15	0.07
FM	-0.0004	-0.04
FM%	-0.02	-0.03
MM	0.19	0.15
MM%	0.20	0.28
FVC	0.30	0.26
FVC % pred.	0.24	0.25
FEV1	0.28	0.16
FEV1% pred.	0.33	0.22
FEV1/FVC % pred.	0.17	0.03
Hand grip strength	0.33	0.29
peak VO2	-0.02	-0.01
peakVO2 % pred.	0.05	0.13