Original Article

Predictive ability of pulmonary volume measurements of the Physical Fitness Index among the players of team sports games at Palestine Technical University "Kadoorie"

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Published online: June 30, 2020

(Accepted for publication: June 22, 2020)

DOI:10.7752/jpes.2020.04258

Abstract

This study aims to identify the predictive ability of some pulmonary volumes measurements of the physical fitness index (PFI) among the players of team sports games at Palestine Technical University "Kadoorie". To achieve this, the study was conducted on a purposive sample of (30) players, with (10) players for each game of handball, volleyball and soccer, ranging in age from (18-23) years. The researchers used the descriptive correlative approach, due to its suitability for the nature of this study. VC, FVC, FEV1, FEV1 / FVC%, MVV, TV, IRV, ERV, IC and (Harvard Step Test) measurements of pulmonary volumes were performed to measure Physical Fitness Index (PFI). After data collection, it was statistically processed using the statistical packages for social sciences (SPSS) software. The results of the study showed that the most pulmonary volumes measurements were able to predict physical fitness was (FEV1, FVC), which contributed to the interpretation of the series (73.5, 78.3)% of the physical fitness index. Accordingly, the following equation has been proposed: Physical Fitness Index (PFI) = 57.315 + ((FEV1 (l / min) x 3.163) + ((FVC (l / min) x 3.936)) The study also found that there are statistically significant differences at the level of significance ($\alpha \leq 0.01$) between the mean measurements of pulmonary volumes and physical fitness among soccer, handball and volleyball players in all variables and in favor of soccer. The researchers recommended relying on the equation reached as a reference value to assess the physical and functional fitness of the players of team sports and individual sports.

Keywords: Soccer, Volleyball, Handball, SPSS, Equation.

Introduction:

Physical education colleges and departments are some of the practical fields for creating athletic champions. Knowledge, information, skills, plans, physical and psychological capabilities which are received by students who represent university teams in team sports during theoretical and practical lectures contribute significantly to the development of top form athletic aptitude in them. Competitions and competitive games organized by the Palestinian Federation for University Sports between colleges of physical education and their departments are competitive forums in which it is possible to observe the splendor of physical performance and the human miraculous ability to formulate the motor skills and tactical sequences performed by the players individually, in pairs or in a team, with the ball or without it, sometimes using the feet and at other times using the arms to win the match and earn medals.

Soccer, handball and volleyball are considered to be popular, mass and simplified team games, where the player and the spectator feel the pleasure, young or old. Both men and women love it, even writers and readers, as these games have witnessed an increasing development on a large international scale in recent years in the physical, skill, planning and psychological aspects, therefore, it was very difficult, in light of the huge technological progress in the science of training and multiple and complex defensive methods, the large area of the stadium and the amount of the effort required during the time of the game, and the evolution in the playing methods and their team-shaped and individual offensive and defensive plans, to keep physical potentials the same. The player has a tactical obligation that he cannot perform without having a balanced amount of fitness, vitality and vigilance for a long time without experiencing fatigue (Salameh, 2013, p2).

The efficiency of the pulmonary system is one of the most important physiological indicators that trainers rely on in assessing the physical fitness of players due to its association with various physical capabilities, and it is one of the basic physiological requirements for success in various sports and sporting activities, specifically aerobic activities (Maher & Figueroa, 2016).

As indicated by the results of the studies of (Rawashdeh & Alnawaiseh, 2018; Cicek et al, 2018; Hartz et al, 2018; Maher & Figueroa, 2016; Hebisz et al, 2015; Cantela & Chopparar, 2015; Akhade, 2014; Fatima et al 2013; Taman et al, 2010; Amonette & Dupler, 2002), regular athletic training improves the functional efficiency of the lungs and increases their size, aside from improving the strength of the inspiratory muscles

(diaphragm muscle, external intercostal muscles, sternocleidomastoid muscle, and spinalis muscle), the efficiency of the alveoli is improved in extracting a greater amount of oxygen from the inspiratory air, thus increasing the amount of oxygen carried into the blood when exchanging gases, as well as increasing the speed of disposal of CO₂ gases with exhaled air, and this improves pulmonary volumes measurements that are closely related to the efficiency and strength of pulmonary muscles which are MVV, FVC, FEV1, FEV1 / FVC%. In this regard, Fatima et al (2013) indicates that MVV is one of the most influential measurements of pulmonary volumes affected by sports training. Brooks & Fahey (1984) states that ice skaters scored the highest value of (239) liters per minute. McArdle, et al (1986) add that MVV is an important measure for winter sports, diving and swimming. Cold & Koth (2016) considers it an accurate measure of endurance (tolerance). As for FVC, it is considered by Wilmore & Costill (1994) as one of the most important basic measures to ensure the safety of the pulmonary system and its freedom from diseases, with regard to FEV1/ FVC%, FEV1 is considered by Tony, Kelly, & Joseph (1997); Al-Hazzaa (2008) as one of the most important dynamic pulmonary measurements and an important indicator in determining the strength of pulmonary muscles, the efficiency of lungs and their freedom from disease.

On the other hand, pulmonary volumes are among the most important functional measurements and indexes that doctors use to ensure the safety and efficiency of the pulmonary system and its freedom from diseases (Gold & Koth, 2016, p406), while (Fatima et al, 2013; Rawashdeh & Alnawaiseh, 2018) indicated that the decrease in the efficiency of lungs and their functions as a result of the lifestyle characterized by lack of movement and smoking increases the possibility of some pulmonary diseases such as bronchial asthma, and may also lead to sudden death. Alonso-Calvete et. al. (2020) study showed that pulmonary function and anthropometric characteristics influence athletes' performance and development during their trainings and also during their competitions. Based on the importance of the pulmonary system to humans in general, and to athletes and coaches in particular, this study came as a practical attempt by researchers to evaluate physical fitness by measuring the level of some pulmonary volumes that can be relied upon as a predictor of the condition and physical fitness of players in light of the unsatisfactory results achieved by the players of team sports at the Technical University of Palestine "Kadoorie" at the Palestinian universities level, which is where the problem of the study appeared to the researchers.

Methodology

The researchers conducted the study on a purposive sample (S) of (30) players from the players of team sports games, and by (10) players for each game (soccer, handball, and volleyball), and Table (1) illustrates the characteristics of the study sample, pulmonary volume measurements were made related to the measurements of (VC, FVC, FEV1, FEV1 / FVC% MVV, TV, IRV, ERV, IC) using a spirometer, and physical fitness index (PFI) was measured using (Harvard Step Test), and for data processing the researchers used the SPSS software through the use of the following statistical treatments:

- Means, standard deviations and Pearson correlation coefficient to determine the relationship between some measurements of pulmonary volumes and the index of physical competence among players of team sports teams at Palestine Technical University "Kadoorie".
- Linear stepwise regression analysis to identify the possibility of developing a predictive equation from some measurements of pulmonary volumes which are statistically related.
- One-way analysis of variance (ANOVA) to determine the differences according to the game type variable.
- *Least Significant Difference* (LSD Test) for post hoc comparisons between the means to determine for whose favor the differences are.

Table (1) Characteristics of the study sample according to the variables of age, height & body mass (S = 30).

Variables	Mean	Standard deviation	Skewness coefficient
Age (year)	20.06	1.46	0.517
Height (meter)	1.77	0.07	0.407
Body mass (Kg)	71.50	9.99	0.427

It is clear from the results of Table(1) that the values of the skewness coefficient are between (± 3) and this indicates that the study sample is consistent with the normal distribution.

Pulmonary Function Testing

The researchers used the American-made electronic spirometer (AstraTouch), which is manufactured by SDI Diagnostics, as it is a modern and accurate device, which measures more than 40 measurements.

Measurement instructions and guidelines:

- The measurements were performed at (10-12) am, at a temperature of (27°C).
- Smoking students and students with pulmonary diseases were excluded.
- Students were asked to eat breakfast at least two hours before the test date.
- Students were asked not to practice any sports activity before the measurement.

Mechanism of performing measurements:

The measurements were performed according to the guidelines of the American Thoracic Society and the European Pulmonary Society (ATS / ERS), according to the following steps:

- The measurement mechanism was explained to all players before starting the measurement, with an example for each test.
- The measurements were performed on players while they are in a sitting position in a chair.
- Players' noses were closed with some specific plastic forceps.
- The player performed the tests with three attempts for each test, and the best result was scored for him.
- (FVC, FEV1 FEV1 / FVC%,) was measured by the player taking the maximum inhalation and then following it with the maximum exhalation.
- (VC) was measured by the player breathing three times normal breath in the spirometer. The fourth time the player takes the maximum inhalation and follows it with the maximum exhalation, by this way the measurements (ERV, IRV, SVC, TV) is obtained.
- (MVV) was measured by performing the breathing maneuver (Valsalva maneuver) with the maximum possible inhalation and exhalation for a period of (12) seconds (ATS, 2001).

Table (2): Terminology of study and standards of pulmonary volumes measurements

Pulmonary function	Definition	Pulmonary function tests
Tidal Volume (TV)	volume of air inhaled or exhaled with each breath during quiet breathing	500 ML
Inspiratory Reserve Volume (IRV)	maximum volume of air inhaled from the end-inspiratory tidal position.	3000 ML
Expiratory Reserve Volume (ERV)	maximum volume of air that can be exhaled from resting end-expiratory tidal position.	1500 ML
Vital Capacity (VC)	TLC minus RV or maximum volume of air exhaled from maximal inspiratory level.	4-6 L
Forced Vital Capacity (FVC)	the maximum volume of air that can be breathed out as forcefully and rapidly as possible.	4.5- 5 L
Inspiratory Capacity (IC)	Sum of IRV and TV or the maximum volume of air that can be inhaled from the end-expiratory tidal position.	2400- 3800 ML
Forced Expiratory Volume in 1 sec (FEV1)	the volume exhaled during the first second of the forced breath.	3- 4.5 L
Maximal Voluntary Ventilation (MVV)	the air that can be breathed in and out of the lungs in 1 minute by maximum voluntary effort .	150- 175 L/M
(FEV1/ FVC%)	Forced expiratory volume in 1 sec to the Forced Vital Capacity	81%

(Hyatt et al, 2008, pp2-15).

Harvard Step Test:

The objective of this test is to monitor the development of the athlete's cardiovascular system.

Required resources:

- To undertake this test, you will require:
- Gym bench (45cm high)
- Stop watch.
- Assistant.

How to conduct the test?

The Harvard step test is conducted as follows:

- Step up on to a standard gym bench once every 2 seconds for 5 minutes (150 steps).
- 1 minute after finishing the test take your pulse rate (bpm) – Pulse1.
- 2 minutes after finishing the test take your pulse rate (bpm). – Pulse2.
- 3 minutes after finishing the test take your pulse rate (bpm) – Pulse3.

Analysis:

Analysis of the result is done by comparing it with the results of previous tests. It is expected that, with appropriate training between each test, the analysis would indicate an improvement.

Using the three pulse rate your level of fitness can be determined as follows:

Result = $3000 / (\text{pulse1} + \text{pulse2} + \text{pulse3})$ (Mackenzie, 2015, p20- 21).

Results:

Results related to the first question, which states:

“What is the relationship between some pulmonary volumes measurements and physical fitness Index (PFI), and what is the possibility of developing a predictive equation to foresee the measurement of physical fitness index (PFI) among the players of team sports games at Palestine Technical University "Kadoorie"?”

To answer the first part of the question, means, standard deviations and the Pearson correlation coefficient were extracted to determine the relationship between some measurements of pulmonary volumes and physical fitness index (PFI) among the players of team sports teams at the Palestine Technical University "Kadoorie", and Table (3) shows that.

Table (3) Relationship between some measurements of pulmonary volumes in physical fitness index (S = 30).

Pulmonary volumes measurements	mean	Standard deviation	R-value*
VC (L / min)	4.69	4.81	0.25
FVC(L / sec)	4.81	0.54	**0.83
FEV1(L / min)	4.61	0.49	**0.85
FEV1/FVS (%)	94.83	0.81	**0.53
MVV(L / min)	192.34	4.19	**0.70
TV(L / min)	1.64	22.76	**0.54
IRV(L / min)	1.94	0.46	0.16
ERV(L / min)	1.61	0.54	**0.50
IC(L / min)	3.20	0.51	0.12

* Statistically significant at ($\alpha \leq 0.05$). **Statistically significant at ($\alpha \leq 0.01$).

From the results of Table (3), it is clear that there is a statistically significant relationship at the level of significance ($\alpha \leq 0.01$) between measurements of pulmonary volumes related to measurements: (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV) and physical fitness index (PFI), while there is no statistically significant relationship with the rest of the measurements.

To answer the second part of the question, Linear stepwise regression analysis was applied to identify the possibility of developing a predictive equation from some pulmonary volumes measurements (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV) (as independent variables) with physical fitness index (PFI) (as a dependent variable), and Table (4) shows this.

Table (4) Results of ANOVA analysis to identify the regression coefficient of the predictive equation for the physical fitness index (S = 30).

Pulmonary volumes measurements	Source of Variance	Sum of Squares	Degrees of freedom (DF)	Mean squares	F	Sig.	R ²
FEV1	Regression	493.397	1	493.397	77.785	**0.000	0.735
	Residual	177.606	28	6.343	-	-	-
	Total	671.002	29	-	-	-	-
FVC	Regression	535.416	1	267.708	53.310	**0.000	0.783
	Residual	135.587	28	5.022	-	-	-
	Total	671.002	29	-	-	-	-

* Statistically significant (sig.) at ($\alpha \leq 0.05$). **Statistically significant at ($\alpha \leq 0.01$).

It is clear from the results of Table (4) that the most statistically related pulmonary volumes measurements are (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV), it was also found that many measurements of pulmonary volumes were able to predict the physical fitness index (PFI) were (FEV1, FVC), where the value of (R²) for them reached (0.735 and 0.783) respectively, and to identify the equation of the regression line (t-test) and beta coefficient were used, and Table (5) shows that.

Table (5) Results of the (T) test and beta coefficient for the regression line equation for the predictive ability of some pulmonary volumes measurements in the physical fitness index (PFI).

Equation components of pulmonary volumes	Unstandardized Coefficients		Beta coefficient	T- value	Sig.	Cumulative contribution rate %
	Value	Standard error				
Constant	57.315	4.259	-	13.45	**0.000	-
FEV1	3.163	0.830	0.536	3.810	**0.001	73.5
FVC	3.936	1.361	0.407	2.893	**0.007	78.3

* Statistically significant (sig.) at ($\alpha \leq 0.05$). **Statistically significant at ($\alpha \leq 0.01$).

Table (5) clearly shows that the value of (t-test) was statistically significant at the level of significance ($\alpha \leq 0.01$), where measurements of pulmonary volumes (FEV1, FVC) contributed to the explanation of the values (73.5, 78.3) % respectively of the physical fitness index (PFI). Therefore, the proposed equation becomes: **Physical Fitness Index (PFI) = 57.315 + ((FEV1 (l / min) x 3.163) + ((FVC (l / min) x 3.936)).**

Figure (1) The regression line of the predictive ability of some measurements of pulmonary volumes in the physical fitness index(PFI).

Results related to the second question, which states:

Are there statistically significant differences at the level of significance ($\alpha \leq 0.05$) between measurements of pulmonary volumes and the physical fitness index (PFI) attributed to the game type variable?

To answer this question, the researchers used ANOVA test to determine the differences in pulmonary volumes (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV) and the Physical Fitness Index (PFI) according to the game type variable, and the results of tables (6) show that.

Table (6) Results of ANOVA analysis to determine the differences in pulmonary volumes (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV) and the physical fitness index (PFI) according to the game type variable (S = 30).

Dependent variables	Source of Variance	Sum of Squares	Degrees of freedom (DF)	Mean squares	F	Sig.
VC	Between groups	3.643	2	1.822	9.310	*0.001
	Within groups	5.283	27	0.196		
	Total	8.926	29			
FVC	Between groups	3.171	2	1.586	10.676	*0.000
	Within groups	4.010	27	0.149		
	Total	7.182	29			
FEV1	Between groups	9.688	2	4.844	13.616	*0.000
	Within groups	9.606	27	0.356		
	Total	19.294	29			
FEV1/FVS%	Between groups	140.461	2	70.231	5.118	*0.013
	Within groups	370.534	27	13.723		
	Total	510.995	29			
MVV	Between groups	5150.366	2	2575.183	7.042	*0.003
	Within groups	9874.234	27			
	Total	15024.600	29	365.712		
TV	Between groups	2.293	2	1.146	7.667	*0.002
	Within groups	4.037	27	0.150		
	Total	6.330	29			
IRV	Between groups	2.145	2	1.073	4.457	*0.021
	Within groups	6.497	27	0.241		
	Total	8.642	29			
ERV	Between groups	6.051	2	3.026	46.569	*0.000
	Within groups	1.754	27	.0650		
	Total	7.805	29			
IC	Between groups	1.057	2	0.529	3.705	*0.038
	Within groups	3.852	27	0.143		
	Total	4.909	29			
PFI	Between groups	254.85	2	127.42	8.267	*0.002
	Within groups	416.14	27	15.413		
	Total	671.00	29			

* Statistically significant (sig.) at ($\alpha \leq 0.05$).*(PFI): Physical Fitness Index.

From the results of Table (6), it is clear that there are statistically significant differences at the level of significance ($\alpha \leq 0.05$) in the statistically measurements of the pulmonary volumes (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV) and the physical fitness index (PFI) for the players of the team sports games at the Technical University of Palestine, "Kadoorie" depends on the game type variable.

To determine for whose favor the differences are, the researchers use the *Least Significant difference* (LSD Test) for comparisons between the mean, and the results of Table (7) show that.

Table (7) Results of (LSD) for the post hoc comparisons between some pulmonary volumes and physical fitness index means according to the type of game variable (S = 30).

Dependent variables	Independent variable levels (game type)	Mean	Handball	Volleyball	Soccer
VC	Handball	4.54	=====	0.14	*-0.54
	Volleyball	4.36		=====	*-0.82
	Soccer	5.18			=====
FVC	Handball	4.64	=====	0.12	*-0.62
	Volleyball	4.52		=====	*-0.74
	Soccer	5.26			=====
FEV1	Handball	4.44	=====	0.42	*-0.94
	Volleyball	4.02		=====	*-1.36
	Soccer	5.38			=====
FEV1/FVS%	Handball	93.57	=====	0.53	*-4.30
	Volleyball	93.04		=====	*-4.83
	Soccer	97.87			=====
MVV	Handball	186.46	=====	6.40	*-20.44
	Volleyball	180.06		=====	*-14.04
	Soccer	210.50			=====
TV	Handball	1.49	=====	0.09	*-0.54
	Volleyball	1.40		=====	*-0.63
	Soccer	2.03			=====
IRV	Handball	1.80	=====	0.16	*-0.47
	Volleyball	1.64		=====	*-0.73
	Soccer	2.27			=====
ERV	Handball	1.38	=====	0.17	*-0.86
	Volleyball	1.21		=====	*-1.03
	Soccer	2.24			=====
IC	Handball	3.15	=====	0.15	*-0.30
	Volleyball	3.00		=====	*-0.45
	Soccer	3.45			=====
PFI	Handball	90.16	=====	2.47	*-4.54
	Volleyball	87.69		=====	*-7.03
	Soccer	94.72		=====	=====

* Statistically significant at ($\alpha \leq 0.05$).

It is clear from the results of Table (7) that there are statistically significant differences between the mean of soccer, the mean of handball and of volleyball players in all variables and in favor of soccer, while there are no statistically significant differences between the mean of handball and the mean of volleyball players in all variables, and from the surface, the soccer players' means were at the first followed by handball and finally volleyball.

Discussion

Discussion of the results related to the first question.

The results of the study shown in Table(2) indicated that there was a statistically significant relationship at the level of significance ($\alpha \leq 0.01$) between Physical Fitness Index (PFI) and the measurements of related pulmonary volumes (FEV1, FVC, FEV1 / FVS%, MVV, TV, ERV), and the results of ANOVA analysis in Table (4) showed that the measurements (FEV1, FVC) were the most important pulmonary volume measurements that could predict functional efficiency, as it contributed to the interpretation of the values (73.5,

78.3%) respectively, of the physical fitness Index (PFI). In general, the results of the current study came in line with the studies of (Luzak et al, 2017; Mihailova & Kaminska, 2016; Wibmer et al, 2014) whose results showed a statistically significant relationship between some physical abilities and related pulmonary volume measurements (FEV1, FVC), the researchers attribute this to the nature and physical requirements of the game which depends heavily on endurance, which improves the strength and efficiency of the inspiratory muscles (diaphragm muscle, external intercostal muscles, sternocleidomastoid muscle, and spinalis muscle), this reflects positively on the measurements of Pulmonary volumes associated with inspiratory breathing muscles (FEV1, FVC), and this was confirmed by (Wilmore & Costill, 1994; Tony, Kelly and Joseph, 1997; Al-Hazzaa, 2008) by saying that FEV1 and FVC are among the most important dynamic pulmonary measurements and are important indicators in determining the strength of breathing muscles, the efficiency of the lungs and their freedom from diseases. Many other studies showed that sports training improves the efficiency of the lungs and increases their size and enhances the strength and the efficiency of the inspiratory breathing muscle, which reflects positively on the measurements of Pulmonary volumes related to FVC, FEV1.

Discuss the results related to the second question.

The results in the tables (6,7) showed that there are statistically significant differences between the mean measurements of some pulmonary volumes and the Physical Fitness Index between soccer, handball and volleyball players in all variables and in favor of soccer, while there are no statistically significant differences between the mean of handball and the mean of volleyball in all the variables, and from the surface, the soccer means were at the first followed by handball and finally volleyball. The researchers attribute this to the nature of the soccer and its physical requirements in light of the large area of the stadium and the time of the game, which requires a high efficiency of the pulmonary system. Whereas Salameh (2013) indicated that Soccer is a periodical game that includes work and rest in a different intensity for a period of (90) minutes, which confirms the importance of the aerobic and anaerobic systems represented in the anaerobic capacity. This is further supported by Tomas et al (2005) which suggested that soccer player performs (1000-1400) short activities, distributed on sudden running, intense rapid running, holding (grabbing) the opponent, hitting the ball with the head, passing, changing direction and rotation, such movements require high efficiency of the lungs and high strength in the inspiratory breathing muscles. Therefore, this is reflected positively on the measurements of pulmonary volumes associated with breathing muscles (FEV1, FVC, FEV1/ FVS%, MVV), contrary to the physical requirements of handball due to the small area of its stadium compared to the Soccer stadium, as well as a complete contrast to Volleyball, which is completely different from soccer and handball in terms of performance, physical requirements, stadium area, and the number of matches that don't require a great effort. Therefore, Soccer players were distinguished from their peers in volleyball and handball, and also handball players had some distinction compared to volleyball players. In general, the results of current research were consistent with the research done by (Kariyawasam et al, 2019; Shivani & Tripathi, 2017; Popovic et al, 2014; Tülin et al, 2012) whose results showed that soccer players are distinguished in measurements of pulmonary volumes and physical abilities from handball, basketball and volleyball players.

Conclusions:

This research provided a comprehensive account of the predictive ability of some pulmonary volumes measurements of the physical fitness index among the players of team sports games. Thus, pulmonary volumes measurements should be used as reference values when assessing the physical efficiency of the players of team sports through the use of a predictive equation reached by researchers that saves a lot of time and effort. In addition, the Soccer means were first followed by handball and finally volleyball in pulmonary volumes measurements and Physical Fitness Index, this indicates the significance of appropriate physical exercises in developing pulmonary volumes and the physical fitness index among the players of team sports games in future.

Acknowledgments:

I extend my sincere thanks to everyone who participated in the success of this work, from administration of Palestine Technical University "Kadoorie", and the players of team sports games at Palestine Technical University "Kadoorie".

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