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RESEARCH ARTICLE

The Contribution of Some Anthropometric Measurements and Pulmonary Volumes to The Digital achievement of the Sprint 400-meter Competition Among Elite Runners in Palestine

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Abstract
The study aimed to identify the contribution of some anthropometric measurements and pulmonary volumes to the digital achievement of the sprint 400-meter running distance among elite runners in Palestine. A total of 18 elite runners in Palestine, (age: 20.16+1.15 years; body mass: 67.75+5.04 kg; height: 173.11+6.01 m; body mass index (BMI):23.3 +3.1 kg/m2) were categorized as. Anthropometric measurements and Pulmonary volume measurements were taken (VC, FVC, FEV1, FWV1/FVC%, MVV, TV, RV, IC). The authors used Multiple linear Regression. Simple Linear Regression (T) and (Beta) to determine the regression line equation. It was determined that there was no statistically significant relationship between some anthropometric measurements (≤0.05). In order to determine the contribution of measurements chest circumference (r=*0.599), chest circumference (r=*0.573) in inspiration, thigh circumference (r=*0.773) calf (Gastrocnemius) muscle circumference(r=*0.554) it was determined that there was a statistically significant relationship between the digital success of the 400 meter sprint run. It was determined that there was no statistically significant relationship (α≤0.05) between lung volume measurements (FVC, FEV1, FWV1/FVC%, MVV). It was determined that there was no statistically significant relationship (α≤0.05) between lung volume measurements (FVC, FEV1, FWV1/FVC%, MVV). However, VC (p = 0.00); It was determined that there was a significant relationship in terms of (R^2 = 0.616). In conclusin researchers recommend the necessity of using the predictive equations that have been developed as a predictor of digital achievement in the sprint 400-meter running competition.

Keywords
Pulmonary Volume Measurements, Numerical Achievement, Sprint 400-Meter Running Competition

INTRODUCTION

Running is the most popular and at the same time the simplest form of movement that provides versatile benefits to the body, including improving the functioning of the heart, nervous and digestive systems (Pedersen & Saltin, 2015). The fact that it can be done at various distances and that there are various technical solutions to support training control makes it easier for this sport to become widespread among amateurs (Janssen et al., 2017; Janssen et al., 2020). The spread of running as a form of physical recreation in recent years has led to the reflection of this subject in many scientific studies (Eime et al., 2015).

The sprint 400-meter running competition is classified as a short-distance sprint competition according to the International Association of Athletics Federations classifications, as this competition is considered one of the most violent, most thrilling and exciting track competitions. This is reflected by name that was given to it, “the killer

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of men or the graveyard of runners" as a result of the pain and fatigue that the runners of this competition experience during the race distance. This pain results from the accumulation of large amounts of lactic acid as a result of the incomplete consumption of glycogen, which is used as energy fuel in the anaerobic system. Therefore, maximum speed, maximum strength, strength characterized by speed, and speed endurance are considered the most important physical elements for success and achievement in this competition (Salama & Khalifa, 2018). Achieving good results in this competition depends heavily on the anthropometric and physiological specifications that the runners possess at the level of the heart muscle, lungs, nervous and muscular systems, in addition to height, leg length, and a fat-free muscular body (Salameh, 2018).

Physiological aspects of running performance were examined and issues related to running economy and energy costs were analyzed. Additionally, biomechanical aspects affecting running economy were also examined (Folland et al., 2017). The issue of morphological diversity of runners focuses on the body proportions, body composition and somatic structure characteristics of competitors at certain distances, as well as the impact of anthropometric characteristics on the results achieved by athletes (Laumets et al., 2017). It has been shown that professional athletes (Olympic champions, finalists and running event participants) clearly differ in age, height and body weight. Sprint champions tend to weigh more than lower-ranked competitors, while distance runners show the opposite trend (Pavlović & Kozina, 2022).

The importance of these specifications was highlighted by one study (Zar et al, 2008; Mande, 2016) by saying that understanding the anthropometric, physical and physiological specifications for each sporting activity is an important and influential factor in sporting achievement, as each sporting activity has its own anthropometric, physical and physiological requirements that pave the way for a player who possesses these requirements to achieve good results. It was also pointed out (Gursavek & Mishra, 2012) that these factors are not less important than the technique used by an athlete in any game, and this requires the attention of coaches and teachers when selecting athletes.

It was pointed out by one study (Parseh & Hassan, 2015) that the medals won by Eastern European players in 1972 and 1976 are due to attention to anthropometric, physical and physiological requirements when selecting talented athletes, according to the requirements of each game, and this has been confirmed by many studies that dealt with studying the relationship of anthropometric and physiological measurements with sporting achievement. One of these studies (Salama & Khalifa, 2018) showed that abdominal circumference and instep length were the most contributing anthropometric measurements to the level of digital achievement for the 400m running event, as they contributed to explaining (13.8%) of the achieved time. Another study (Rathore, 2016 & Mishra) found a statistically significant relationship between height, body mass, leg length, and thigh circumference with the 50-yard speed test, and another study (Singh & Malik, 2015) showed a statistically significant relationship exists between height, leg length, shoulder circumference, hip circumference, shoulder diameter, elbow diameter, thigh skin thickness, biceps brachii skin thickness and the 100-meter sprint achievement. Moreover, one study (Singh & Malik, 2015) showed a statistically significant relationship between height, leg length, shoulder circumference, hip circumference , shoulder diameter, elbow diameter, thigh skin thickness, biceps brachii skin thickness and sprint 400-meter running achievement. A different study (Omelchenko et al, 2023) showed a positive and direct relationship between height and body mass with measurements of related pulmonary volumes (VT, FEV1, FVC, MV, ERV, IRV, VC, MVV). Another study (Salameh et al, 2020) showed that the Pulmonary volume measurements that were most capable of predicting physical efficiency are (FEV1, FVC), which contributed to explaining 73.5%, 78.3% of the physical efficiency index respectively. Another study (Mazic et al, 2014) showed that there was a statistically significant relationship between the (VC) measurement and players who played boxing and rugby. It also showed that there was a relationship between the (FVC) measurement and players who played cycling, football, and boating, as well as a relationship between the FEV1 measurement and boxing and water polo players. Another study (Yasuaki et al, 2006) showed that high school football players in Yanazaki Prefecture in Japan are characterized by high levels of pulmonary volume measurements related to (TLC, VC). A different study (Cheng et al, 2003) found that people who

practice sports activities have high levels of Pulmonary volume measurements (FVC, FEV1, FEV1/FVC%).

Given the importance of anthropometric measurements and pulmonary volumes among runners in the sprint 400-meter competition, this study came as a practical scientific attempt by the researchers to determine the most contributing of these measurements to the digital achievement of the of the sprint 400-meter running in light of the unsatisfactory results achieved by the runners of this competition at the national level, which is the basis for the problem statement of the study.

MATERIALS AND METHODS

The researchers conducted the study on a purposive sample of (18) elite sprint 400-meter runners in Palestine, also the researchers obtained ethical permission from participants to do study, and Table No. (1) shows the characteristics of the study sample. The study was approved and supervised by the departmental research committee, Palestine Technical University - kadoorie (Ref: 2024/2 Date: 20. Feb. 24). Also the current study involving human participants was approved and obtained ethical permission from them.Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Table 1. Characteristics of the study sample according to the variables of age, height, and body mass (N = 18)

Variables	Measuring unit	Minimum	Maximum	M	SD	Skewness coefficient
Age	Year	18.00	22.00	20.16	1.15	-0.101
Body mass	Kg	60.00	78.00	67.75	5.04	.3890
Height	Cm	160.00	183.00	173.110	6.010	-0.379

Mean:M; Standard Deviation: SD

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 subject to the normal distribution.

Study procedures

Anthropometric measurements were performed related to (age, body mass, height, arm length, leg length, thigh length, lower leg length, instep length, chest circumference, chest circumference with inspiration, abdominal circumference, thigh circumference, calf (Gastrocnemius)circumference, and upper arm (humerus) circumference using a ristameter and tape measure.

Measurements of Pulmonary volumes (VC, FVC, FEV1, FWV1/FVC%, MVV, TV, RV, TLC) were performed using a spirometer.

The digital achievement measurement for the sprint 400-meter running event was conducted on the track of the College of Physical Education and Sports Sciences at Palestine Technical University "Kadoorie."The study was conducted in the time period 1-8/ 10-8-2023.

The following is an explanation of the study procedures:

Anthropometric measurements

***First*: Height and body mass (body weight)**

To measure height, the researcher used a "rectameter" device, which is a stand installed vertically on a wooden edge, 250 cm long, so that the zero is at the level of the wooden base. There is also a stand installed horizontally on the stand so that it can be moved down and up. The test subject stands on the wooden base with his back facing the stand so that it touches it at three points: the area between the two shoulder boards, the farthest point of the pelvis from the back, and the furthest point of the calves of the legs. Care must be taken to pull the body up and look forward, and the stand is lowered until it touches the upper edge of the skull so that the number facing the stand expresses the length.

Second: The lengths of the limbs include

Arm length: A tape measure in centimeters is used to measure the arm from the lateral edge of the acromial process to the end of the middle finger when it is straight**.**

Leg length: The length of the lower limb is measured using a measuring tape from the greater trochanter of the upper head of the thigh joint to the floor.

Thigh length: Thigh length is measured using a tape measure from the greater trochanter of the superior head of the femur to the lateral edge of the middle of the knee.

Lower Leg length: Leg length is measured using a measuring tape from the medial edge of the middle of the knee joint to the medial prominence of the heel.

Instep length: The instep length is measured using a tape measure from the end of the heel bone to the tip of the big toe.

Third: The circumferences and they include

Chest circumference in the normal position: The chest circumference is taken at a level exactly above the nipple and the average circumference of the maximum inhalation and the minimum circumference during maximum exhalation are calculated.

Chest circumference during inhalation: The chest circumference is taken as in the previous method, but after the tester takes the maximum breath (inhalation) and holds it until the chest circumference is read.

Upper arm circumference during diastole: The largest circumference during contraction and relaxation .***Abdominal circumference***: The smallest circumference of the abdomen above the navel is 2-3 cm.

Thigh circumference: The largest circumference of the thigh directly below the buttocks.

Calf circumference: The largest circumference is at the calf (Salama, 2018)

Pulmonary Function Measurement

The researchers used an electronic spirometer, type of AstraTouch, American made and manufactured by SDI Diagnostics company. It is considered one of the modern and accurate devices that measures more than 40 dimensions.

Measurement instructions

Measurements were carried out at (10:00-12:00) in the morning, at a temperature of (27) degrees Celsius.

Students who smoke and students who have respiratory diseases were excluded.

Students were told to eat breakfast at least two hours before the test time.

The students were asked not to engage in any sporting activity before the measurement.

Measurements mechanism

Measurements were performed according to the American Thoracic Society and European Respiratory Society (ATS/ERS) guidelines according to the following steps:

The measurement mechanism was explained to all players before starting the measurement, along with the performance of a model for each test.

Measurements were taken from a sitting position on a chair.

The noses were closed with plastic forceps designated for this purpose.

Players take tests with three attempts for each test, with the best one being recorded.

(FVC,FEV1FEVI/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 normally in the spirometer, and the fourth time the player took the maximum inhalation followed by the maximum exhalation, so we obtained measurements (ERV, IRV, SVC, TV).

(MVV) was measured by performing a breathing maneuver with the maximum possible inhalation and exhalation for 12 seconds (ATS, 2001).

The digital achievement measurement was taken for the sprint 400-meter running competition on the Olympic track of the Physical Education and Sports Sciences Faculty at Palestine Technical University "Khadoorie".

Statistical analysis

The authors used IBM SPSS version 26 to analyze data by using means, standard deviations, skewness and Stepwise Multiple linear Regression. Simple Linear Regression (T) and (Beta) to determine the regression line equation

RESULTS

Results related to the first study question, which states

What are the most anthropometric measurements contribute in the digital achievement of the sprint 400-meter running competition among elite runners in Palestine?

To answer this question, firstly, the researchers found the values of the Pearson correlation coefficient between anthropometric measurements and the digital achievement of the sprint 400-meter running competition among elite runners in Palestine, and Table (2) shows that.

Table 2. Pearson correlation coefficient between some anthropometric measurements and the digital achievement of the sprint 400-meter running (N= 18)

Anthropometric measurements	M	SD	R-value*
Age (year)	20.16	1.15	0.299
Body Mass (kg)	67.75	5.04	0.441
Height (cm)	173.11	6.01	0.213
Arm Length(cm)	73.50	5.03	0.153
Leg Length (cm)	90.78	3.66	0.105
Thigh Length (cm)	47.39	3.91	0.289
Lower Leg Length (cm)	43.44	2.38	-0.364
Instep Length (cm)	26.56	1.76	-0.339
Chest Circumference (cm)	86.44	5.49	*0.599
Chest Circumference With Inspiration (cm)	89.50	5.23	*0.573
Abdominal Circumference Abdominal Circumference (cm)	76.17	4.08	-0.098
Thigh Circumference (cm)	50.78	3.39	*0.773
Calf (Gastrocnemius) Muscle Circumference (cm)	35.39	2.87	*0.554
Upper Arm Circumference (cm)	28.94	2.15	0.297

From the results of Table (2), it is clear that there is no a statistically significant relationship at the level of significance ($\alpha \leq 0.05$) between some measurements of anthropometric related to measurements: (age, body mass, height, arm length, leg length, thigh length, lower leg length, instep length, abdominal circumference, upper arm circumference), and the digital achievement of the sprint 400-meter running, while there is statistically significant relationship with chest circumference, chest circumference with inspiration, thigh circumference, calf (Gastrocnemius) muscle circumference) and the digital achievement of the sprint 400-meter running. In order to determine the contribution of (chest circumference, chest circumference with inspiration, thigh circumference, calf (Gastrocnemius) muscle circumference) measurements, linear stepwise regression analysis was applied to identify the possibility of developing a predictive equation from some Pulmonary volumes measurements chest circumference, chest circumference with inspiration, thigh circumference, calf (Gastrocnemius) muscle circumference) as an independent variables with the digital achievement of the sprint 400-meter running as a dependent variable, and Table (3) shows this.

Table 3. Results of ANOVA analysis to identify the regression coefficient of the predictive equation for the digital achievement of the sprint 400-meter running (n=18).

Model	Source of variance	Sum of Squares	df	Mean Square	F	P-Value	R^2
Thigh circumference	Regression	181.881	1	81.881	23.817	*0.000	0.598
	Residual	55.006	16	3.438			
	Total	136.887	17				

* Significance level ($\alpha \leq 0.05$).

Table (3) indicates that the some anthropometric measurements that contribute the most to the numeric achievement of the sprint 400-meter competition among the elite runners in Palestine was Thigh circumference, where the (R^2) value was calculated at (0.598), and to identify the equation of the regression line, the (t) test and the beta coefficient were used and the results of the table (4) Explain that.

Table 4. Results of the t-test and the beta coefficient of the regression line equation for the contribution of some anthropometric measurements to the digital achievement of the sprint 400-meter running competition among elite runners in Palestine.

Model	Value	Standard Error	Beta	T	P-Value	R^2
Constant	21.859	6.754		3.236	*0.005	
Thigh circumference	0.648	0.133	-0.773	4.880	*0.000	0.598

*Significance level ($\alpha \leq 0.05$)

It is clear from the results of Table No. (4) that the value of (T) was statistically significant at the level of significance ($\alpha \leq 0.05$), as the Thigh circumference measurement contributed to explaining (59.8)% of the digital achievement of the sprint 400-meter run, and therefore the proposed equation becomes as follows: **Digital achievement for the 400 meter sprint competition** = 21.859 + ((Thigh circumference (cm) × 0.648)).

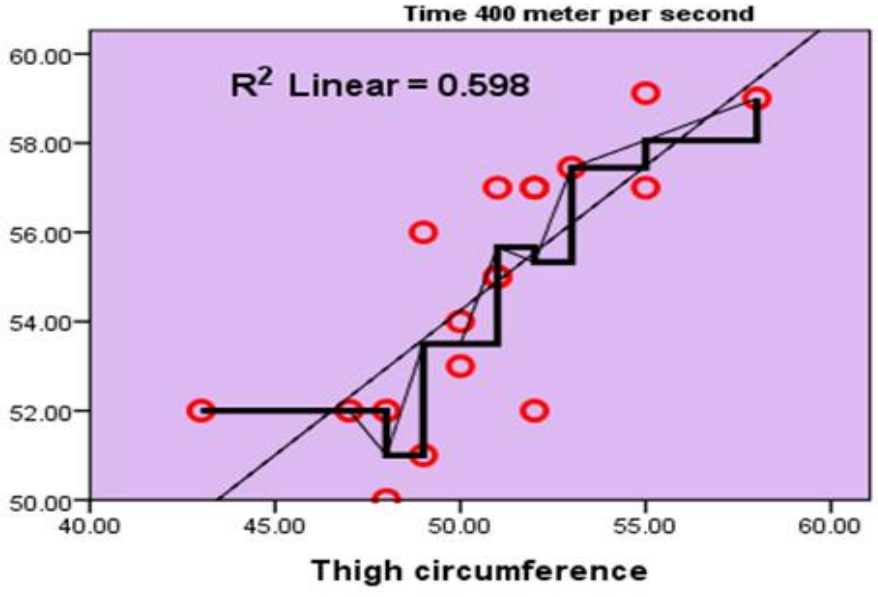

Figure 1. Thigh circumference measurement as a predictive in the digital achievement of sprint 400 meter.

Results related to the second study question, which states

What are the most pulmonary volume measurements contribute in the digital achievement of the sprint 400-meter running competition among elite runners in Palestine?

To answer this question, firstly, the researchers found the values of the Pearson correlation coefficient between pulmonary volume measurements and the digital achievement of the sprint 400-meter running competition among elite runners in Palestine, and Table (5) shows that.

Table 5. Pearson correlation coefficient between pulmonary volume measurements and the digital achievement of the sprint 400-meter running (N= 18)

Pulmonary volumes measurements	Measuring unit	M	SD	R-value*
VC	L / min	4.80	0.61	*0.785
FVC	L / sec	4.26	0.49	0.298
FEV1	L / min	4.13	0.45	0.249
FEV1/FVC%	%	95.68	4.78	-0.01
MVV	L / min	166.79	24.53	0.18
TV	L / min	1.39	0.57	0.184
IRV	L / min	1.57	0.56	0.455
ERV	L / min	1.43	0.65	-0.269
IC	L / min	3.39	0.65	*0.48
RV	L / min	1.09	0.13	0.458

Standard deviation:SD; Mean:M; * Significance level ($\alpha \leq 0.05$).

From the results of Table (5), it is clear that there is no a statistically significant relationship at the level of significance (α≤0.05) between measurements of Pulmonary volumes related to measurements: (FVC, FEV1, FWV1/FVC%, MVV, TV, RV,) and the digital achievement of the sprint 400-meter running, while there is statistically significant relationship with (VC, IC) and the digital achievement of the sprint 400-meter running. In order to determine the contribution of (VC, IC) measurements, linear stepwise regression analysis was applied to identify the possibility of developing a predictive equation from some Pulmonary volumes measurements (VC, IC) as an independent variables with the digital achievement of the sprint 400-meter running as a dependent variable, and Table (6) shows this.

Table 6. Results of ANOVA analysis to identify the regression coefficient of the predictive equation for the digital achievement of the sprint 400-meter running (n=18).

Model	Source of variance	Sum of Squares	df	Mean Square	F	P-Value	R^2
VC	Regression	84.306	1	84.306	25.654	*0.000	0.616
	Residual	52.581	16	3.286			
	Total	136.887	17				

* Significance level (α ≤ 0.05).

Table (6) indicates that the pulmonary volume measurement that contributed the most to the digital achievement of the sprint 400-meter running competition among elite runners in Palestine was VC, as its (R^2) value was calculated at (0.616). To identify the equation of the regression line, the t-test and the beta coefficient were used and Table (5) shows the results.

Table 7. Results of the t-test and the beta coefficient of the regression line equation for the contribution of some Pulmonary volume measurements to the digital achievement of the sprint 400-meter running competition among elite runners in Palestine.

Model	Value	Standard Error	Beta	T	P Value	R^2
Constant	37.274	3.477		10.719	*0.000	
VC	3.643	.719	0.785	5.065	*0.000	0.616

* Significance level (α ≤ 0.05).

It is clear from the results of Table No. (7) that the value of (T) was statistically significant at the significance level (α≤0.05), as the VC measurement contributed to explaining (61.6)% of the digital achievement of the sprint 400-meter race, and therefore the proposed equation becomes as follows:

Digital achievement for 400 meters = 37.274 + ((VC (unit of measurement) x 3.643)).

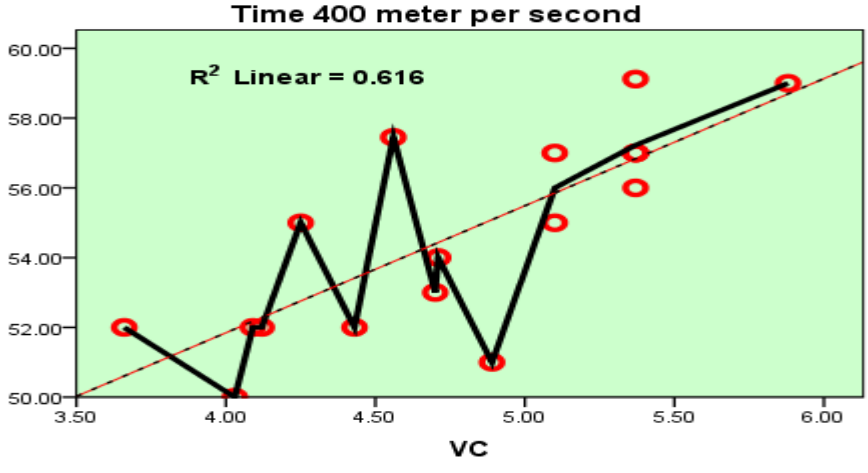

Figure 2. VC measurement as a predictive in the digital achievement of sprint 400 meter.

DISCUSSION

The intensity and frequency of sports performed by athletes determine the level of strengthening of the inspiratory muscles by increasing the volume and capacity of the lungs. Exercise increases the endurance and strength of athletes' breathing muscles, reduces resistance in the respiratory tract, and increases lung elasticity and alveolar expansion by promoting expansion of lung volume and capacity (Khosravi et al. 2013). Vital capacity is a reflex of the ability of lung tissue elasticity, or stiffness of the movement of the thoracic wall. The main factors that affect vital capacity are the anatomical shape of the body, position during measurement of vital capacity, respiratory muscle strength and lung and chest skeletal development (Guyton and Hall, 2014).

Discussing the results related to the first question:

The results in tables (2 and 3) indicate that the most contributing anthropometric measurements to the digital achievement in the sprint 400-meter running competition among elite runners in Palestine is the "Thigh circumference", as it contributed to explaining (59.8)% of the digital achievement in the sprint 400-meter running competition among elite runners in Palestine. The results of this study are consistent with the results of other studies (Salama & Khalifa, 2018; Ali & Nasser, 2016; Mishra & Rathore, 2016; Singh & Malik, 2015; Aldhiabat, 2014; Goswami, 2013; Mishra & Gursavek, 2012; Majhol, 2006). The researchers attribute this consistency to the nature of the physical and anthropometric requirements for this competition, in addition to the fact that it relies heavily on a combination of phosphogonic and lactic system training (strength, speed, strength characterized by speed, and speed endurance), the intensity of which may reach 100% of the runner's maximum ability, and this would target white (fast-twitch) muscle fibers, thus increasing the size of the muscle and its cross-section, and this was confirmed by Al-Jumaili and Al-Alwani (2024) when they said that (80%) of the muscle fibers of short-distance runners are of the type of white muscle fibers (Fast Twitch Fibers). The sprint 400-meter runners are also characterized by having fast oxidative glycolytic muscle fibers. What is new is that the percentage of white muscle fibers in skeletal muscles is (40-50%), and is greatly affected by training for maximum strength, maximum speed, strength characterized by speed, and speed endurance. This leads to important training adaptations, such as increasing the strength and speed of muscle contraction and increasing the size of the muscle and the thickness of its fibers. These adaptations are among the most important anthropometric requirements for short-distance runners, specifically sprint 400-meter runners.

Results related to the second study question,:

The results shown in Tables (4,5) indicate that the Pulmonary volume measurement that most contributed to the digital achievement in the sprint 400-meter running competition among elite runners in Palestine was Vital Capacity (VC), which contributed to explaining (61.6%) of the digital achievement in the sprint 400-meter running competition among elite runners in Palestine. The results of this study are consistent with the results of other studies (Salameh et al, 2020; Hulke & Phatak, 2011; Can, 2010; Balcom et al, 2006; Yasuaki et al, 2006; Falaschetti et al, 2004; Cheng et al, 2003). The researcher attributes these results to the nature of the physical requirements of the sprint 400-meter running competition, which are linked to the element of speed, and speed is closely related, and therefore, training for this event requires the contribution of the anaerobic system (phosphatase and lactate) to producing energy, and this improves the strength and efficiency of the breathing muscles (the diaphragm muscle, the intercostalis, the external intercostal muscle, the clavicular mastoid, and the spinalis muscle), which increases the flexibility and expansion of the rib cage during the breathing process. This allows for better performance of respiratory operations in runners during physical exertion. The density of the surrounding blood capillaries in the alveoli of the lungs also increases as a result of the opening of a number of closed or inactive capillaries, or new capillaries are generated under the influence of continuous repetitions of physical effort. This leads to an increase in the surface area on which gases are exchanged between the capillaries and pulmonary alveoli, not to mention an increase in the elasticity of the lungs and their ability to expand and contract to perform strong and deep breathing movements, and thus the efficiency of Pulmonary volumes improves, both static and kinetic, the most important of which is measuring vital capacity (VC), which is one of the most important functional indicators of Pulmonary efficiency, thus increasing the volume of inspiratory reserve over expiratory

reserve in runners as a result of speed endurance training.

Conclusion

It is clear from the results of the study that anthropometric measurements, as well as pulmonary volume, can be used to predict measurements of achievement in the sprint 400-meter running competition.

Conflict Of Interest

No potential conflict of interest relevant to this article was reported.

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Ethics Statement

The study was approved and supervised by the departmental research committee, Palestine Technical University - kadoorie (Ref: 2024/2 Date: 20. Feb. 24). Also the current study involving human participants was approved and obtained ethical permission from them.

Author Contributions

Study Design: LH, AQ; Data Collection: LH,HS, MA,KQ and RK; Statistical Analysis: LH and AQ; Data Interpretation: LH,HS,KQ and RK; Manuscript Preparation, LH, AQ and RK; Literature Search: LH,MA and HS. All authors have read and agreed to the published version of the manuscript.

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