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EVALUATION OF PHYSICAL FITNESS AND ISOKINETIC TEST PARAMETERS OF AMPUTEE FOOTBALL PLAYERS

AMPÜTE FUTBOLCULARIN FİZİKSEL UYGUNLUK VE İZOKİNETİK TEST PARAMETRELERİNİN DEĞERLENDİRİLMESİ

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ABSTRACT

Objective: This study was designed to investigate the effect of participation in sports on the functional capacity of a person with an amputation.

Material and Method: The study included a sports group of 29 male football players with unilateral lower limb loss aged between 18-45 years and a control group of 11 sedentary persons with an amputation. Body composition, postural stability, and trunk muscle strength were measured with a skinfold, Biodex Stability System, and dynamometer. A pulmonary function test and cardiopulmonary exercise test were performed. Aerobic capacity was evaluated by cardiopulmonary exercise test using the breath-by-breath method.

Result: Skinfold thickness measurements performed at the triceps, thigh, and calf regions were higher in the sports group ($p<0.05$), whereas body fat percentage indicated no significant difference among both groups ($p>0.05$). The sports group had higher postural stability, trunk muscle strength, and endurance ($p<0.05$). Predicted maximum voluntary ventilation (MVV%) and peak expiratory flow (PEF%) values were significantly higher in the sports group ($p<0.05$). The sports group had higher heart rates corresponding to the anaerobic threshold ($p<0.05$). At the same time, no significant difference was observed between the two groups concerning resting and maximum heart rate ($p>0.05$). The sports group had longer exercise times and higher gas exchange values ($p<0.05$).

ÖZET

Amaç: Bu çalışma, ampütasyonu olan kişilerin spora katılımının fonksiyonel kapasiteleri üzerindeki etkisini araştırmak için yapılmıştır.

Gereç ve Yöntem: Çalışmaya 18-45 yaş arası tek taraflı alt ekstremite kaybı olan 29 erkek futbolcudan oluşan spor grubu ve ampütasyonu olan sedanter 11 kişiden oluşan kontrol grubu dahil edildi. Vücut kompozisyonu, postural stabilite ve gövde kas kuvveti sırasıyla skinfold, Biodex Stabilite Sistemi ve izokinetik dinamometre ile ölçüldü. Solunum fonksiyon testi ve kardiyopulmoner egzersiz testi yapıldı. Aerobik kapasite, breath-by-breath (her nefeste) yöntemi kullanılarak kardiyopulmoner egzersiz testi ile değerlendirildi.

Bulgular: Triseps, uyluk ve baldır bölgelerinden yapılan deri kıvrım kalınlığı ölçümleri spor yapan grupta daha yüksek bulundu ($p<0,05$), vücut yağ yüzdesi ise her iki grup arasında anlamlı bir fark göstermedi ($p>0,05$). Postural stabilite, gövde kas kuvveti ve dayanıklılığı spor yapan grupta anlamlı olarak yüksekti ($p<0,05$). Tahmin edilen maksimum istemli ventilasyon (%MVV) ve tepe ekspiratuar akış (%PEF) değerleri spor yapan grupta anlamlı olarak yüksekti ($p<0,05$). Anaerobik eşiğe karşılık gelen kalp hızları spor grubunda daha yüksek bulunurken ($p<0,05$), istirahat ve maksimum kalp hızı açısından iki grup arasında anlamlı bir fark gözlemlenmedi ($p>0,05$). Spor yapan grubun egzersiz süreleri ve gaz değişim değerleri daha yüksekti ($p<0,05$).

*This study is based on the master thesis of the first author.
**The study was presented as an oral presentation at the 44th National Congress of Physiology in Turkey, held on November 1st-4th, 2018.
***In this study, 6 participants with upper extremity amputations included in the sports group were excluded to ensure homogeneity, and the results were re-evaluated.

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Conclusion: Postural stability, trunk muscle strength, and physical condition were better in football players. These findings suggest that performing regular physical activities positively affects the development of physical performance in a person with an amputation.

Keywords: Football, cardiopulmonary exercise test, muscle strength, amputation

Sonuç: Postural stabilite, gövde kas kuvveti ve fiziksel kondisyon futbolcularda daha iyi seviyedeydi. Bu bulgular, ampütasyonu olan kişilerde düzenli fiziksel aktivite yapmanın fiziksel performans gelişimi üzerine olumlu etkileri olduğunu düşündürmektedir.

Anahtar Kelimeler: Futbol, kardiyopulmoner egzersiz testi, kas gücü, ampütasyon

INTRODUCTION

Amputation that disrupts the biomechanics of the musculoskeletal system is a significant trauma leading to physical, psychological, and occupational losses. It also leads to decreased walking and running activities and increased energy needs, difficulty in adapting to a prosthesis, fatigue, atrophy in the stump, joint limitation, and loss of physical ability, thereby leading to immobilization and, as a result of complications, worsened general health condition (1-4). In disabled individuals, physical and sports activities improve public health, reduce the risk of chronic diseases, prevent complications, and decrease anxiety and depression (2, 5, 6). In addition, encouraging disabled individuals to participate in such sports activities may also lead to reduced health expenditures (7).

Studies evaluating body composition, respiratory capacity, and physical fitness level in healthy professional athletes are frequently encountered in the literature (8, 9). However, studies examining the effect of sports activities on amputees' lifestyles are limited. In most studies, indirect measurement-field tests determine aerobic capacity and physical condition (10-12). Although field tests provide information on individuals' aerobic capacity, there is a need for evaluation with laboratory test methods, which can provide more reliable results. In addition, although many studies investigate the physical ability of healthy sedentary individuals, there are only a limited number of studies investigating the sedentary lifestyle caused by amputation (2, 13).

Amputee football is becoming a growingly popular sport in Turkiye and the world. Moreover, amputee football has recently emerged as an exciting subject among sports scientists. However, since there are a limited number of studies on this subject, it is not easy to standardize the data obtained due to the wide variation in the evaluation methods used by these studies. A recent systematic review showed that studies investigating amputee football are scarce (14). Thus, there is a need for more research on the characteristics of this sport, particularly in terms of the physiological and anthropometric parameters of the athletes (14). In this cross-sectional controlled study, we aimed to investigate the effect of playing football on body composition, postural stability, trunk muscle strength, pulmonary functions, and aerobic capabilities in individuals with unilateral lower limb loss.

MATERIAL and METHODS

Design and participants

This study included a sports group of 29 male football players with unilateral lower limb loss aged between years (recruited at Pendikspor Amputee Football Team) and a control group of 11 sedentary peer individuals who applied to a prosthetics unit at Istanbul. All the participants had unilateral lower limb loss and had adequate cognitive and physical abilities to complete the tests in the study. The inclusion criteria were playing football actively for at least one year for the sports group and not regularly participating in any sport for at least six months before the study for the control group. We excluded a person with amputation with visual and cognitive defects and chronic systemic diseases from the survey.

Procedures

We performed all the tests in two days between 09.00 and 11.00 AM. On the first day, we recorded the descriptive and clinical characteristics of the participants and measured body composition, postural stability, trunk strength, and endurance. On the second day, we performed pulmonary function tests (PFTs) and cardiopulmonary exercise tests (CPET). Following data analysis, the participants were informed about the results obtained in the study.

Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. Holtain skinfold caliper (Cambridge Scientific Industries, Cambridge, MD, USA) was used to determine body fat percentage. Skinfold measurements were performed on the right side in a standing position. In the participants with right limb loss, measurements were obtained on the left side, and eight values obtained from different regions were recorded. Body fat percentage was measured using the Jackson Pollock (J-P) method (15).

Biodex Balance System (Biodex, Inc, Shirley, New York) platform was used to evaluate single-leg stance postural stability. During the test, all the participants were barefoot and remained on one foot, with hands parallel to the body and eyes open and fixed on the horizon. At the beginning of the trial, the participants were instructed to maintain balance throughout the procedure. The same procedure was repeated three times for the non-amputated limb, and each repetition lasted twenty seconds, with a 10-second rest interval. Overall Stability Index (OSI), Anterior-Posterior Stability Index (APSI), and Medial-Lateral Stability Index (MLSI) were assessed for each participant.

Isokinetic trunk flexion and extension strength were evaluated using a computerized isokinetic dynamometer (Cybex Humac Norm 2, USA). Pads stabilize the lower limb or limbs. A belt was used to secure the pelvis and limit hip flexor muscles' use. A shoulder harness and backrest provided anchorage to the moving upper section of the apparatus. Strength was measured with a trunk flexion-extension movement consisting of 5 repetitions at 60°/sec, and the endurance test was performed with 15 repetitions at 90°/sec. The interval (rest time) was 20 sec. Peak torque for flexor and extensor muscles was measured under isokinetic conditions, and the muscle torque was adjusted to body weight (BW).

The lung volumes, capacities, and flow velocities were measured by spirometry (Spirobank). The slow vital capacity maneuver, forced vital capacity, and maximal voluntary ventilation were performed three times, and the highest value was calculated for each. The highest values of forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), forced expiratory ratio ([FEV1/FVC] x100), predicted peak expiratory flow (%PEF), vital capacity (VC), and predicted maximum voluntary ventilation (%MVV) were recorded. These maneuvers were performed in the sitting position with the nasal clip attached.

After obtaining resting electrocardiograms (ECG), cardiopulmonary exercise tests were performed on a Quinton 65 double-arm ergometry bicycle with a Q 5000 stress test system (Quinton 5000, USA) using an Ergospirometry system (Metalyzer 3B system, Metasoft 2.7 software, Cortex, Germany) to measure cardiopulmonary parameters including oxygen uptake and carbon dioxide output, using the breath-by-breath method with a two-way non-rebreathing facemask (Series 7910-Hans Rudolph Inc, Kansas City, Missouri, USA). After a 3-minute steady-state workload at 25 watts, the workload was increased continuously by 15 watts every 3 min. After reaching maximal volitional fatigue, participants cycled for recovery every 3 minutes at 0 watts. Twelve-lead ECG and gas exchange measurements were recorded continuously (Mason-Likar type). The breath-by-breath gas exchange method measured ventilation, oxygen consumption, and carbon dioxide production, and data were averaged in 10 seconds periods. A Peak Oxygen Consumption (VO_2 peak) was calculated as the mean value of three measures of VO_2 during the final 10 seconds of the exercise. Exercise duration (min), peak, and resting heart rate were measured. The anaerobic threshold value was calculated using the V-Slope method.

G*Power Analysis program (http://www.gpower.hhu.de/) was used to determine the sample size. According to the data from the studies, the size of effect size was evaluated at 0.97. We concluded that we could obtain meaningful data when we included a minimum of 24 participants in the evaluations, where we received a Type 1 error amount (α value) of 0.05 and a Type II error amount (β value) of 0.5 (12).

The protocol for this study was approved by the Ethics Committee of Istanbul University (Date: 27.10.2017, No: 17) and performed following the principles of Declarations of Helsinki. A written declaration of informed consent was obtained from each participant.

Statistical analysis

Data were analyzed using SPSS ver.21.0 (IBM Corp. Armonk, NY). Descriptive statistics were expressed as frequencies (n) and percentages (%) for categorical variables and as mean, standard deviation (SD), and median for continuous variables. Anthropometric parameters, including postural stability, muscle strength, and aerobic capacity, were compared between the two groups using the Student's t-test. A p-value of <0.05 was considered significant.

RESULTS

The two groups had similar demographic characteristics (p>0.05) (Table 1). The amputation features of the participants in both groups are presented in Table 2. Table

Table 1: Demographic characteristics of the participants

Parameters	Control group (n=11)	Sports group (n=29)	p
Age (years)	30.4±8.57	30.3±6.07	0.97
Height (cm)	175±3.7	174±6.39	0.63
Weight (kg)	75±16	67.9±10.3	0.11
BMI (kg/m^2)	24.36±5.1	22.38±3	0.81
Age at amputation (years)	12±11.7	15.8±7.76	0.24

BMI: Body mass index

3 shows the body composition of the participants. The measurements performed at the triceps, femur, and calf regions were significantly lower in the sports group compared to the control group (p<0.05). No significant difference was found between the two groups concerning body fat percentage (p>0.05) (Table 3). The OSI – APSI values were lower in the sports group (p<0.05). The MLSI value was significantly lower in the sports group compared to the control group (p=0.01) (Table 3). It means the sports group had better postural stability than the control group. According to trunk muscle strength assessment, the flexor and extensor muscle strength at 60^0/sec angular velocity values were significantly higher in the sports group compared to the control group (p<0.05) (Table 3). In addition, 60°/sec flexor and extensor peak torque/%body weight values were significantly higher in the sports group (p=0.01) (Table 3). The flexor and extensor muscle endurance at 90°/sec angular velocity values were significantly higher in the sports group (p<0.05), and at 90°/sec, flexor and extensor peak torque/%body weight values were higher in the sports group than the control group (p=0.01) (Table 3).

In the respiratory capacity assessment, the %PEF and %MVV values were significantly higher in the sports group compared to the control group (p<0.05) (Table 4). CPET results showed that the sports group had higher heart rates corresponding to the anaerobic threshold,

Table 2: Amputation features of the participants

Parameters		Control group (n=11)	Sports group (n=29)
Amputation level (n, %)	Above knee	7 (63.6)	19 (65.5)
	Below knee	4 (36.4)	10 (34.5)
Amputation Side (n, %)	Right	5 (45.5)	13 (44.8)
	Left	6 (54.5)	16 (55.2)
Cause of amputation (n, %)	Congenital	1 (9.09)	3 (10.35)
	Traumatic	10 (90.9)	23 (79.31)
	Neoplasm	0	3 (10.35)

Table 3: Comparison of body composition, balance, and trunk muscle strength parameter values between two groups

Parameters	Control group (n=11)	Sports group (n=29)	p
Abdominal (mm)	23.57±12.05	18.98±10.03	0.28
Pectoral (mm)	11.15±6.66	8.05±4.66	0.18
Suprailiac (mm)	23.35±12.43	15.38±8.34	0.07
Biceps (mm)	7.71±5.26	4.59±1.38	0.08
Triceps (mm)	12.85±4.52	8.02±3.21	0.006*
Subscapular (mm)	21.16±11.14	14.97±7.47	0.11
Femur (mm)	15.93±8.52	8.4±4.05	0.016*
Calf (mm)	8.78±3.24	4.59±2.44	0.001*
Body fat percentage (%)	15.16±7.82	10.47±5.25	0.09
OSI (°)	1.44±0.71	0.92±0.29	0.04*
APSI (°)	1.02±0.58	0.61±0.26	0.04*
MLSI (°)	0.95±0.45	0.55±0.22	0.01*
60°/sec FPT	224.55±62.85	276.45±56.74	0.02*
60°/sec FPT %BW	302.45±70.93	408.41±72.95	0.001*
60°/sec EPT	184.27±53.73	228.35±49.97	0.035*
60°/sec EPT %BW	246.36±54.88	339.79±80.62	0.001*
90°/sec FPT	220.45±54.79	271.07±53.27	0.02*
90°/sec FPT %BW	295.82±59.35	401.41±71.34	0.001*
90°/sec EPT	163±51.26	204±55.2	0.046*
90°/sec EPT %BW	217.18±55.21	304.28±87.56	0.001*

Values are mean±SD, APSI: Anterior-Posterior Stability Index, MLSI: Medial-Lateral Stability Index, OSI: Overall Stability Index, FPT: Flexor peak torque, EPT: Extensor peak torque, %BW: % Body weight, *Statistical significance (p<0.05) and this group exercised longer than the control group ($p<0.05$). However, no significant difference was found between the groups regarding resting and maximum heart rate ($p>0.05$) was found. The mean ventilation (anVE, VE peak), oxygen consumption (anVO_2, VO_2 peak), and carbon dioxide production (anCO_2, CO_2 peak) values were significantly higher in the sports group compared to the control group (p=0.01) (Table 4).

DISCUSSION

In this study, the effect of football on amputees was measured with different physical fitness tests (body composition, postural stability, strength, pulmonary functions, aerobic and anaerobic capacity), and the results were compared with the values of sedentary amputees and evaluated statistically. In the skinfold fat measurement used to determine the body composition, the fat ratio of the triceps region of the amputee football players was lower. This may be due to the use of crutches during training and matches. In addition, the fat ratios of the thigh and calf regions were also found to be lower than sedentary amputees. These regions show the positive effect of football-specified activities on the body composition of amputee football players. When the body fat percentage obtained by J-P method was compared, no difference was found between the groups. The fact that the fat ratios in the chest and abdomen regions were similar in both groups may have caused this result. The J-P method may not be a specific measurement method for this amputee football players. However, when the literature is examined, the body fat ratio of amputee players is similar to the results in our study (10, 12, 16).

Football-specific movements such as defending, running, attacking, throwing, and dribbling are performed by providing postural stabilization. The ability to kick the ball and perform different technical movements in football requires a standing posture on one leg. In amputee football, while the football players fix their bodies with forearm crutches,

Table 4: Comparison of respiratory function and cardiopulmonary exercise test parameters values between two groups

Parameters	Control group (n=11)	Sports group (n=29)	p
%FVC	89.64±16.08	91.26±12.28	0.77
%FEV_1	95.18±13.33	97.47±12.32	0.64
%FEV_1/FVC	110.55±11.47	109.43±7.14	0.77
FEV %25-75	99.09±16.97	101.57±24.16	0.73
FEV %50	93.63±16.65	97.57±24.53	0.59
%PEF	76.55±11.04	88±15.82	0.021*
%MVV	88.64±13.70	107.00±15.88	0.002*
%IC	89.18±22.26	85.08±13.56	0.58
HR-rest (bpm)	78.27±8.91	80.22±14.85	0.64
HR-peak (bpm)	150.73±19.39	164.26±25.75	0.10
HR-AT (bpm)	108.27±12.7	133.52±19.22	0.001*
Exercise duration (sec)	273.09±136.76	483.86±180.79	0.001*
anVO_2 (L/min)	0.95±0.26	1.44±0.38	0.001*
anVO_2 (ml/kg/min)	14±3.66	21±6.33	0.001*
anVCO_2 (L/min)	0.92±0.24	1.41±0.41	0.001*
anVE	28.23±7.8	40.57±11.86	0.001*
VO_2peak (L/min)	1.15±0.33	2.00±0.65	0.001*
VO_2peak (ml/kg/dk)	17.36±3.88	29.65±9.49	0.001*
VCO_2peak (L/min)	1.29±0.44	2.23±0.78	0.001*
VEpeak	41.38±15.3	66.34±21.46	0.001*

Values are presented as mean±SD, FVC: Forced vital capacity, FEV_1:Forced expiratory volume in the first second, FEV: Forced expiratory ratio, %PEF: Predicted peak expiratory flow, %MVV: Predicted maximum voluntary ventilation, IC: Inspiratory capacity, HR: Heart rate, AT: Anaerobic threshold, anVO_2: Oxygen consumption at anaerobic threshold, anVCO_2: Production of carbon dioxide at anaerobic threshold, anVE: Ventilation amount at anaerobic threshold, VO_2peak: Peak oxygen consumption, VCO_2peak: Peak carbon dioxide production, VE-peak: Peak ventilation amount, *Statistical significance ($p<0.05$)

they interfere with the ball with their intact limbs. When we examined the postural stability on one leg in our study, it was observed that amputee football players' general, anterior-posterior, and medial-lateral stability index values were lower than sedentary amputees.

Due to the displacement of the center of gravity in amputees, the balance is disturbed, and more energy is needed to control the balance (2). It is known that amputees need more power in daily life activities and depend on using assistive devices (2, 4). This can result in amputees getting tired more quickly, a lack of motivation during mobility, and increased energy costs (2, 4, 5). However, this study also shows that amputee football players' physical condition values were higher than the control group, indicating that participation in sports reduces the disadvantages of amputation.

Buckley et al. compared static and dynamic balance values of six healthy and six amputee individuals and reported that the balance values were worse in a person with an amputation (17). The authors also noted that the anterior-posterior balance control was worse than the medial-lateral direction balance control in dynamic balance testing. In our study, amputated individuals could not be compared with healthy individuals since there was no healthy control group. However, in our study, amputee football players showed better postural stability than sedentary amputees. Therefore, we can say that football positively affects postural stability.

Trunk stabilization is explained according to the principle of proximal stability for distal mobility (18). Good trunk stabilization is required for football-specific technical skills such as dribbling, passing, shooting, tackling, and defending. Guchan et al. evaluated the strength and endurance of back extensor and abdominal muscles in amputated football players and sedentary amputee individuals (12). They reported that football players' trunk muscle strength (flexion, extension) and endurance improved (12). In our study, the strength and endurance of the trunk flexor and extensor muscles were evaluated at 60°/sec and 90°/sec angular velocities. Moreover, we found that amputee football players had higher trunk muscle strength and endurance. According to these data, we can say that football positively affects strength, which is one of the physical fitness parameters.

The central nervous system, musculoskeletal system, and cardiopulmonary system should coordinate to perform different movements in a 50-minute football match. Low and high levels of effort can be completed by inhaling oxygen, ensuring the passage of inhaled oxygen from the lungs to the blood, transmitting oxygen through the blood, and ultimately generating energy. Therefore, a pulmonary function test is essential in determining physical fitness. In this study, %FEV1, %FVC, %FEV1/FVC values were similar. These results depend on many factors, such as respiratory muscle strength, lung capacity, and airway resistance. The fact that there was no significant difference in respiratory muscle test results between amputee football players and sedentary amputees suggests that respiratory functions may be similar. However, further research may be needed to determine the exact reasons for these results.

Vital capacitiy is another parameter that is evaluated in football players. However, maximum voluntary ventilation is the value to be considered (%MVV) (19). Vital capacity can give misleading results because it is affected by factors such as body structure, body condition during measurement, the strength of respiratory muscles, and lung and chest wall ability to expand. Therefore, the %MVV value should be examined. %MVV, 110-120 lt/min in normal individuals, increases to 170-180 lt/min in football players (19). In our study, the %MVV value of the amputee football players was 107 lt/min. The shorter duration of the match and the differences in the game characteristics of amputee football may have caused the %MVV value to be lower. However, in this study, amputee football players' %MVV value was significantly higher than sedentary amputees. Considering this result, we can say that football positively affects respiratory functions, one of the physical fitness parameters. In addition, the present study is the first to evaluate the respiratory functions of amputee football players.

As stated in the study, the average resting and maximum heart rate values were similar between amputee football players and sedentary amputees. This is because resting and maximum heart rates are typically determined by genetic factors, training level, overall health, and related exercise capacity (21). Therefore, even high-level athletes like amputee football players may have similar maximum heart rate values as sedentary amputees. However, more research is needed to understand this relationship fully. Anaerobic capacity is a metabolic pathway the body uses to produce energy without oxygen. The pathway is used during high-intensity exercise and is essential for short, intense activities. High-performance athletes like amputee football players can increase their anaerobic capacity by working out according to their training programs. This can result in high anaerobic heart rate values than sedentary amputees. Our results support this pathway's effects. The mean maximum heart rate run by the football players corresponded to 85.69% of the targeted heart rate value. A previous study that involved eight amputee players and 20 healthy individuals reported that the mean heart rate of amputee players was 161 bpm in the cardiopulmonary exercise test (double-arm ergometer bicycle test), which corresponded to 86% of the targeted heart rate value (20). These results are consistent with those of our study.

In our study, the peak oxygen value used by the muscles during the double-arm ergometer bicycle test was determined by the Breath-by-Breath method. The mean VO_2 peak value reached 29.65 ml/kg/min in the amputee football players. Mikami et al. evaluated eight amputee players using the Arm Ergometer Bicycle Test and Breath-by-Breath method and reported a mean VO_2 peak value of 30.3 ml/kg/min (20). This finding is similar to our study. However, the VO_2 peak value during the double-arm ergometer bicycle test is approximately 70% of that in bicycle ergometer exercise due to the smaller muscle mass and the maximum achievable workload. Many studies have shown that the cycling ergometer VO_2 peak value is approximately 89–95% of the value obtained with treadmill exercise (21, 22). Therefore, measurement with a double-arm ergometer bicycle may have resulted in a lower VO_2 peak value.

The VO_2 level is an indicator of the use of oxygen by the muscles during exercise. Considering that one of the extremities of the athletes included in our study is amputated, it is seen that a large muscle group that will carry the most oxygen is removed from the body during exercise. In addition, the VO_2 values found in these athletes are inevitably below the expected values since the blood circulation in the entire lower extremity does not increase as much as in a test performed with treadmill since the test in this study was performed with the arm ergometer.

The high heart rate at the anaerobic threshold (HR-AT) and oxygen consumption capacity ($anVO_2$) of amputee football players are indicators of improvement in aerobic capacity. The high amount of oxygen used by the muscles in amputee football players during the cardiopulmonary exercise test is an essential indicator of the development of aerobic capacity (26). Likewise, the significant increase in the VO_2 peak values of football players supports this finding. Moreover, our metabolic evaluation findings indicated that the mean $anVO_2$ (L/min), $anVO_2$ (ml/kg/min), $anVCO_2$ (L/min), $anVCO_2$ (ml/kg/min), VO_2 peak (L/min), VO_2 peak (ml/kg/min), VCO_2 peak (L/min), and VCO_2 peak (ml/kg/min) were also significantly higher in the amputee football players. This notion supports the hypothesis that performing sports activities positively affects the aerobic conditions of amputated individuals.

In conclusion, the results indicated that playing football positively affects body composition, postural stability, muscle strength, pulmonary functions, and aerobic and anaerobic capacity in amputee players. This is the first study to compare sedentary amputees and amputee football players in a laboratory environment. Our findings indicated that physiological parameter variability would guide health scientists studying this field. Further studies are needed to substantiate our findings.

The limitation of this study is the small number of amputee athletes included since amputee football is a disabled sport played with seven players in each team (six outfield players and one goalkeeper). Outfield players have lower-extremity amputations, and goalkeepers have upper-extremity amputations. We could not include and evaluate goalkeepers in this study, as we could not get sedentary amputees with upper extremity amputation to participate. Also, laboratory test that measure aerobic and unaerobic capacity in goalkeepers are different from outfield players (treadmill vs arm ergometer). For this reason, the values obtained may be lower than expected. We propose developing a cardiopulmonary exercise test specifically for amputee football players.

CONCLUSION

This study proves that amputee football players have significantly better physical conditions than sedentary amputees. The findings suggest that participation in amputee football can positively impact the physical condition of amputees. Further research is needed to identify strategies to encourage more amputees to participate in football-specified activities. The study highlights the importance of promoting football activities and training programs for amputees to improve their health.

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