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BILATERAL DIFFERENCES OF UPPER EXTREMITY FUNCTIONAL PERFORMANCE IN ADOLESCENT KICKBOXING ATHLETES

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Abstract: It is important to measure the functional asymmetry between the extremities to determine if athletes are at risk of injury or performance deficits. This study aimed to investigate bilateral differences in upper extremity performance of adolescent kickboxing athletes. The study included 32 adolescent kickboxing athletes (13 females, 19 males; age: 16.72 ± 0.95 years; body mass index: 22.07 ± 2.66 kg/m²). Functional dominance was determined based on the leading hand, which was accepted as the non-dominant extremity. The Seated Single Arm Shot Put Test (SSASPT) and Upper Quarter Y Balance Test (YBT-UQ) evaluated upper extremity performance. When the dominant and non-dominant sides of kickboxing athletes were compared, a statistically significant difference was found in terms of SSASPT scores between the two sides ($p = 0.038$). However, there was no difference between the dominant and non-dominant sides in terms of YBT-UQ scores ($p > 0.05$). As a result of the study, it was observed that the anaerobic power values of the dominant side were higher than those of the non-dominant side in adolescent kickboxing athletes. However, the asymmetry between both sides was within normal limits. It was also found that dominance did not affect upper quarter balance and stability. These findings suggest that, in adolescent kickboxing athletes, comparing the affected extremity with the unaffected side may provide a reliable reference for return-to-sport decisions after injury, as well as for training planning and monitoring performance development.

Keywords: Kickboxing, dominance, upper functional performance, y balance test, shot put test.

ADÖLESAN KICK BOKS SPORCULARINDA ÜST EKSTREMİTE FONKSİYONEL PERFORMANSINDAKİ BİLATERAL FARKLILIKLAR

Öz: Ekstremiteler arasındaki fonksiyonel asimetrisinin ölçülmesi sporcuların yaralanma veya performans kaybı için risk altında olup olmadığını belirlemek için önemlidir. Bu çalışmanın amacı adölesan Kick Boks sporcularının üst ekstremitte performansındaki bilateral farklılıkları ortaya koymaktır. Çalışmaya 32 adölesan Kick Boks sporcu (13 kadın, 19 erkek, Yaş: $16,72 \pm 0,95$ yıl, Vücut kütle indeksi: $22,07 \pm 2,66$ kg/m²) dahil edildi. Fonksiyonel dominantlık, önde kullanılan el esas alınarak belirlendi; önde kullanılan el dominant olmayan ekstremitte olarak kabul edildi. Üst ekstremitte performansları Oturarak Tek Kol Gülle Atma Testi (Seated Single Arm Shot Put Test/SSASPT) ve Üst Çeyrek Y Denge Testi (Upper Quarter Y Balance Test/YBT-UQ) ile değerlendirildi. Kick Boks sporcularının dominant ve dominant olmayan tarafları karşılaştırıldığında iki taraf arasında SSASPT skoru bakımından istatistiksel olarak fark olduğu tespit edildi ($p = 0,038$). Ancak dominant ve dominant olmayan taraf arasında YBT-UQ skorları bakımından fark olmadığı saptandı ($p > 0,05$). Çalışma sonucunda adölesan Kick Boks sporcularının dominant taraflarındaki anaerobik güç değerlerinin dominant olmayan taraftan daha fazla olduğu görüldü. Ancak her iki taraf arasındaki asimetrisinin normal sınırlarda olduğu saptandı. Ayrıca üst çeyrek denge ve stabilite üzerinde dominantlığın bir etkisinin olmadığı tespit edildi. Bu bulgular, adölesan Kick Boks sporcularında yaralanma sonrası spora dönüş kararında, antrenman planlamasında ve performans gelişimi takibinde etkilenen ekstremitenin sağlam taraf ile karşılaştırılmasının güvenilir bir referans olabileceğini göstermektedir.

Anahtar Kelimeler: Kick Boks, dominantlık, üst ekstremitte performans, y denge testi, gülle atma testi.



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INTRODUCTION

Kickboxing is one of the most popular combat sports worldwide, and its popularity continues to grow (Gençoğlu & Şen, 2021). It is a dynamic, high-intensity combat sport based on interval strikes, requiring complex skills and tactical excellence for success. Athletes are classified according to gender, body mass, and age categories (Slimani et al., 2017). In various competition disciplines (point fighting, kick light, full contact, etc.), a high level of technical and tactical skills, along with upper and lower body strength, anaerobic power, aerobic capacity, and speed, is required (Özbay et al., 2025).

The primary purpose of kickboxers during a match is to attack their opponent with effective kicks and punches to score points and gain superiority (Ulupinar et al., 2021). Punching is a fundamental skill in kickboxing and is performed more frequently than kicking in international kickboxing competitions (Gençoğlu et al., 2023; Ouergui et al., 2013). In kickboxing, hand techniques include classic boxing punches (such as the straight punch, hook, and uppercut) and additional techniques, such as spinning backfists and jumping punches (Niewczas et al., 2024). In order to establish the technical-tactical profile of high-level kickboxing competitions, Ouergui et al. (2013) analyzed a total of 45 matches performed by male kickboxers in the 2009 and 2011 World Championships. The authors reported that straight punches were the most frequently used punch techniques in these kickboxing matches (Ouergui et al., 2013). Another study stated that the left straight punch was the most used technique among the attacks. The dominant left position among athletes means that the left upper extremity is the most frequently used, making the left straight punch one of the most effective techniques. This observation reveals that actions to compensate for asymmetry are also important in injury prevention (Niewczas et al., 2024).

Functional (inter-extremity) asymmetries refer to side-to-side differences in function or performance between corresponding upper and lower extremities that occur due to the application of repetitive movement patterns over time (Chapelle et al., 2021). Functional performance tests are important tools for evaluating strength and power deficiencies. They identify injury susceptibility, assess rehabilitation progress, determine return-to-play status, and measure strength and power related to optimal physical performance (Riemann et al., 2018). Four standard upper extremity functional tests reported in the literature are the Closed Kinetic Chain Upper Extremity Stability Test, Single Arm Hop Test, Seated Single Arm Shot Put Test (SSASPT), and Upper Quarter Y Balance Test (YBT-UQ) (Myers et al., 2017). SSASPT is a unilateral, open kinetic chain upper extremity functional performance test that involves throwing a medicine ball over the maximum horizontal distance (Watson et al., 2020). SSASPT provides a thrust distance for each side that is independent of body mass when scaled allometrically (Degot et al., 2021). The YBT-UQ is a reliable test for measuring unilateral upper limb function in the closed chain position. It can be used to identify bilateral differences in upper limb mobility and stability for injury prevention in athletes (Borms et al., 2016). Performing reaching movements in all directions during the test requires a combination of trunk stabilization, thoracic spine rotation, and scapular mobility and stability. Therefore, it assesses the individual's balance, proprioception, strength, and range of motion (Ribnikar et al., 2024). SSASPT and YBT-UQ are used to assess bilateral differences in the upper extremity (Borms et al., 2016; Riemann et al., 2018).

Many studies in the literature have evaluated the upper extremity performance of kickboxing athletes due to the importance of the upper extremity in this sport (I Ouergui, 2013; Kocaoğlu, 2024; Rydzik & Ambroży, 2021; Sayaca & Erkan, 2024; Slimani et al., 2016; Ulupinar et al.,

2021). Among these studies, only one study has been found that investigated differences between sides in kickboxing athletes (Kocaoğlu, 2024). To our knowledge, no study has investigated bilateral differences in upper extremity functional performance in kickboxing athletes. As an asymmetrical combat sport, we consider it important in kickboxing to investigate the differences between both sides in order to prevent injuries and optimize performance. Therefore, this study aimed to reveal the differences in strength and balance/stability between the sides in kickboxing athletes.

METHOD

Research Design and Ethical Approval

In this study, a quantitative research method was employed. The study was approved by the Ethics Commission of Gazi University (Research Code No. 2024-1211, Date: July 30, 2024). The adolescent participants and their parents were informed about the study and signed an “Informed Voluntary Consent Form” indicating voluntary participation.

Participants

Kickboxing athletes aged 15-19 years who had been kickboxing for at least one year and had not undergone any surgery in the shoulder region were included in the study. Athletes who were not between the ages of 15-19, who had any shoulder injury in the last six months before the test, who had shoulder pain in the last 6 weeks before the test, who were interested in another sports discipline other than kickboxing, and who had systemic and neurological disorders were excluded from the study. Six athletes were excluded because they did not meet the inclusion criteria; the study was therefore completed with 32 adolescent kickboxing athletes.

Data Collection

Age, gender, body weight, height, body mass index (BMI), guard sides, weekly training hours, and years of participation in the sport were recorded. The punch of the leading hand was questioned to determine functional dominance. Functional dominance refers to the laterality indicated by an athlete’s preference for performing different sports skills (Ardá Suárez et al., 2016). In boxing, the punch of the leading hand is performed by the non-dominant hand (Mosler et al., 2024); therefore, the leading hand punch is accepted as a non-dominant extremity. The measurements were conducted simultaneously in the evenings at the training halls of the clubs. Athletes performed a 5-minute standard warm-up before the tests. The upper extremity performance of kickboxing athletes was evaluated with SSASPT and YBT-UQ. The tests were administered to the athletes in a randomized order. Scores were recorded on the dominant and non-dominant extremities for both tests. The limb symmetry index (LSI) was also calculated for normalization based on extremity dominance. LSI was calculated from the raw values using the formula (dominant extremity / non-dominant extremity) \times 100 (Chmielewski et al., 2014).

Seated Single Arm Shot Put Test (SSASPT): Athletes began the test by assuming a prolonged sitting position leaning against a backrest. They were asked to keep their elbows towards their torso and as far back as possible while gripping the ball. The arm not being tested was positioned on the lap. When performing the test, athletes were instructed to keep their backs against the backrest and not to cross the tested arm across the midline of the torso. They were also told not to bend their knees during the test. Finally, athletes were instructed to avoid preloading (stretching shortening) movements with the tested limb before starting the maneuver. Before each recorded test trial, athletes were verbally instructed to “throw the medicine ball as hard as possible to achieve the greatest distance”. Test trials were repeated when the torso crossed the midline with the test arms and moved away from the backrest, or

when bent knees or preloading were performed before completing the test (Riemann et al., 2018). A warm-up throw was performed before conducting three maximal-effort trials. The distance from the wall to the first point where the medicine ball touches the ground was measured and averaged over the three test trials (Riemann et al., 2023).

Upper Extremity Y balance test (YBT-UQ): The YBT-UQ was performed after a test-specific warm-up consisting of three sub-maximal reaches per arm and reach direction for each athlete. The assessor gave all athletes standardized verbal instructions and a visual demonstration of the procedure. The athletes had no prior experience with assessing YBT-UQ performance. For the test, athletes were asked to assume a push-up position on a central platform with their feet shoulder-width apart. From this starting position, athletes moved the reach indicator in the medial (MD), inferolateral (IL), and superolateral (SL) directions. All reach directions were performed sequentially, maintaining the push-up position with the other arm on the central platform. Trials were invalidated when athletes pushed the indicator boxes without making contact, failed to maintain the push-up position, or lost contact with the ground with their feet. A 30-second rest period was given after each trial. Each reach direction was recorded. The score was normalized using arm length (AL). AL was measured in centimeters with a tape measure from the seventh cervical spinous process to the distal tip of the middle finger with the arm held in 90° abduction. The best trial was calculated as the absolute maximal reach distance (cm) for each direction divided by the individual's AL and then multiplied by 100 (% AL). A composite score (CS) was calculated as the mean of the maximum reach distances for every direction and both arms separately (Bauer et al., 2021).

Data Analysis

The SPSS 26.0 program was used for data analysis. The normality of the variables was confirmed using visual (histogram and probability plots) and analytical methods (Kolmogorov-Smirnov test). Descriptive statistics were calculated as mean and standard deviation. The Paired Sample t-test was used to compare the differences between the extremities. The effect sizes were calculated as Cohen's (Cohen, 2013) and interpreted according to Hopkins's thresholds (trivial <0.20, small 0.20–0.59, moderate 0.60–1.19, large 1.20–1.99, very large 2.0–3.9, nearly perfect ≥4.0) (Hopkins, 2000). The significance level was accepted as $p < 0.05$.

RESULTS

Table 1 presents the demographic characteristics of the athletes included in the study.

Table 1. Demographic information of adolescent kickboxing athletes

Characteristic		Kickboxing athletes (n=32) (mean ± SD)
Age (years)		16.72 ± 0.95
Weight (kg)		65.46 ± 9.20
Height (cm)		172.28 ± 8.66
BMI (kg/m ²)		22.07 ± 2.66
Playing experience (years)		3.31 ± 2.30
Training hours (hour)		8.16 ± 3.55
		n (%)
Gender	Female	13 (40.66%)
	Male	19 (59.4%)
Functional Dominance	Right	30 (93.7%)
	Left	2 (6.3%)

SD: Standard Deviation. BMI: Body Mass Index

When the dominant and non-dominant extremities of kickboxing athletes were compared, a statistically significant difference was found between the two sides regarding the SSASPT score

($p = 0.038$, $d = 1.93$), indicating a large effect size (Table 2). The dominant side's throwing distance was greater than the non-dominant side.

There was no difference between the dominant and non-dominant sides in terms of reach distance in all directions (% AL) and CS in YBT-UQ ($p > 0.05$, Table 2).

Table 2. Comparison of the dominant and non-dominant sides of adolescent kickboxing athletes

	LSI (%)	Dominant Side	Non-Dominant Side	Effect Size (Cohen's d)	p
SSASPT (cm)	107.38 ± 15.44	434.31 ± 104.07	411.38 ± 115.89	1.93	0.038*
YBT-UQ-MD score (% AL)	100.98 ± 13.16	86.78 ± 9.79	86.71 ± 10.61	0.08	0.967
YBT-UQ-IL score (% AL)	99.50 ± 8.94	74.03 ± 11.52	74.83 ± 12.46	0.85	0.494
YBT-UQ-SL score (% AL)	97.10 ± 14.84	55.40 ± 11.31	57.25 ± 9.52	1.03	0.212
YBT-UQ-CS (% AL)	99.25 ± 8.21	72.07 ± 8.61	72.93 ± 9.24	1.36	0.375

* $p < 0.05$, The data are presented as mean ± standard deviation. LSI: Limb Symmetry Index, SSASPT: Seated Single Arm Shot Put Test, YBT-UQ: Upper Quarter Y Balance Test, MD: Medial, IL: Inferolateral, SL: Superolateral, CS: Composite Score, AL: Arm Length

DISCUSSION

This study aimed to compare upper extremity performance between extremities in adolescent kickboxing athletes. To the best of our knowledge, this is the first study to investigate the effect of dominance on upper extremity performance in adolescent kickboxing athletes. For this purpose, upper extremity performance was evaluated in the open kinetic chain using the SSASPT and the closed kinetic chain using the YBT-UQ. The study's results revealed that, as expected, the anaerobic power of the dominant extremity was greater than that of the non-dominant extremity; however, this asymmetry was within normal limits. Additionally, it was found that the balance/stability of the dominant and non-dominant extremities was symmetrical.

For combat sports athletes, the explosive power of both lower and upper limbs is considered essential for executing kick and punch techniques (Gençoğlu et al., 2023). Because kickboxing is characterized primarily by rapid and explosive movements of the arms and hands, upper limb power and speed are critical for the effective execution of techniques (Wang & Hu, 2025). Moreover, kickboxing is an asymmetrical combat sport that requires targeted training on individual body parts of the athlete and compensatory measures to prevent injuries (Niewczas et al., 2024). For these reasons, we consider it important to assess power and to identify bilateral differences in kickboxing athletes. Ouergui and colleagues found in their study that kickboxers have above-average upper anaerobic power (I Ouergui, 2013). Slimani and colleagues, in their study, found that winning kickboxers had greater upper-body muscular power than those who lost (Slimani et al., 2016). Ouergui and colleagues assessed power using the Wingate test, and Slimani and colleagues evaluated it with the medicine ball throw test. In our study, however, we assessed power using the SSASPT to identify differences between the two sides. The SSASPT can measure the ability of each limb to produce short bursts of maximal effort in an open chain. In contrast to throwing tasks, the seated throwing movement has the advantage that

the task requires less coordination. This may allow the assessor to better isolate upper extremity strength and power independent of coordination (Riemann et al., 2018). In our study, the anaerobic power score on the dominant side was higher than on the non-dominant side in adolescent kickboxing athletes. This result is not surprising in kickboxing athletes, a sport characterized by asymmetry. In the literature, few studies have investigated bilateral differences in upper extremity strength and power among kickboxing athletes. Kocaoğlu compared the grip strength between the dominant and non-dominant hands of kickboxing athletes and found that the grip strength of the dominant hand was higher than that measured with the non-dominant hand (Kocaoğlu, 2024). The results of this study support our findings.

In cases of unilateral SSASPT pathology, calculating an LSI can provide a unitless metric to assess a patient's performance, thereby avoiding confounding issues in normative data comparisons (Riemann et al., 2023). Degot et al. found that the SSASPT showed good inter-session reliability and agreement for the LSI (Degot et al., 2021). Previous literature reported that the LSI value in healthy subjects ranged from 103 to 111%, favoring the dominant limb (Chmielewski et al., 2014; Degot et al., 2021; Riemann et al., 2023). Riemann et al. found that LSI in healthy and physically active individuals ranged from 107 to 111% for each ball mass (1, 2, and 3 kg). The authors stated that their results support the use of SSASPT to compare the functional performance of the bilateral upper extremities (Riemann et al., 2018). In our study, LSI was found to be 107% in SSASPT, consistent with the literature. This indicates that although a statistical difference existed between the dominant and non-dominant sides, the asymmetry was within normal ranges.

The YBT-UQ was developed to examine upper extremity stability, core stability, and contralateral upper extremity mobility simultaneously. The YBT-UQ is one of the first tests reported to assess dynamic unilateral upper extremity function in a closed-chain position. This test allows a unilateral comparison of dominant and non-dominant performance or injured and uninjured performance (Myers et al., 2017). In our study, we found no significant difference between the two sides in YBT-UQ. Although there is no literature evaluating upper extremity balance/stability in kickboxing athletes, this result is consistent with many studies on the YBT-UQ test. Butler et al. found no difference in YBT-UQ performance between the throwing and non-throwing extremities of high school baseball and softball players (Butler et al., 2014). Bubić and Kozinc found no difference between the dominant and non-dominant sides in healthy, recreationally active individuals for the YBT-UQ (Bubić & Kozinc, 2022). Tooth et al. observed that in 587 athletes (handball, rugby, tennis, and volleyball players, as well as swimmers), there were no significant bilateral differences in the YBT-UQ for any sports discipline or age group. They stated that this demonstrates the surprising consistency of this aspect of shoulder performance despite significant differences across sports (Tooth et al., 2024). The results of the current study continue to support the established evidence that extremity asymmetries should not be an expected outcome of the YBT-UQ, regardless of the nature of the sport.

It has been stated that the YBT-UQ is useful in assessing upper extremity stability, determining training regimens in various sports disciplines, and predicting injury risks (Ribnikar et al., 2024). The average distances reached by each upper extremity can be compared with one another to assess symmetry and with reference values from the literature to evaluate mobility and function (Fares et al., 2022). Like our study, Westrick et al. found that the LSI for the YBT-UQ was above 95% AL in SL and above 98% AL in MD, IL, and CS (Westrick et al., 2012). Then et al. reported that individuals (mean age: 24.7 ± 5.2 years) with a maximum SL reach distance $\leq 80.1\%$ AL and IL reach asymmetry $\geq 7.75\%$ on the YBT-UQ were at an increased

risk of future musculoskeletal injuries (risk ratio: 1.2, odds ratio: 1.4) (Teyhen et al., 2020). Additionally, Campbell et al. identified a lower CS \leq 81.1% AL reach as a risk factor for upper quarter musculoskeletal injuries in military personnel (mean age: 28.6 ± 6.8 years) (Campbell et al., 2022). Although IL asymmetry was not found in our study, SL and CS values were below the cut-off values. Considering that this may be a risk factor for injury, it is recommended that coaches incorporate injury prediction and prevention programs into the training routine, especially for adolescent kickboxing athletes. In this context, existing programs that are effective in reducing the risk of upper extremity injuries can be implemented.

This study has several limitations. The upper extremity functional performance tests used in this study were the SSASPT and YBT-UQ. Although these are the most frequently used tests to identify bilateral differences, they provide information only on strength and power, as well as balance and stability. Considering that parameters such as agility and reaction time are also important for kickboxing athletes, future studies could investigate the effect of dominance on different functional performance tests. Additionally, the athletes included in this study were adolescent male and female kickboxing athletes, without any distinction by gender. Therefore, the results cannot be generalized to all kickboxing athletes. Future research could examine the effect of dominance in different age groups, especially considering that asymmetry may change with experience (years of sport).

RECOMMENDATIONS

To the best of our knowledge, this study is the first to compare upper extremity functional performance between adolescent kickboxing athletes. As kickboxing is an inherently asymmetrical sport, identifying and quantifying upper extremity asymmetries is crucial for injury prevention. Our results demonstrated that the anaerobic power of the dominant side was significantly greater than that of the non-dominant side; however, LSI indicated that this difference remained within clinically acceptable thresholds for functional asymmetry. Moreover, limb dominance did not influence upper quarter balance/stability measures. These findings suggest that, in adolescent kickboxing athletes with upper extremity musculoskeletal problems, the unaffected limb may serve as a reliable clinical reference when making decisions about returning to sport. In addition, by presenting detailed measurements of open- and closed-kinetic chain upper extremity performance in this specific athletic population, this study offers preliminary descriptive data that could contribute to establishing future reference values.

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