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Physical and Functional Responses Associated to Rope and Stepping Box Exercises in Students of the Faculty of Physical Education.

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Abstract

This research aims at identifying the physical and functional responses associated to rope and stepping box exercises in students of the faculty of physical education. The basic study was conducted on a random sample of the second year students in the faculty of physical education for men, Alexandria University (N = 30). Sample was divided into two experimental groups, each consisting of 15 students. The experimental method was used and the suggested program was applied in ten weeks one of which was assigned to teaching the stepping and rope exercises, while the remaining 9 weeks were used in training. There were 36 training units in all given at the rate of 4 units per week. The main results of the study were: 1) superiority of the first experimental group, using the stepping box exercise program in physical variables (muscular strength, muscular endurance, agility and coordination); 2) superiority of the second experimental group, using the rope exercise program in speed and cardio-respiratory endurance variables (1500 m run); 3) there are no significant differences between the two groups in cardio-respiratory endurance (800 m run); 4) superiority of the second experimental group (rope exercises) over the first experimental group (stepping box exercises) in all functional variables, except for the respiratory exchange ratio (REP) variable where there are no significant differences. Accordingly, the following recommendations were made: 1) applying the 2 suggested exercise programs (stepping box and rope) to different sport activities in order to improve the physical and functional variables, with a view to upgrading the performance level of athletes and reach top levels; 2) conducting further research using exercises tools according to standardized training programs to determine the efficiency thereof.

Introduction:

The standardized sports training and the related physical and skillful requirements are major factors in improving the physiological processes, leading to functional changes under the impact of systematic training loads. Training programs and loads are stimuli with determined aims that lead to upgrading the functional, physical and skillful levels thus reaching higher levels (5:71) (24:70) (8:17)

The standardized training programs help improve the physical and functional level and develop the body systems, thus improving the motor activity and reaching high sport levels through the practice of physical exercises which are essential in enhancing the vital systems of the human body. (63:9)

Certain physical abilities are very important in the specialized sport achievement. These include flexibility, explosive power, endurance, agility, coordination, balance and speed. These all work in an integrated manner to accurately complete the movement performed. (23:22) (59:15) (39:1)

Both the sport achievement level and a player's mastering of motor performance are determined by his or her physiological ability. According to the latest trends in upgrading a player's physiological efficiency, training programs should be directed and focused in such a manner as to develop the level of energy fitness, because one of the major goals of physiological training is capitalizing the maximum potentials of aerobic and anaerobic energy production systems (20:2). The aim of the training process is to identify the best methods to upgrade the player's achievement level. (2:114).

Practicing aerobic exercises improve lung efficiency and capacity and positively affect the heart and blood circulation through reducing heart rate during rest, expanding blood vessels and increasing their elasticity and increasing the heart's ability to pump more blood every minute. (3:12) (21:3,4)

Jump ropes are one of the best tools used for improving internal systems, especially the respiratory system. They also help develop the jumping force, improve foot work and leg work, increase neuro-muscular coordination and master compound movements (63:432).

There are four rope jumping motor skills: jumping. criss-cross, shifting movements, such as running, jumping and jogging, and swing and wave movements. (63:433-441) (31:60-65).

Rope exercises require a high degree of coordination which can be achieved by moving more than one part of the body at the same time and in different directions. They improve the cardio-respiratory endurance, strength, flexibility, agility speed, performance accuracy, feeling the motion and balance (19:196) (53: 277, 278). To avoid stress and fatigue when performing the rope jump exercise after a short time, a combination can be made of running, jumping, jogging, swinging and rope turns. (36: 202)

The positive effect of stepping exercises is also obvious in improving the cardio-respiratory system fitness, the increase of heart and blood circulation output in order to save the effort exerted. (41: 137). There is a similar effect of stepping exercises combined with running exercises, as they improve the VO2 max. (61: 225). Such exercises throw high burdens both on the circulatory and respiratory systems and increase cardiac response more than can be done through training on the bicycle or the treadmill with loads equal intensities. (60: 167)

Tracking the performance level of students doing their practical examinations, the authors of this paper noticed a remarkably low level of physical and functional performance as a result of fatigue and inability to continue. There were obvious differences between such students and distinguished students who practice different sport activities whether as members in the faculty teams participating in competitions held by Alexandria University or in Egyptian national teams.

In the light of information given in the previous paragraphs concerning the importance of the rope and stepping box exercises, this study was undertaken with the aim of identifying and comparing their effect on improving some physical and functional variables in students of the faculty of physical education.

- **Objective of the research**

The research aims at identifying physical and functional responses associated to rope and stepping box exercises in students of the faculty of physical education.

- **Research hypotheses**

1- There are statistically significant differences between pre-measurements and post-measurements in the first experimental group (stepping box exercises) in physical and functional variables favoring post-measurements.

2- There are statistically significant differences between pre-measurements and post-measurements in the second experimental group (rope exercises) in physical and functional variables favoring post-measurements.

3- There is a variance between results of post-measurements in the two research groups in physical and functional variables.

- **Research procedures**

The experimental method was used, being suitable to this type of research.

- **Human scope**

Research was conducted on a sample of the second year students in the faculty of physical education for men, Alexandria University.

- **Time scope**

Pilot studies were conducted in the period 28/9/2013 – 3/10/2013. Pre-measurements were taken in the period 5/10/2013 – 10/10/2013. The basic experiment was conducted in the period 19/10/2013 -26/12/2013. Post-measurements were taken in the period 28/12/2013 – 2/1/2014.

- **Geographical scope**

The gymnastics and exercises training hall in the faculty of physical education for men, Alexandria University; the physical effort physiology laboratory in the faculties of physical education for men and for girls, Alexandria University.

- **Research sample**

The basic study was conducted on a random sample of the second year students in the faculty of physical education for men, Alexandria University (N = 30). Sample was divided into two experimental groups, each made up of 15 students. The pilot study was conducted on a non-random sample of 12 students. 6 of these were distinguished students who practice different sport activities as members in the faculty teams participating in competitions held by Alexandria University or in Egyptian national teams. The remaining 6 were non-distinguished students.

- **Physical and physiological tests and measurements**

I. Physical tests

1- broad jumping from standing test to measure muscle strength (11: 93) (25:399);

2- 30 m sprint test (in seconds) to measure speed (25:292);

3- Push-up from standing test (by number) to measure muscle endurance (11: 160) (25:313);

4- 800 m run test (in minutes) to measure anaerobic endurance (16: 231), (33: 17);

5- 1500 m run test (in minutes) to measure aerobic endurance (16: 231), (33: 17);

6- Zigzag run test (in seconds) to measure agility (11: 244).

7- Numbered circles test (in seconds) to measure coordination (25: 245).

II. Physiological tests

Measuring respiratory functions using ergospirometre (22)

(Measurements in rest)

1-Vital capacity (VC);

2- Expiratory reserve volume (ERV);

3- Inspiratory reserve volume (IRV);

4- Tidal volume (TV);

5- Inspiratory Capacity (IC);

(measurements in effort)

1- VO2max;

2- VO2 max/kg;

3- VCO2 max;

4- Respiratory exchange ratio (RER) ;

5- Ventilation(VE)

- **Scientific coefficients:**

Table 1

Differences between distinguished group and non-distinguished group to find validity factor in physical tests

Statistical significance / variables		Distinguished group N=6		Non-distinguished group N=6		Difference between the two means	T value	Validity factor
		Mean	Standard deviation ±	mean	Standard deviation ±			
Muscle strength	broad jumping from standing (in cm.)	224.948	13.169	200.945	4.013	24.002	**6.523	0.891
Speed	30 m. sprint (in seconds)	3.207	0.091	3.674	0.206	0.466	**7.752	0.919
Muscle endurance	Push-up from standing (by number)	49.523	3.815	33.729	2.830	15.794	**12.440	0.966
Cardio-respiratory endurance	800 m. run (in minutes)	2.723	0.261	3.298	0.047	0.575	**8.099	0.925
	1500 m. run (in minutes)	5.657	0.480	6.475	0.076	0.818	**6.295	0.885
Agility	Zigzag run (in seconds)	10.120	1.023	17.976	2.002	7.856	**13.075	0.969
Coordination	Numbered circles (in seconds	6.728	0.581	9.809	0.958	3.082	**10.289	0.952

*** significant at the level 0.05 = 2.20** **** significant at the level 0.01 = 3.11**

Table 1 (significance of the differences between distinguished group and non-distinguished group to find the validity factor in physical tests) shows significant differences between the two groups, favoring the distinguished group, with a calculated T value ranging between 6.295 and 13.075, which are significant values at the level 0.01. Validity factor also ranged between 0.885 and 0.969, thus proving the discriminatory validity of variables.

Table 2

Differences between first application and second application to find reliability factor in physical tests N = 12

Statistical significance / variables		First application		Second application		Difference between the two means		T value	Reliability factor
		Mean	Standard deviation ±	Mean	Standard deviation ±	Mean	Standard deviation ±		
Muscle strength	broad jumping from standing (in cm.)	212.946	15.512	213.375	17.015	0.429	20.716	0.109	0.896
Speed	30 m. sprint (in seconds)	3.440	0.284	3.434	0.257	0.006	0.238	0.143	0.888
Muscle endurance	Push-up from standing (by number)	41.626	8.691	41.662	8.378	0.036	6.831	0.028	0.924
Cardio-respiratory endurance	800 m. run (in minutes)	3.010	0.346	3.061	0.303	0.051	0.299	0.896	0.939
	1500 m. run (in minutes)	6.066	0.536	6.079	0.542	0.013	0.552	0.127	0.908
Agility	Zigzag run (in seconds)	14.048	4.294	13.933	4.272	0.115	3.110	0.195	0.931
Coordination	Numbered circles (in seconds	8.269	1.751	8.126	1.704	0.143	1.558	0.484	0.946

*** significant at the level 0.05 = 2.18**

Table 2 (significance of the differences between first application and second application and coefficient of correlation between the two applications to find the reliability factor in physical tests) shows no significant differences between first application and second application, with a calculated T value ranging between 0.028 and 0.896, which are insignificant values at the level 0.05. Reliability factor also ranged between 0.888 and 0.946, thus proving the reliability of variables, which would give the same results if re-applied to the same sample in the same circumstances.

- **Statistical treatments**

The SPSS program was used to find the following treatments: arithmetic mean – standard deviation – median – contortion coefficient – difference between the two means – T value – validity factor – coefficient of correlation – percentage of improvement – differences percentages.

- **Sample homogeneity**

Table 3

Statistical description of the whole sample data in basic variables before experiment N = 30

Basic variables	Statistical significance of the description			
	Mean	median	Standard deviation	Coefficient of contortion
Age (years)	18.491	18.5	0.214	0.019
Height (cm)	175.019	175	2.548	0.273-
Weight (kg)	72.589	72	2.388	0.596

Table 3 (homogeneity of sample data concerning the basic variables) shows that coefficients of contortion ranged between -0.273 and 0.596, indicating normalcy of measurements. Values of normal coefficients of contortion were 3±, very close to zero, thus confirming homogeneity of sample subjects in the basic variables before experiment.

- **Equivalence of the two groups**

Equivalence of the two groups was found in the basic variables of age, height and weight and also in the physical and functional variables studied, as illustrated in tables 4, 5 and 6.

Table 4

Differences between the first experimental group and the second experimental group in basic variables before the experiment

Statistical significance / variables	First experimental group N = 15		Second experimental group N = 15		Difference between the two means	T value
	Mean	Standard deviation ±	mean	Standard deviation ±		
Age (years)	18.466	0.208	18.515	0.224	0.049	0.625
Height (cm)	174.749	2.496	175.289	2.657	0.540	0.574
Weight (kg)	72.488	1.721	72.689	2.972	0.201	0.226

*** significant at the level 0.05 = 2.05**

Table 4 (differences between the first experimental group and the second experimental group in basic variables before the experiment) shows that the calculated T value ranged between 0.226 and 0.625 which are insignificant at the level 0.05, thus indicating the absence of significant differences between the two groups and the equivalence of the two groups in the basic variables.

Table 5

Differences between the first experimental group and the second experimental group in physical variables before the experiment

Statistical significance / Variables		First experimental Group N = 15		Second experimental Group N = 15		Difference between the two means	T value
		Mean	Standard deviation ±	Mean	Standard deviation ±		
Muscle strength	broad jumping from standing (in cm.)	202.482	4.866	201.044	4.843	1.438	0.811
Speed	30 m. sprint (in seconds)	3.490	0.118	3.500	0.049	0.010	0.303
Muscle endurance	Push-up from standing (by number)	33.910	2.696	33.503	3.054	0.407	0.387
Cardio-respiratory endurance	800 m. run (in minutes)	3.307	0.054	3.303	0.062	0.003	0.157
	1500 m. run (in minutes)	6.458	0.079	6.459	0.074	0.001	0.048
Agility	Zigzag run (in seconds)	18.377	2.057	18.111	1.888	0.266	0.369
Coordination	Numbered circles (in seconds	9.548	1.147	10.022	1.050	0.474	1.180

*** significant at the level 0.05 = 2.05**

Table 5 (differences between the first experimental group and the second experimental group in physical variables before the experiment) shows that the calculated T value ranged between 0.048 and 1.180 which are insignificant at the level 0.05, thus indicating the absence of significant differences between the two groups and the equivalence of the two groups in the physical variables before the experiment.

Table 6

Differences between the first experimental group and the second experimental group in functional variables before the experiment

Statistical significance / Variables		First experimental group N = 15		Second experimental group N = 15		Difference between the two means	T value
		Mean	Standard deviation ±	Mean	Standard deviation ±		
In rest	Vital capacity (VC) (liter)	4.230	0.292	4.274	0.301	0.044	0.407
	Expiratory reserve volume (ERV) (liter)	1.228	0.103	1.203	0.093	0.025	0.705
	Inspiratory reserve volume (IRV) (liter)	2.688	0.084	2.715	0.084	0.027	0.865
	Tidal volume (TV) (liter)	0.595	0.020	0.598	0.024	0.003	0.331

Statistical significance / Variables		First experimental group N = 15		Second experimental group N = 15		Difference between the two means	T value
		Mean	Standard deviation ±	Mean	Standard deviation ±		
	Inspiratory Capacity (IC) (liter)	3.324	0.089	3.373	0.086	0.049	1.544
In effort	VO2max (L/min)	3.005	0.143	2.975	0.141	0.030	0.581
	VO2 max (ml/minute//kg)	41.885	1.209	42.123	1.561	0.238	0.467
	VCO2 max (L/min)	2.602	0.261	2.674	0.234	0.072	0.795
	RER	0.914	0.040	0.901	0.035	0.013	0.921
	VE (L/min)	77.233	4.643	77.657	2.166	0.425	0.321

*** significant at the level 0.05 = 2.05**

Table 6 (differences between the first experimental group and the second experimental group in functional variables before the experiment) shows that the calculated T value ranged between 0.321 and 1.544 which are insignificant at the level 0.05, thus indicating the absence of significant differences between the two groups and the equivalence of the two groups in the functional variables.

• Pilot studies

The first pilot study was conducted with the aim of making sure that the physical tests are suitable for the sample subjects and that the tools used for measurement and program application are appropriate.

The second pilot study was conducted with the aim of

- setting performance rates and the different speeds and the best suitable heights of the stepping box in order to determine the load degree. Stepping rates were determined according to references used as illustrated in table 7.

Table 7

Performance rates and the different speeds

variables	Measuring unit	Stepping rates					
Performance rate	t/minute	26	28	30	32	34	36
Speed rate	Beat/minute	104	112	120	128	136	144

(42:82)

The training load can be advanced by controlling stepping rates (performance and speed) and the type of exercises used, while fixing the box height at 15 cm, so that it is used at the height of 10 cm for short persons, at 15 cm for beginners and at 20 cm for regularly trained persons. (15: 30) (42: 82) (14: 97)

- determining the exercise content for the stepping box and rope programs and measuring heart rates after a 3 minute effort. Consequently, 16 exercises were assigned for the stepping box and 15 for the jumping rope. Heart rates were separately taken for each exercise.

• Tools used in the experiment

1- jumping ropes (N = 15) suitable for the sample subjects

2- stepping boxes (N = 15) with a height of 15 cm

3- stop watches

• the basic study

The study started by applying the program as follows:

- the first experimental group was trained using the stepping box exercises
- the second experimental group was trained using the rope exercises.

• The suggested program

Basics of the program

- The changing load style was used, combining periodic training and continuous training for the anaerobic endurance training, the mixed training and the aerobic training. (42: 49-50), using heart beats as indicator to standardize the load. Load intensity was 70-85% of the maximum heart rate for aerobic training, 85-90% for mixed training and over 90% for anaerobic training. (54:104) (34:54)

- The Karvonen equation was used to determine the targeted heart rate, finding the pulse reserve as follows:

$$\text{*Targeted heart rate} = \frac{\text{Required intensity } \mathbf{x} \text{ pulse reserve}}{100} + \text{rest pulse}$$

*pulse reserve = maximum pulse - rest pulse

*maximum pulse = 220 – age (7: 28) (44:322) (34 20)

- Rest pulse rates were measured every three weeks to identify adaptability with the training load.
- The load and rest principle was used as a rule for the training, taking into consideration the individual loads given according to a person's physical ability. (12:71) (25:101) (46:45).
- Loads were increased gradually and in continuity. (30:44) (9:65) (2: 70)
- The experiment was conducted for 10 weeks distributed as follows: 1 week for teaching the stepping and rope exercises and 9 weeks for training at the rate of 36 training units, 4 units per week.

The first experimental group (the stepping box)

- The average time for the training unit was 70-80 minutes distributed as follows: 5 minutes for the warm-up activity; 60-70 minutes for the main part of the program (stepping box exercises) and 5 minutes for the finishing.
- Each training unit consisted of 6 exercises.
- Duration of the exercise ranged between 60 and 240 seconds.
- Interval rest between groups ranged between 3 and 6 minutes.
- Interval rest between exercises ranged between 30 and 120 minutes.
- Stepping exercises groups ranged between 2 and 4 groups.
- Exercises were accompanied by music at speeds of 104, 112, 120, 128, 136 and 144, played by a professional musician.

The second experimental group (the jumping ropes)

- The average time for the training unit was 60-90 minutes distributed as follows: 5 minutes for the warm-up activity; 50-80 minutes for the main part of the program (stepping box exercises) and 5 minutes for the finishing.
- Each training unit consisted of 6 exercises.
- Duration of the exercise ranged between 90 and 180 seconds.
- Interval rest between groups ranged between 3 and 6 minutes.
- Interval rest between exercises ranged between 45 and 90 minutes.
- Stepping exercises groups ranged between 2 and 4 groups.

- Result presentation and discussion after experiment

Table 8
Differences between pre-measurement and post-measurement of the first experimental group in physical variables N = 15

Statistical significance / variables		Pre-measurement		Pos-measurement		Difference between the two means		T value	Improvement %
		Mean	Standard deviation ±	Mean	Standard deviation ±	Mean	Standard deviation ±		
Muscle strength	broad jumping from standing (in cm.)	202.482	4.866	212.951	3.655	10.469	6.166	*6.576	5.170
Speed	30 m. sprint (in seconds)	3.490	0.118	3.297	0.036	0.193	0.116	*6.456	5.540
Muscle endurance	Push-up from standing (by number)	33.910	2.696	48.422	3.742	14.511	5.015	*11.207	42.793
Cardio-respiratory endurance	800 m. run (in minutes)	3.307	0.054	2.943	0.268	0.363	0.262	*5.375	10.988
	1500 m. run (in minutes)	6.458	0.079	6.227	0.088	0.231	0.118	*7.612	3.582

Statistical significance / variables		Pre-measurement		Pos-measurement		Difference between the two means		T value	Improvement %
		Mean	Standard deviation ±	Mean	Standard deviation ±	Mean	Standard deviation ±		
Agility	**Zigzag run (in seconds)**	**18.377**	**2.057**	**10.349**	**0.972**	**8.028**	**2.264**	***13.732**	**43.685**
Coordination	**Numbered circles (in seconds**	**9.548**	**1.147**	**6.748**	**0.603**	**2.800**	**1.268**	***8.554**	**29.325**

***significant at the level 0.05 = 2.14**

Table 8 (differences between pre-measurement and post-measurement of the first experimental group in physical variables shows differences between the two measurements at the level 0.05 in all physical variable tests, with a T value ranging between 5.375 and 13.732, which are higher than the tabular T value at the level 0.05. Improvement percentages ranged between 3.582% and 43.685%.

The stepping exercises positively and strongly affect endurance, coordination, agility, flexibility, balance and speed. (18) (17). Besides, they have an effect on developing the neuro-muscular coordination and muscular endurance, thus increasing a person's physical fitness (60). Going up and down the stepping box is a physical exercise that can positively affect general physical fitness (12). Stepping exercises also improve the muscular tone (55) through regular training and the effect it has on different physical abilities (38).

Table 9

Differences between pre-measurement and post-measurement of the first experimental group in functional variables N = 15

Statistical significance / variables		Pre-measurement		Pos-measurement		Difference between the two means		T value	Improvement %
		Mean	Standard deviation ±	Mean	Standard deviation ±	Mean	Standard deviation ±		
In rest	Vital capacity (VC) (liter)	4.230	0.292	5.247	0.173	1.017	0.305	*12.916	24.035
	Expiratory reserve volume (ERV) (liter)	1.228	0.103	1.451	0.053	0.223	0.131	*6.610	18.187
	Inspiratory reserve volume (IRV) (liter)	2.688	0.084	3.135	0.125	0.447	0.130	*13.287	16.617
	Tidal volume (TV) (liter)	0.595	0.020	0.698	0.014	0.103	0.023	*16.962	17.245
	Inspiratory Capacity (IC) (liter)	3.324	0.089	3.845	0.141	0.521	0.165	*12.232	15.664
In effort	VO2max (L/min)	3.005	0.143	3.502	0.256	0.497	0.270	*7.118	16.526
	VO2 max (ml/min/kg)	41.885	1.209	49.850	1.714	7.965	2.493	*12.376	19.017
	VCO2 max (L/min)	2.602	0.261	3.189	0.133	0.587	0.259	*8.775	22.547
	RER	0.914	0.040	0.838	0.040	0.076	0.050	*5.857	8.315
	VE (L/min)	77.233	4.643	90.168	5.976	12.935	7.079	*7.077	16.749

***significant at the level 0.05 = 2.14**

Table 9 (differences between pre-measurement and post-measurement of the first experimental group in functional variables shows differences between the two measurements at the level 0.05 in all measurements, with a T value ranging between 5.857 and 16.962, which are higher than the tabular T value at the level 0.05. Improvement percentages ranged between 8.315% and 24.035%.

Sports training improve the work of respiratory muscles and the safety of respiratory paths (28: 53).endurance training in particular lead to an increase in the strength of respiratory muscles, thus improving respiratory functions. (13: 291). This is becomes obvious in lung function tests,

including the evaluation of respiratory exchange ratio and the mechanical functions of pulmonary tissues and air paths. The evaluation of the mechanical functions of the lungs is done by comparing the lung size, the air moving ratio and the strength of respiratory muscles. (8:27)

Measuring oxygen consumption (VO2max) is used as an objective measurement of the functional fitness level and for identifying the effect of different training loads. Thus, a player's physical fitness can be determined according to his or her ability to consume, transfer and use oxygen in his or her muscles. VO2 can per se indicate the functional condition of both the circulatory and respiratory systems. (31: 28).

Improvement is due to the muscles' ability to consume oxygen, as a sign of adaptability to the training load, and the improvement in muscle efficiency in consuming more oxygen through the increase in the number of mitochondria, the increase in the activity of aerobic oxidation enzymes and the increase in the surface area of blood cilia in muscular fibers, in addition to improving the efficiency of organs responsible for providing muscles with oxygen as a result of the increase in the efficiency of respiratory functions.

Regular aerobic exercises improve the absolute VO2max, the VO2max/kg, the RER and the VE (amount of air moved in and out of the lungs) as a result of the improvement in lung functions, cardiac output and the difference between arterial and venous oxygen (45:**115) (4:15) (32:20) (57:12) (43:94).**

Practicing sport, especially endurance exercises leads to an increase in the vital capacity because the player needs an amount of air from which he can take as much oxygen as possible so that oxygen volume is greater in the blood, thus leading to the strengthening of the chest muscles, increasing respiratory rate and depth in the circulation of the blood (22) (47) (16: 78) (50:202).

Table 10
Differences between pre-measurement and post-measurement of the second experimental group in physical variables N = 15

Statistical significance / variables		Pre-measurement		Pos-measurement		Difference between the two means		T value	Improvement %
		Mean	Standard deviation ±	Mean	Standard deviation ±	Mean	Standard deviation ±		
Muscle strength	broad jumping from standing (in cm.)	201.044	4.843	208.622	4.680	7.578	6.098	*4.813	3.769
Speed	30 m. sprint (in seconds)	3.500	0.049	3.205	0.079	0.295	0.066	*17.332	8.438
Muscle endurance	Push-up from standing (by number)	33.503	3.054	41.617	2.274	8.113	3.870	*8.120	24.217
Cardio-respiratory endurance	800 m. run (in minutes)	3.303	0.062	2.808	0.270	0.495	0.296	*6.482	14.995
	1500 m. run (in minutes)	6.459	0.074	5.581	0.121	0.878	0.159	*21.323	13.593
Agility	Zigzag run (in seconds)	18.111	1.888	11.947	0.979	6.164	2.330	*10.244	34.032
Coordination	Numbered circles (in seconds	10.022	1.050	7.535	0.638	2.487	0.825	*11.669	24.812

***significant at the level 0.05 = 2.14**

Table 10 (differences between pre-measurement and post-measurement of the second experimental group in physical variables shows differences between the two measurements at the level 0.05 in all physical variable tests, with a T value ranging between 4.813 and 21.323, which are higher than the tabular T value at the level 0.05. Improvement percentages ranged between 3.769% and 34.032%.

Rope exercises upgrade the general level of a player's ability in sport activities in general and in exercises in particular. (37) through continuous and regular training which develop and enhance physical qualities. (56) (36) (63) (13). The improvement in all physical measurements is due to the effectiveness of the training program because rope exercises highly improve physical qualities and delay fatigue. (27) (49) (1) (37).

Table 11
Differences between pre-measurement and post-measurement of the second experimental group in functional variables N = 15

Statistical significance / variables		Pre-measurement		Pos-measurement		Difference between the two means		T value	Improvement %
		Mean	Standard deviation ±	Mean	Standard deviation ±	Mean	Standard deviation ±		
In rest	Vital capacity (VC) (liter)	4.274	0.301	5.900	0.197	1.626	0.224	*28.156	38.044
	Expiratory reserve volume (ERV) (liter)	1.203	0.093	1.546	0.062	0.343	0.119	*11.217	28.548
	Inspiratory reserve volume (IRV) (liter)	2.715	0.084	3.675	0.100	0.960	0.150	*24.811	35.363
	Tidal volume (TV) (liter)	0.598	0.024	0.771	0.057	0.173	0.066	*10.140	28.874
	Inspiratory Capacity (IC) (liter)	3.373	0.086	4.434	0.052	1.061	0.110	*37.401	31.443
In effort	VO2max (L/min)	2.975	0.141	3.809	0.145	0.833	0.216	*14.927	28.008
	VO2 max (ml/min/kg)	42.123	1.561	57.558	1.842	15.435	2.479	*24.118	36.644
	VCO2 max (L/min)	2.674	0.234	3.808	0.803	1.134	0.874	*5.027	42.408
	RER	0.901	0.035	0.811	0.065	0.120	0.058	*7.987	13.314
	VE (L/min)	77.657	2.166	100.327	3.350	22.670	4.138	*21.219	29.192

***significant at the level 0.05 = 2.14**

Table11 (differences between pre-measurement and post-measurement of the second experimental group in functional variables shows differences between the two measurements at the level 0.05 in all measurements, with a T value ranging between 5.027 and 37.401, which are higher than the tabular T value at the level 0.05. Improvement percentages ranged between 13.314% and 42.408%.

The functional changes occurring as a result of physical effort include a reduction in the speed of respiration (number of times). VE increases and improves through practicing exercises and changes to the better before, during and after exercises. (35: 132). Reduction of the times of respiration moves the same amount of air before the exercise and increases the surface area of blood cilia thus increasing the respiratory exchange ratio. (26:60) (53:89, 90). It also improves endurance level in respiratory muscles (52:56) and increases volume of air respired inhaled in one cycle (TV). Resistance to air flow is also reduced thus making the respiratory exchange process easier (48: 114).

Anaerobic exercises improve lung functions by increasing the strength and endurance of intercostal muscles, diaphragm muscles, improving the volume of respired air (TV), increasing the ability of the muscles to push the air out of the lungs, thus increasing the vital capacity. (26: 6, 50).

Compared to low-intensity training, the high intensity training improves the efficiency of the respiratory system faster. It also increases endurance capacity, absolute VO2max, VO2max/kg and VE (29: 45) (40: 174) (58: 1).

Table 12
Differences between the first experimental group and the second experimental group in physical variables after the experiment

Statistical significance / Variables		First experimental group N = 15		Second experimental group N = 15		Difference between the two means	T value	Statistical significance	Variables
		Mean	Standard deviation ±	Mean	Standard deviation ±				
Muscle strength	broad jumping from standing (in cm.)	212.951	3.655	208.622	4.680	4.329	*2.823	2.033	
Speed	30 m. sprint (in seconds)	3.297	0.036	3.205	0.079	0.092	*4.120	2.791	
Muscle endurance	Push-up from standing (by number)	48.422	3.742	41.617	2.274	6.805	*6.019	14.053	
Cardio-respiratory	800 m. run (in minutes)	2.943	0.268	2.808	0.270	0.135	1.379	4.598	

Statistical significance / Variables		First experimental group N = 15		Second experimental group N = 15		Difference between the two means	T value	Statistical significance / Variables
		Mean	Standard deviation ±	Mean	Standard deviation ±			
endurance	1500 m. run (in minutes)	6.227	0.088	5.581	0.121	0.645	*16.702	10.364
Agility	Zigzag run (in seconds)	10.349	0.972	11.947	0.979	1.599	*4.487	15.447
Coordination	Numbered circles (in seconds	6.748	0.603	7.535	0.638	0.787	*3.472	11.667

*** significant at the level 0.05 = 2.05**

Table 12 and graph 1 (differences between the first experimental group and the second experimental group in physical variables after the experiment) show:

- significant differences between the two groups favoring the first experimental group in the tests of broad jumping from standing to measure muscle strength; push-up from standing to measure muscle endurance; zigzag run to measure agility; numbered circles to measure coordination.
- significant differences between the two groups favoring the second experimental group in the tests of 30 m sprint to measure speed; 1500 m run to measure cardio-respiratory endurance.
- no significant differences between the two groups in the 800 m run test (to measure cardio-respiratory endurance.

The calculated T value ranged between 2.823 and 16.702, values which are significant at the level 0.05. Percentage differences between the two groups ranged between 2.033% and 15.447%. Comparing the physical qualities in the two groups showed an improvement in the physical variables studied in both experimental groups. This is due to the nature of each program (stepping exercises and rope exercises) and the training style alternately using different intensities, which greatly improved the different physical abilities, a fact confirmed by other studies (4), (6)

Figure 1

The arithmetic mean of the two experimental groups in physical variables after experiment

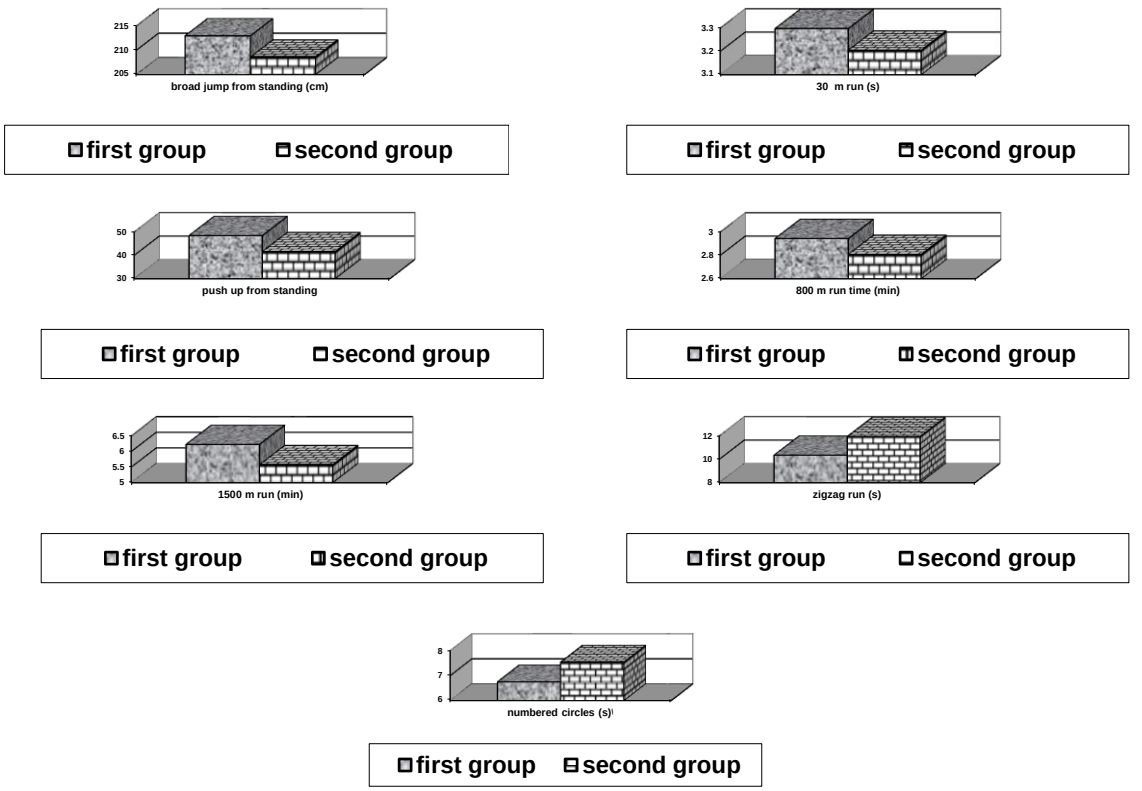


Table 13
Differences between the first experimental group and the second experimental group in functional variables after the experiment

Statistical significance / Variables		First experimental group N = 15		Second experimental group N = 15		Difference between the two means	T value	Statistical significance Variables
		Mean	Standard deviation ±	Mean	Standard deviation ±			
In rest	Vital capacity (VC) (liter)	5.247	0.173	5.900	0.197	0.653	*9.656	12.452
	Expiratory reserve volume (ERV) (liter)	1.451	0.053	1.546	0.062	0.095	*4.476	6.523
	Inspiratory reserve volume (IRV) (liter)	3.135	0.125	3.675	0.100	0.540	*13.036	17.227
	Tidal volume (TV) (liter)	0.698	0.014	0.771	0.057	0.073	*4.790	10.411
	Inspiratory Capacity (IC) (liter)	3.845	0.141	4.434	0.052	0.589	*15.165	15.329
In effort	VO2max (L/min)	3.502	0.256	3.809	0.145	0.307	*4.041	8.757
	VO2 max (ml/min/kg)	49.850	1.714	57.558	1.842	7.708	*11.864	15.462
	VCO2 max (L/min)	3.189	0.133	3.808	0.803	0.619	*2.945	19.423
	RER	0.838	0.040	0.811	0.065	0.027	1.588	3.222
	VE (L/min)	90.168	5.976	100.327	3.350	10.159	*5.743	11.267

*** significant at the level 0.05 = 2.05**

Table 13 and graph 2 (differences between the first experimental group and the second experimental group in functional variables after the experiment) show significant differences between the two groups favoring the second experimental group at the level 0.05 in all measurements except for the respiratory exchange ratio (RER) where the T value was 1.588, which is insignificant at the level 0.05, with a percentage difference of 3.222%. the T value for the other measurements ranged between 2.945 and 15.165, values which are higher than the tabular T value at the level 0.05 . Percentage differences between the two groups ranged between 6.523% and 19.423%.

Superiority of the second experimental group is due to the nature of the rope exercise program whose merits are noticeable if the program was well utilized. This, however, does not exclude the good effect of the stepping box exercises.

Sports training has positive effects on improving respiratory functions (absoluteVO2max, relative VO2max/kg, VE, reducing the number of respirations necessary to move the same amount of air before training, increasing the surface area of blood cilia leading to an increase in RER processes (26:60) (53: 89, 90) (62:226). This was also confirmed by other studies (49) (4) (45).

Regular training saves respiratory functions because the body of athletes need less oxygen when doing the same effort, compared to non-athletic persons (10:26)

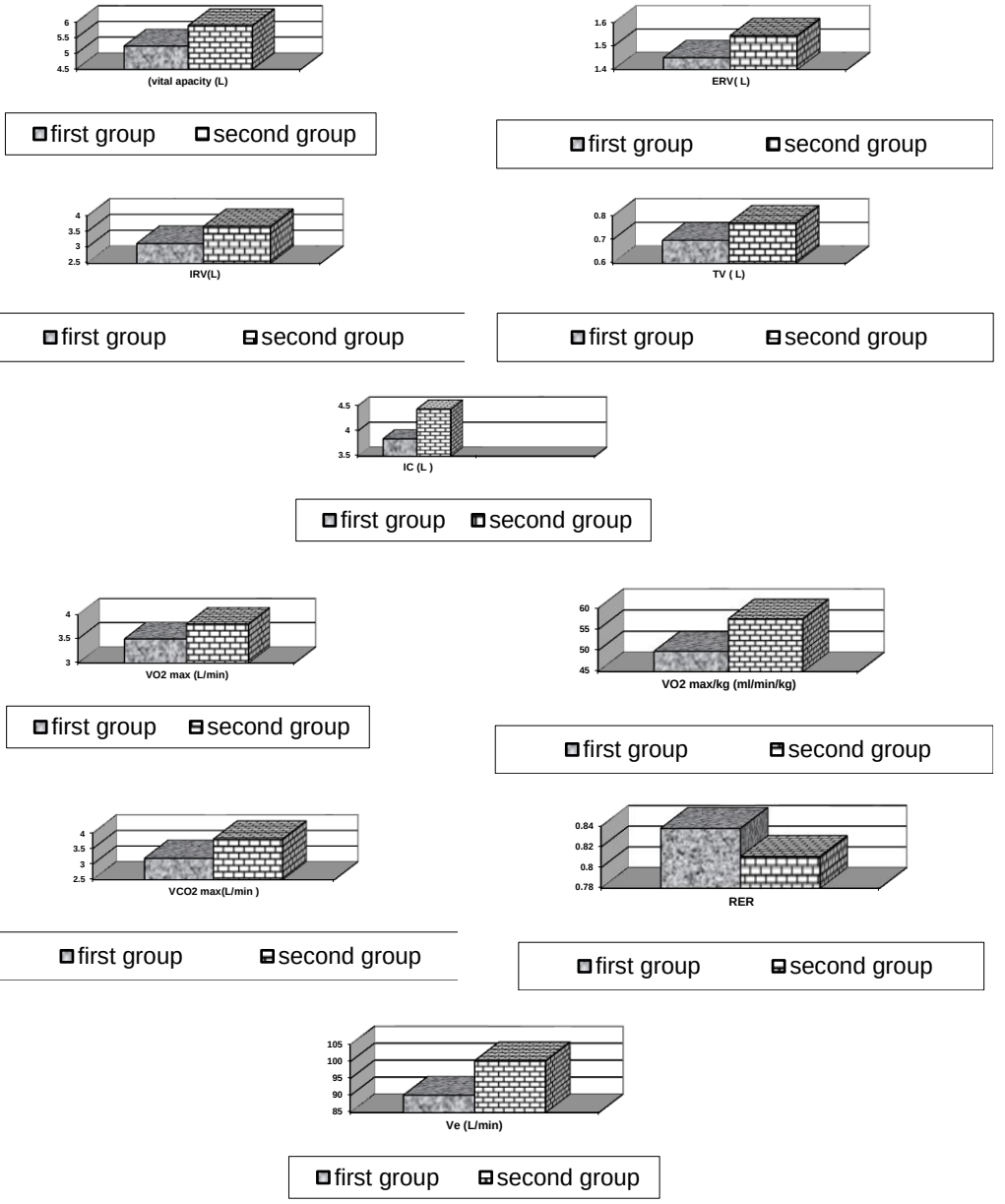
Respiratory functions improve by sports training with the increase in the volume of the air inhaled in one cycle (TV). Resistance to air flow is also reduced thus making the respiratory exchange process easier (48: 114).

Endurance exercises also increase the strength of respiratory muscles, thus improving respiratory functions (13:291) (28:53). This in turn reduces the number of respirations (52:95) because physiological adaptations that occur as a result of train

ing improve the efficiency of oxygen carrying systems which improves endurance and saves energy when performing muscular work and helps maintain the physical performance as long as possible. This also improves the work of both the circulatory and respiratory systems as a result of regular training. (51: 85, 99).

Authors of this paper believe that the stepping box and rope exercises program can effectively contribute to the development of the physical and functional abilities of a person.

Figure 2
The arithmetic mean of the two experimental groups in functional variables after experiment



Conclusions

1. Superiority of the first experimental group using the stepping box exercises in physical variables (muscle strength, muscle endurance, agility and coordination).
2. Superiority of the second experimental group using the rope exercises in variables of speed, cardio-respiratory endurance (1500 m. run).
3. No significant differences between the two groups in the cardio-respiratory endurance (800 m. run).
4. Superiority of the second experimental group (rope exercises) over first experimental group (stepping box exercises) in all functional measurements except for the respiratory exchange ratio (RER) where no differences existed between the two groups.

Recommendations

1. Applying the two suggested exercise programs using the stepping box and the rope indifferent sports activities to improve physical and functional variables and upgrade performance level thus reaching higher standards;

2. Conducting further studies using the exercise tools according to standardized training programs to identify their effectiveness.

References

1. **Abdel Fattah, I., :** The Effect of the Development of Anaerobic Ability on Certain Physiological and Special Physical Variables and Straight Serve Speed in Tennis, Scientific Conference for Health, Physical Education and Recreation, Faculty of Physical Education and queens, El-Menia University, 1999.
2. **Abdel Khaliq, E., :** Athletic Training, Theories and Applications, 10th edition, Darul-Maarif, Alexandria, 2000.
3. **Abdel Rahman,N., :** Aerobic Activities, Monshaat Al-Maarif, Alexandria, 2000.
4. **Abdel Samie ,E., :** Effect of Energy Fitness Training Using High-Intensity Aerobic and Anaerobic Interval Running and Rebound Running on the Development of Speed, Ph.D. thesis, Faculty of Physical Education for Men, Helwan University, 2005.
5. **Abdel Wahab ,F., :** Sport - Health and Physical Fitness, Daru Shorook, Cairo, 1995.
6. **Abu Bakr, A., :** The Effect of Rope Aerobic and Anaerobic Exercises on the Physical and Functional Condition of the Students of the Faculty of Physical Education in Alexandria, Master Thesis, Faculty of Physical Education for Men, Alexandria University, 2012.
7. **Ackland, J. :** The Complete Guide To Endurance Training A&C Black, London, 1999.
8. **Alassad, K.,& karlinskyo,J.B.,:** Pulmonary function testing ,N:A practical approach to pulmonary medicine edited by, Goldstein, R.H, Connell, J.J., Karlinsky, J. B., Lippincott –Reven, Philadelphia,U.S.A,1997.
9. **AlBissati, A., :** Basics and Rules of Sports Training and its Applications, Monshaat Al-Maarif, Alexandria, 1998.
10. **Alge, V., Alfonsas, V., Virginija, S.,& Jonas, p., :** The influence of aerobic exercise to cardiovascular functional parameters of 30- 40 year old women Kaunas University of medicine Lithuanian academy of physical education, 2004.
11. **Allawi,M.,& Radwan,M., :** Motor Performance Tests, Darul-Fikr El-Arabi, Cairo, 2001.
12. **Borhom,A., & Abu Namira,M., :** Sports Exercises Encyclopedia, volume I, 2nd edition, Darul-Fikr for Publishing and Distribution, 1995.
13. **Celli, B.R.,: Pulmonary rehabilitation ,N:** A practical approach to pulmonary medicine ,edited by Goldstein, R.H, Connell, J.J., Karlinsky, J. B., Lippincott –Reven, Philadelphia,U.S.A,1997.
14. **Champion, N. & Hurst, G., :** The Aerobics Instructor's Handbook. A&C Black, London, 2005.
15. **Darwish,A., & Hassan,N., :** Scientific and Practical Fundamentals for Using Stepping Box in Aerobic Exercises, Monshaat Al-Maarif, Alexandria, 1997.
16. **Dick, W. :** Sports Training Principles, Thired edition, A&C Black, London, 1997.
17. **ElAlfi,H.,& Mohamed,N., :** Effect of Aerobic Exercises Using Stepping Box on Performance Motivation and Certain Motor and, Sport & Woman Conference, Faculty of Physical Education for Girls, Alexandria University, 1995.
18. **ElBassiouni, S., :** The Effect of a Training Programme for Aerobic Exercises Using Stepping on Certain Physical and Physiological Variables among Female Smokers in the 30-40 Year-Old Age Span, Sports Sciences Journal, Faculty of Physical Education for Girls, Volume V, No. 2, Cairo, 1993.
19. **ElBatal ,F., :** Effect of a Proposed Programme Using the Rope on the Development of Neuromuscular Compatibility, and the Level of Motor Performance among Junior Female Rhythmic Gymnastics Players, Sports Sciences and Arts Journal, Faculty of Physical Education for Girls in Cairo, Helwan University, 1993.
20. **ElSayed, A., :** Effectiveness of Stepping Exercises to Promote Aerobic and Anaerobic Energy System for the 13-15 Year-Old Age Span, Master Thesis, Faculty of Physical Education for Men, Alexandria University, 2002.
21. **ElSayed,N., & Noor, M., :** Effect of Mixed Physical Exercises (Aerobic and Anaerobic) on Certain Breathing Functions among Teenagers in Some Different Climatic Environments, Theories and Applications Journal, Faculty of Physical Education for Men, Alexandria University, 2003.
22. **Everson. M .,** : The Measurement of physiology ZAN - 680 ergo spirometry system ZAN messgract , Gmbh . by 7723 ober thulba Germany , 2001.
23. **Gallahue,L.D.,:** Development physical Education Of Today Elementary Children, 1 St., ed., Macmillan publishing, 1993.
24. **Hammad, M., :** Juniors Athletic Training and Successful Coach, Darul-Ketab El-Hadeeth, Cairo, 2009.
25. **Hassanein,M.,** : Measurement and Evaluation in Sports and Physical Education, volume I, 4th edition, Darul-Fikr El-Arabi, Cairo, 2001.
26. **Hayes, F., :** The complete guide to cross training ,A&C black London,1998.
27. **Herez ,E., :** Effect of Breathing Exercises on Certain Physiological and Physical Variables, Master Thesis, Faculty of Physical Education, Banha University, 2008.
28. **Heshmat,H., & Salah El-Din,M., :** Health and Sport Biology, Markazul-Ketab for Publishing, Cairo, 2009.
29. **Hoogeveen.A.R., :** The effect of endurance training on the Ventilator exercise in elite cyclists .Eur.J.APPL.Physiology . Mayvol. 82 (12).pp.45-51,2000.
30. **Hossam El-Din, T., :** Scientific Encyclopedia of Training, 1st edition, Markazul-Ketab for Publishing, Cairo, 1997.
31. **Ibrahim,F., & Nofal ,E., :** Setting a Standard for Evaluating Performance in Rope Jumping Exercises for the Students of the Faculty of Physical Education for Men, Theories and Applications Journal, No. 15, Faculty of Physical Education for Men, Alexandria University, 1993.

32. **Jackson ., A, W., Morrow, J, R., Hill, D, W., Dishman, R, K., :** Physical Activity for Health And Fitness, Human Kinetics , Hong Kong ,2004 .
33. **Janssen G. :** Lactate Threshold Training, Human Kinetics Champion, U.S.A, 2001.
34. **Juba, K. :** Swimming for Fitness. A & C Black, London, 2007.
35. **Kemash,Y., & Bashir,S., :** Introduction to Sport Biology, Darul-Wafaa for Publication, 1st edition, Alexandria Physiological Variables in Exercises, 2011.
36. **Khattab,A., :** Exercises for Girls, 8th edition, Darul-Maarif, Cairo, 1997.
37. **Khattab,A., & Maha Fekry,M., & Shokeir,S., :** Basics of Exercises and Rhythmic Exercises, Markazul-Ketab for Publishing, Cairo, 2006.
38. **Kravitz, L.,:** Physiological profile of step aerobics instruction research quarterly for exercise and sport , DEC .Vol .64 (1) pp:37 , 1994.
39. **Kudo, E., :** The Martial Arts Education in Akita Han, http://ci.nii.ac. Jp/naid/110001919939/en, 2008.
40. **Leuppi JD, Zenhäusern R, Schwarz F, Frey WO, Villiger B,:** The importance of training intensity for improving endurance capacity of patients with chronic obstructive pulmonary disease, J, Dtsch Med Wochenschr. Feb 13;123(7),174-8,1998.
41. **Levy, A. M ., Furest, M.L., :** Sport injury handbook – professional advice for amateur athletes, John Wiley & Sons, New York .1993.
42. **Marei,M., :** Effect of an Exercises Programme Using One of Education Technology Means on Certain Variables Associated with the Compulsory training Routine for Students of the Faculty of Physical Education, Master Thesis, Faculty of Physical Education for Men, Alexandria University, 1997.
43. **Martin D.E. Coe P.N :** Better Training For Distance Runners 2 ed .Human Kinetics U.S.A,1997 .
44. **Mcardle, D., Katch, I.& Katch, L. :** Exercise Physiology, Energy, Nutrition, and Human Performance, 5th Lippincott, edition, Williams & Witkins, U.S.A, 2001.
45. **Mohamed,M.,:** Effect of an Aerobic and Anaerobic Exercises Programme on Tactical Preparation and Achievement Level among Saber Players, Ph.D. thesis, Faculty of Physical Education, Tanta University, 2007.
46. **Osman,M., :** Training Load, Adaptation and Physiological Responses to Training Loads Pressures between Theory and Practical Reality, 1st edition, Darul-Fikr El-Arabi, Cairo, 2000.
47. **Parker . R., :** speed and quicknees training ,The speed star training system is an phase complete program greater performance in simply the best in speed training equipment . GPI – US Track , 2006.
48. **Prentice .W.E.,:** Fitness for college and life, 5th ed, Mosby-year book, ink, U.S.A , 1997.
49. **Ramadan, A., :** The Effect of the Development of Anaerobic Ability at the End of the Training Module on Certain Physical and Physiological Variables and the Basic Skills of Basketball among Juniors (16-18 Years Old) Ph.D. thesis, Faculty of Physical Education in Port Said, Suez Canal University, 2001.
50. **Salama, B., :** Biochemical Characteristics of Sports Physiology, 1st edition, Darul-Fikr El-Arabi, 2008.
51. **Salama, B., :** Physical Effort Physiology, Darul-Fikr El-Arabi, Cairo, 2009.
52. **Salem, A., :** The Effect of the Use of Rope and Stepping Box Exercises on Certain Physical and Functional Variables in the 9-12 Year-Old Age Span, Master Thesis, Faculty of Physical Education for Men, Alexandria University, 2012.
53. **Sharkey,B.J., :** Physiology of Fitness, 3 rd. ed., Human Kinetics Books, U.S.A., 1990.
54. **Sharkey,B.J.,:** Fitness and health, 4th ed., human kinetics, U.S.A, 1997.
55. **Shehata,M.,& Faroz,F., :** Sport for All and Physical Fitness Programmes, Monshaat Al-Maarif, Alexandria, 1996.
56. **Soliman, S., :** Exercises and Graphical Exercises, Darul-Kutub Al-Jameiyah, Cairo, 2001.
57. **Taylor,I.,:** Taylor on hockey first published, Greater House, London, 1998.
58. **Tomlin D.L. & Wenger H.A, :** The Relationship Between Aerobic Fitness And Recovery From High Intensity Intermittent Exercise Sports Med . Vol.31(1) pp 1-11 ,2001.
59. **Wall, j., & Murray,N.,:** Children& Movement, physical education in the Elementary school, 2 nd, Brown & Benchmark, U.S.A, 1995.
60. **Westcott, W., :** Building strength and stamina new nautilus training for total fitness, nautilus international, inc., human kinetics, U.S.A, 1996
61. **Williford, H,N.,Richards L,A., Scharff, O, M., Brown J, Blessing D., Duey, W,J.,:** Bench stepping and running in women changes in fitness and injury status, J, Sports Medicine and Physical Fitness, Vol 38 (3), 1998.
62. **Wilmore, J,H., & Costill D L ., :** Physiology of sport and exercise, human kinetics, U.S.A,1994.
63. **Zahran,L.,** : Exercise Scientific and Practical Fundamentals, Darul-Fikr El-Arabi, Cairo, 1997.