Geliş Tarihi:04.09.2018
Kabul Tarihi:11.10.2018
SPORMETRE, 2018,16(4),12-20
DOI: 10.1501/Sporm_0000000390

RESPIRATORY FUNCTIONS AND ANATOMICAL BALANCE IN BOXERS

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Abstract: The present study aimed to examine the relationship between lung capacity and balance parameters in professional boxers. Twenty-six professional-level male boxers aged 16-20 years volunteered to participate in the study. The respiratory and balance parameters of the athletes were analyzed via Pearson's correlation with values of $P<0.05$ accepted as statistically significant. A positive relationship was determined for the values of volume taken in the first second/forced vital capacity (FEV1/FVC) with the average tracking error (ATE) (%), body mass index (BMI) with ATE (%), FEV1 with area used (E area) (mm^2), FVC with E area (mm^2) and environment used (per mm), and for vital capacity (VC) with the Y-axis pressure to the central point (Av CoPY, mm). A significant relationship was found between values of the distance and the area used by boxers to stand inbalance and the inspiration and expiration parameters. This suggests that the body balance is very effective and that the parameters related to the lung function and balance level should be evaluated together in sports areas where the aerobic capacity is used extensively.

Keywords: Boxing, Balance, Respiratory functions, Prokin, VO_2

BOKSÖRLERDE SOLUNUM FONKSİYONLARI VE ANATOMİK DENGE

Öz: Sunulan çalışmada, profesyonel boksörlerde akciğer kapasiteleri ile denge parametreleri arasındaki ilişkinin incelenmesi amaçlanmıştır. Çalışmaya elit düzeyde mücadele eden, 16-20 yaş arası 26 erkek boksör gönüllü olarak katılmıştır. Sporcuların solunum ve denge parametreleri pearson korelasyonu ile analiz edilerek, $P<0.05$ düzeyindeki değerler istatistiksel olarak anlamlı olarak kabul edilmiştir. Bulgularda, FEV1/FVC ile ortalama denge hatasında (A.T.E %); vücut kitle indeksi (VKI) ile ortalama denge hatasında; FEV1 ile kullanılan alanda (E. Area mm^2); FVC ile kullanılan alan ve kullanılan çevrede (Per mm); VC ile Y ekseninde merkezi noktaya yapılan basınç (Av. C.o.P. Y mm) değerleri arasında pozitif yönde ilişki belirlendi. Boksörlerin dengede durmak için kullandıkları alan ve mesafe değerleri ile inspirasyon ve expirasyon parametreleri arasında anlamlı ilişkiler olduğu saptandı. Vücut dengesinin çok etkili olduğu ve aerobik kapasitenin yoğun olarak kullanıldığı spor dallarında, akciğer fonksiyonları ve denge düzeyi ile ilgili parametrelerin birlikte ele alınarak değerlendirilmesi önerilmektedir.

Anahtar kelimeler: Boks, Denge, Solunum fonksiyonları, Prokin. VO_2

INTRODUCTION

Boxing, one of the oldest endurance-based sports branches, involves high-performance fighting and has a complex structure due to its static and dynamic characteristics, and it exhibits many motoric features (Mitchell et al., 1994). Boxers compete while standing and only using punches; thus, balance is a very important parameter in this sport. An examination of the literature reveals that body balance has become an increasingly studied issue over the last decade (Mainenti et al., 2011; Park et al., 2018). Healthy control of balance is important to properly carry out all daily life activities. The deterioration of balance functions clearly emerges at younger ages and acceleratesin the 60's (Era et al., 2006). In addition, fat accumulation, which is one of the factors that hasten this deterioration, may lead to loss of body balance and the risk of falls,

especially when combined with low muscle mass and the resulting impaired biomechanical responses and decreased stability mechanisms (Mainenti et al., 2011; Kayacan and Makaraci, 2017). In this context, in addition to helping maintain the body mass index atideal rates, regular exercise also contributes positively to the development of body balance.

Many different factors play a role in the performance of the sport of boxing. In recent years, many studies have shown that physical factors such as body balance and reaction time (Cınar et al., 2009; Zemkova, 2014), as well as physiological factors such as functional lung volume and capacity play important roles in in the performance of this sport (Cakmakcı et al., 2005; Mazic et al., 2015; Ringhof and Stein, 2018). In addition, research has recently been conducted on the relationship between body composition and lung functions in boxers (Oke and Agwubike, 2015; Chaabe`ne et al., 2015). The results obtained from these studies examining the physical and physiological parameters indicate that future research aimed at developing the existing data set on boxers and creating more appropriate training programs for them is likely to be of great importance and benefit (Chaabe`ne et al., 2015). In addition, determining athlete profiles by examining their physical and physiological characteristics will be a valuable contribution to sport science.

To date, no other study analyzing the relationship between lung function and balance parameters in boxers has been reported in the literature. For this reason, this study aimed to contribute to sport science by evaluating the relationships between the parameters of balance and functional lung capacity in professional boxers who either play for the Turkish national team or compete in various clubs.

MATERIAL AND METHOD

Twenty-six professional male boxers aged 16-20 years volunteered to participate in the study. Their height was measured barefoot using a standard steel stadiometer with an accuracy of 0.1 cm. The weight of the athletes, barefoot and with no metallic objects on them, was measured via the Tanita BC-418 Segmental Body Analysis System (Tanita Corporation, Tokyo, Japan).

Measurement of Lung Function

To examine the lung capacity of the athletes, dynamic lung tests were performed to measure forced vital capacityand volume-time curves, flow-volume curves, maximal voluntary ventilation, and airway resistance. Measurements were carried out three times on the athletes while in a relaxed state. For the respiratory parameters of the athletes, the forced expiration volume taken in the first second (FEV1), forced vital capacity (FVC), vital capacity (VC), maximum voluntary ventilation (MVV) and FEV1 / FVC were measured using the CPFS / D USB ™ spirometer (MedGraphics CPFS / D ™ USB, St. Paul, MN, USA).

Measurement of Balance Parameters

The dynamic and static evaluation tests in the present study were used to determine the athletes' balance and proprioceptive status. The balance functions of the boxers were determined using the CSMI-TecnoBody PK-252 isokinetic balance system measuring device (Pro-Kin, TecnoBody PK-252, Dalmine, Italy) with a 20 Hz sampling rate and sensitivity of 0.1 ° (Sample measurement chart in figure. 1).

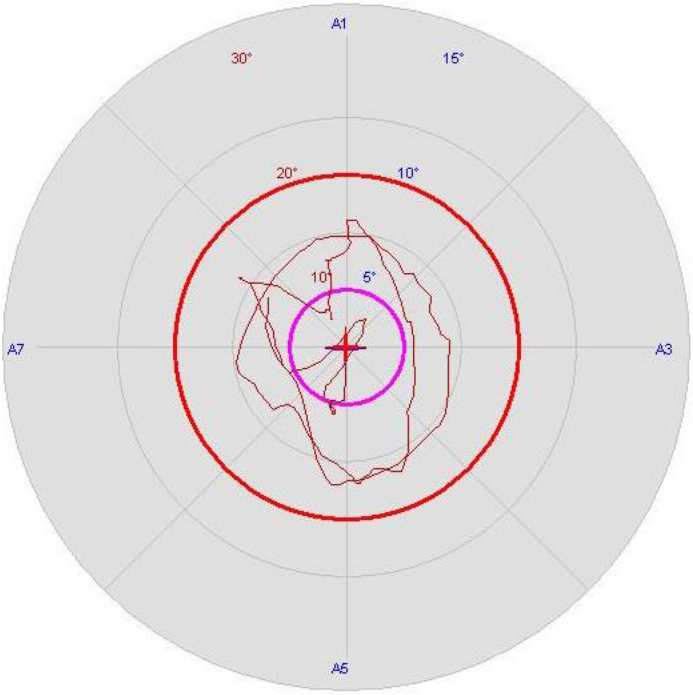

Figure 1. *Prop. A. (Dynamic) Stab. In.° measurement*

In this system, the balance of the moving platform can adjust automatically to calculate the weight and the non-stability coefficient of the person at each point of the platform.

For the dynamic balance of the athletes, the parameters of the stability indices, average tracking error (ATE) and average force variance (AFV) were measured. The average X and Y pressure center (AvCoP), environment used (per mm), and area used (ellipse area: E area) (mm2) were detected for the static balance values. Tests were performed with both feet standing flat. The balance test values were calculated by taking the average of three repetitions. Beforehand, the athletes'test measurements had been taken again in sets of 10 to comply with the static and dynamic balance tests. Participants were asked to avoid movements non-compliant with the protocol and not to speak during the testing period. The tests of participants who had lost their balance were restarted. Pearson's correlation was used to determine the degree of strength of the linear correlation in the obtained findings, and the P value was set as <0.05.

RESULTS

In the present study, it was aimed to analyze the relationship between dynamic and static balance parameters and lung functions.

The average age of the athletes was 16-20 years, height 168.8 ± 1.6 cm, weight 61.7 ± 3.1 kg and the duration of active sports was 2.4 ± 0.5 years (± sem). Descriptive

statistical findings of the balance and respiratory parameters of the athletes are given in Table 1. Findings related to the correlation of balance and respiration parameters of the athletes are shown in Table 2.

Table 1. Descriptive statistics of balance and respiratory parameters of the athletes

Parameters	*Min*	*Max*	*Mean±sem*
(Static) O. E. Av. C.o.P. X	-25	2	-1,34±,97
Av. C.o.P. Y	-43	2	-5,38±1,69
E. Area (mm^2)	84	1821	467,15±72,67
Per. (mm)	327	1094	531,76±35,77
(Static) C. E. Av. C.o.P. X	-28	11	-2,96±1,65
Prop. A. (Dynamic) Stab. In.°	0	7,5	2,20±,59
A.T.E %	2	29	16,42±1,44
AFV (kg)	0,2	4,8	1,27±,19
FEV1/FVC (%)	37	95	75,54±3,25
FEV1*	1,55	5,37	3,12±,18
FVC*	2,65	6,33	4,21±,22
VC*	2,25	6,42	4,08±,23
MVV**	74	237	127,61±7,07
BMI (kg/m^2)	21,42	32,18	18,17±,82

**: Liter;*

*** Liter/ Minute*

According to the results of the statistical analysis, a positive relationship was determined for the values of the FEV1 / FVC with ATE (%), BMI (Body Mass Index) with ATE (%), FEV1 with the E area, FVC with the E area and the environment used, and for VC with the Y-axis pressure to the central point (P<0.05). No statistically significant relationship was found in the other measured parameters. Descriptive statistical information on the athletes is given in Table 1 and the findings of the correlation analysis are shown in Table 2. The relationship between the static and dynamic balance parameters and the lung volume and capacity parameters of the boxers is presented in Table 2.

Table 2. Pearson's correlation findings between respiratory parameters and balance parameters of the athletes

Parameters		*Static Parameters*				*Dynamic Parameters*		
		E. Av. C.o.P. X	***Av. C.o.P. Y***	***E. Area (mm^2)***	***Per. (mm)***	***Prop. A. (Dynamıc) Stab. İn. °***	***A.T.E %***	***AFV (kg)***
FEV1/ FVC (%)	*R*	-.292	-.198	.005	-.154	-.217	.338	.146
	P	.147	.332	.979	.451	.287	**.050***	.477
FEV1	*R*	-.025	.115	.395*	.279	.038	.024	.202
	P	.902	.576	**.046***	.167	.855	.906	.322
FVC	*R*	.197	.265	.361	.356	.294	-.261	.097
	P	.336	.191	**.050***	**.050***	.145	.197	.638
VC	*R*	.190	.349	.234	.197	.279	-.235	-.136
	P	.354	**.050***	.250	.336	.168	.249	.507
MVV	*R*	.070	.033	.162	.123	-.099	.021	.116
	P	.735	.872	.430	.550	.630	.919	.573
BMI (kg/m^2)	*R*	.064	-.104	.162	-.104	.236	.351	.189
	P	.756	.613	.549	.614	.246	**.050***	.355

According to the Pearson's correlation results, a positive relationship was determined for FEV1 / FVC with ATE (%), FEV1 with E area (mm^2), FVC with E area (mm^2) and environment used (per mm), VC with Av CoPY, and for BMI with E area and ATE (%).

DISCUSSION AND CONCLUSIONS

In the present study, an accurate and highly reliable isokinetic balance system was used (Pro-Kin, TecnoBody PK-252, Dalmine, Italy). However, the relationship between lung volumes and these parameters has been analyzed. Proprioceptive control in a static position (stabilometry) is often altered in dynamic situations. However, most of the postural stability is evaluated in static test conditions. The Pro-Kin isokinetic balance measurement system is used to assess the postural stability in a static or dynamic double

or single-legged situation. The platform stability is provided via an electro-hydraulic system driven by two stepper motors. Furthermore, it allows assessing the variation of the trunk using an angle inclination measure fixed on the sternum of the persons. This measure enables differentiating between the upper body and lower body movement.

Changes in the biomechanics of the respiratory thorax affect the overall mechanics of the body. Thus, any increase or decreasein the respiratory metabolism can cause changes in the total body balance. It can be assumed that these changes may result in reduced functional capacity. This information can be used as an important tool in the planning of a boxer training model. For this reason, the present study attempted to verify the relationship between respiratory function and body balance in boxers.

Recent studies have revealed declines in in the balance and coordination of individuals with impaired lung function (Chang et al., 2008; Park et al., 2018). For example, a value exceeding the expected functional replacement capacity can cause postural disorders by affecting the thorax (Boulay et al., 2006). Biomechanical changes related to the thorax affect all the mechanisms in the body (Butcher et al., 2004). Thus, imbalances associated with respiration may lead to changes in total body balance. In other words, all these changes can reduce the functional capacity. Patients with different pulmonary disorders exhibit significant abnormalities in postural balance; therefore, physiopathologically, this condition should be assessed as multifactorial (Park et al., 2018). This information is in parallel with the data on the relationship between balance parameters and respiratory function in the present study. On the other hand, it has been stated in the literature that findings regarding functional lung capacity in boxers differ, and that the reason for this has not been fully determined (Cakmakcı et al., 2005; Mazic et al., 2015; Cotes et al., 2001). For example, Cakmakci et al., (2005) observed a significant increase in the average of the forced vital capacity and inspiratory and expiratory parameters in 16 Turkish national boxers before and after 12 weeks of training. Mazic et al., (2015) found that boxers had significantly lower MVV, FEV1, and FEV1 / VC values than the control group. However, Cotes et al., (2001) reported that MVV values in boxers were significantly higher than in the control group. The frequency and intensity of the training protocol are likely to have been effective in these findings. Moreover, whether the athletes were in a competition or training phase during the time of the measurements may have led to a difference in the findings.

The balance parameter, however, is believed to be a more complex physiological organization, an integration of visual, sensory, vestibular system and motor responses (Soyuer and Mirza, 2006). Balance is thought to be related to variables such as vision, sensation, spasticity and muscle strength (Kawanabe et al., 2007). Decreases in muscle strength are associated with a reduction in performance measures. Lower limb muscle strength is a key component of sensorimotor function that promotes mobility and may be effective on balance. Consequently, investigation of the relationship between exercise and respiratory parameters should include evaluation of the respiratory muscles, which provide the necessary mechanical energy, especially for lung ventilation. Regularly applied aerobic exercise has a significant effect on respiratory function (Kabitz et al., 2014). The result of a sedentary lifestyle is an increased mechanical burden on weakened respiratory muscles due to reduced chest wall and lung compliance. The imbalance between this load on the respiratory muscles and their

capacity can lead to fatigue, postural disturbances and respiratory insufficiency. The weakness of the inspiratory muscles causes a restrictive respiratory pattern. Individuals with inspiratory muscle weakness utilize accessory breathing muscles and gravity to help diaphragmatic movement, resulting in the development of orthopnea and abdominal paradoxical movement (Kartaloglu, 2012; Yeldan, 2014). This situation will affect the balance negatively. In general, exercise increases muscle strength and improves balance function and mobility. It also helps to increase and protect bone mass (Kawanabe et al., 2007; Park et al., 2008). In the present study, the relationship between the balance parameters and lung function in boxers was confirmed. Boxing is a sport that requires force, balance and discipline. For this sport, muscle and bone strength are very effective parameters. The fact that the athletes in the present work are professional boxers required these parameters to be at optimal levels. In other words, the high capacity of bone and muscular densities is related to the lung capacity of boxers who use aerobic training forms extensively. This finding is also consistent with scientific evidence.

In the present study, the correlation between the BMI and the ATE was determined. That is, as the body weight of the athlete increased, the error rate in the body balance increased. This finding also indicated the relationship between BMI and respiratory parameters. Many studies have also shown that body fat percentage and distribution reduce the activity of respiratory muscles (Khani, 2012; Mailo, 2003) and lead to a general decline in the dynamic compliance of the lungs, which has a significant effect on respiratory function (McArdle, 2010). Parallel to this information, Oke et al., (2015) found a positive correlation between forced inspiratory volume (FIV) and weight, height, body fat percentage (% BF) and fat mass per weight (FMWt) values in boxers, as well as between FEV1 and height. As a result, they stated that in male amateur boxers, there was a significant relationship between body composition parameters and inspiratory capacity (Oke et al., 2015).

The present study determined for the first time the relationship between BMI and ATE and between respiratory parameters and body balance in boxers. One of the main limitations of this study was the small size of the sample and the lack of comparison of the boxers' values with those of a control group. Despite these limitations, this was the first study in which balance and lung capacity in sportsmen were evaluated together. The authors believe that this work will be a major contribution to this field, as no study has been published to date concerning lung function and body balance in sports. Moreover, they believe that research involving athletes and control groups in various branches of sport will help in the development of different training methods and in the assessment of athletic performances.

Acknowledgment

All measurements in this study were carried out at the Ondokuz Mayıs University Yaşar Doğu Faculty of Sports Sciences Performance Laboratory (Samsun, Turkey). The authors would like to thank the athletes who participated in the study and the coaches who supported them.

Conflict of Interest

There is no disagreement between the authors concerning any financial resources, conflicts of interest or author contributions.

REFERENCES

1. Boulay C., Tardieu C., Hecquet J., Benaim C., Mouilleseaux B., Marty C, et al. (2006). Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis. Eur Spine J., 15(4), 415-22.
2. Butcher S.J., Meshke J.M., Sheppard M.S. (2004). Reductions in functional balance, coordination, and mobility measures among patients with stable chronic obstructive pulmonary disease. J Cardiopulm Rehabil, 24(4), 274-80.
3. Çakmakcı O., Çınar V., Çakmakcı E., Görücü A. (2005). Effects of 12-week training program on some physical and physiological parameters in the elite boxers. Physical education and sports sciences journal, 7, 1-6.
4. Chaabe`ne H., Tabben M., Mkaouer B., Franchini E., Negra Y., Hammami M., Amara S., Chaabe`ne R.B., Hachana Y. (2015). Amateur boxing: physical and physiological attributes. Sports Med, 45, 337–352.
5. Chang A.T., Seale H., Walsh J., Brauer S.G. (2008). Static balance is affected following an exercise task in chronic obstructive pulmonary disease. J Cardiopulm Rehabil Prev., 28(2):142-56.
6. Çınar V., Polat Y., Savucu Y., Şahin M. (2009). Investigation on some physical parameters of elite female boxing and handball players, Sport Sciences, 4, 162-170.
7. Cotes J.E., Chinn D.J., Reed J.W. (2001). Body mass, fat percentage, and fat-free mass as reference variables for lung function: effects on terms for age and sex. Thorax, 56, 839-844.
8. Era P., Sainio P., Koskinen S., Haavisto P., Vaara M., Aromaa A. (2006). Postural balance in a random sample of 7,979 subjects aged 30 years and over. Gerontology, 52(4), 204-13.
9. Kabitz H.J., Bremer H.C., Schwoerer A., Sonntag F., Walterspacher S., Walker, D.J. & Grünig E. (2014). The combination of exercise and respiratory training improves respiratory muscle function in pulmonary hypertension. Lung, 192(2), 321-328.
10. Kartaloğlu Z, Okutan O. (2012). Current approach to respiratory problem in neuromuscular diseases. Tuberk Toraks, 60(3), 279-290.
11. Kawanabe K., Kawashima A., Sashimoto I., Takeda T., Sato Y., & Iwamoto J. (2007). Effect of whole-body vibration exercise and muscle strengthening, balance, and walking exercises on walking ability in the elderly. The Keio journal of medicine, 56(1), 28-33.
12. Kayacan, Y., & Makaraci, Y. (2017). Analysis of postural structure of handball players with computer based symmetry graph method. Journal of sport and performance researches, 8 (1), 27-33.
13. Khani M., Farrokhi A., Kheslat S.D.N., Sadri K., Farrar A. (2012). Chronic attention impairments in amateur boxing: Effect of repeated blows to the head. Serb J Sports Sci., 6, 23-28.
14. Mailo C., Mohamed E.I., Carbonelli M.C. (2003). Body composition and respiratory function. Acta Diabetol., 40, 32-38.
15. Mainenti M.R.M., Rodrigues E.C., Oliveira J.F., Ferreira A.S., Dias C.M., Silva A.L.S. (2011). Adiposity and postural balance control: Correlations between bioelectrical impedance and stabilometric signals in elderly Brazilian women. Clinics, 66(9), 1513-18.
16. Mazic S., Lazovic B., Djelica M., Suzic-Lazicd J., Djordjevic-Saranovic S., Durmicb T., Soldatovic I., Zikic D., Gluvic Z., Zugicg V. (2015). Respiratory parameters in elite athletes - does sport have an influence? Rev Port Pneumol, 21, 192-197.
17. McArdle W.D., Katch F.I., Katch V.L. (2010). Exercise Physiology; energy, nutrition, and human performance. (7th ed), Lippincot Williams & Wilkins, Philadelphia, pp 478- 1032.
18. Mitchell J.H., Willams W.L., Raveb P.B. (1994). Clasification of sports, J.Am. Coll. Cardiol, 24, 864-866.
19. Oke Kayode I., Agwubike Elias O. (2015). Body composition and pulmonary functional correlates in Nigerian male amateur boxers. Medicina Sportiva, XI, 2563-2568.

20. Park H., Kim K.J., Komatsu T., Park S.K., & Mutoh Y. (2008). Effect of combined exercise training on bone, body balance, and gait ability: a randomized controlled study in community-dwelling elderly women. Journal of bone and mineral metabolism, 26(3), 254-259.
21. Park, E., Son, Y., Johnson, J., Yi, K., & Oh, J. I. (2018). The Effects Of Multi-directional Exercise Training On Body Composition, Physical Fitness, And Mobility In Stroke Patients: 1992 Board# 253 May 31 2. Medicine & Science in Sports & Exercise, 50(5S), 483.
22. Ringhof, S., & Stein, T. (2018). Biomechanical assessment of dynamic balance: Specificity of different balance tests. Human movement science, 58, 140-147.
23. Soyuer F., Mirza M. (2006). Relationship between lower extremity muscle strength and balance in multiple sclerosis. Journal of Neurological Sciences (Turkish), 23(4).
24. Yeldan I. (2014). Pulmonary rehabilitation in patients with neuromuscular diseases: Uzun M. Editor. Cardiac and pulmonary rehabilitation. 1st Edition. Istanbul Medical Bookstore. 445-452.
25. Zemkova E. (2014). Sport-specific balance, Sports Med., 44, 579–590