Comparison of Core Endurance, Strength, Power, Balance and Flexibility in Young Elite Sailors

Beyza BAŞER ÖZTÜRK*, Başar ÖZTÜRK**, Ayça AKLAR***

Abstract

Aim: This study examines and compares the core endurance levels, balance performance, muscle strength, and flexibility among young elite saiflors in different sailing classes.

Method: Athletes were randomly selected from the Galatasaray Sailing Club and divided into three groups: windsurfing (n=14), optimist (n=13), and laser class (n=13). Demographic features, body mass index, and dominant side of the body were recorded. Upper extremity strength was assessed using a hand dynamometer, while lower extremity power was evaluated through vertical jump, standing long jump, and single-leg jump tests. Core endurance was evaluated with sit-up, plank, and rotary stability tests. Balance and flexibility were assessed using Y balance, straight leg raise, shoulder flexibility, sit and reach, shoulder elevation, and total body rotation tests. The data from the three groups were analyzed using the Kruskal-Wallis H test, and inter-group comparisons were performed with the Mann-Whitney U test.

Results: Significant differences were observed among the groups in the hand grip test for both right and left hands ($p<0.001$). The laser group displayed the highest mean value. The standing long jump test also showed a significant difference between the groups ($p<0.05$), with the laser group exhibiting the highest mean value. The single-leg jump test revealed a significant difference among the groups ($p<0.05$), with the windsurfing group having the highest average. The Y balance test indicated a significant difference among the groups ($p<0.05$), with the optimist group displaying the highest average values.

Conclusion: These findings demonstrate that each sailing class necessitates distinct physical attributes and specific performance parameters, particularly in terms of strength and balance.

Keywords: Sailing, performance evaluation, core endurance, muscle strength, balance, flexibility.

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* Physiotherapist Msc, Feneryolu Physiotherapy Clinic, Istanbul, Türkiye. E-mail: beyzabaserrr@gmail.com ORCID https://orcid.org/0000-0001-7888-8044
** Assoc. Prof., Fenerbahçe University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Istanbul, Türkiye. E-mail: fztbasar.ozturk@gmail.com ORCID https://orcid.org/0000-0001-5763-6008
*** Asst. Prof., Ayça Aklar Physiotherapy Clinic, Kalamış, Istanbul, Türkiye. E-mail: aycaaklar@gmail.com ORCID https://orcid.org/0000-0002-2486-3228

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Genç Elit Yelkencilerde Gövde Kas Enduransı, Kuvvet, Güç, Denge ve Esnekliğin Karşılaştırılması

Öz

Amaç: Çalışma, genç elit yelkencilerde core dayanıklılık seviyeleri, denge performansı, kas kuvveti ve esneklik arasındaki ilişkiyi değerlendirmek amacıyla yapılmıştır.

Yöntem: Sporcular Galatasaray yelken kulübünden rastgele seçilmiş ve windsurfing (n=14), optimist (n=13) ve lazer (n=13) yelken sınıfları olmak üzere göre üç gruba ayrılmıştır. Yelkencilerin demografik özellikleri, vücut kitle indeksleri ve dominant tarafları kaydedilmiştir. Üst ekstremite kuvveti, el dinamometresi kullanılarak değerlendirildi, alt ekstremite gücü ise dikey sıçrama, uzun atlama ve tek ayakla sıçrama testleriyle değerlendirildi. Core dayanıklılık değerlendirmesi için mekik, plank ve rotary stabilite testleri uygulanmıştır. Denge ve esneklik değerlendirmesi için Y denge, düz bacak kaldırma, omuz esneklik, otur- uzan, omuz elevasyon ve tüm vücut rotasyon testleri uygulanmıştır. Üç gruptan elde edilen veriler Kruskal-Wallis H testi kullanılarak analiz edildi ve gruplar arası karşılaştırmalar Mann-Whitney U testi ile yapıldı.

Bulgular: Yelken sınıfları gruplar arası karşılaştırıldığında hem sağ hem de sol elin ortalama değerleri açısından el kavrama testi sonuçlarında anlamlı bir fark vardır ve en yüksek ortalama değer laser grubundadır ($p<0,001$). Durarak uzun atlama testi sonuçlarında gruplar arasında anlamlı fark olduğu görülmüştür ve en yüksek ortalama değer laser grubundadır ($p<0,001$). Tek bacak zıplama testi sonuçlarına göre anlamlı fark vardır ve en yüksek ortalama değer rüzgar sörfü grubundadır ($p<0,05$). Y dengesi testi sonuçlarına göre hem sağ hem de sol tarafta gruplar arasında anlamlı bir fark vardır ve en yüksek ortalama değer optimist grubundadır ($p<0,05$).

Sonuç: Bu sonuçlar özellikle kuvvet ve denge parametrelerinde, her yelken sınıfının farklı fiziksel özelliklere sahip olduğunu ve spesifik performans parametrelerine ihtiyacı olduğunu göstermektedir.

Anahtar Sözcükler: Yelken sporu, performans değerlendirme, gövde kas enduransı, kas kuvveti, denge, esneklik.

Introduction

Sailing is a sport that calls for a variety of energy and movement requirements across various boat classes, as well as tactical ability and strategy. All sailing categories require a certain level of physical strength, muscle endurance, flexibility, and balancing skills[1,2]. For the sailing sport, a variety of performance factors are crucial, including understanding weather patterns, tactical proficiency, and strategic planning[2-4]. Furthermore, the components that contribute to such competency are determined by boat class[5,6].

Isometric endurance is essential for effective performance in sailing sports because sailors must maintain specific positions for extended period of times. Enhancing isometric muscular endurance is particularly crucial for the lower limb and core muscles, as these muscles are heavily utilized during sailing activities. Research has shown that for monohull sailing, the strength and symmetry of both the upper and lower extremities are critical for performance. Maintaining the boat's stability is closely correlated with the sailor's muscular endurance and overall strength[7–11].

One of the challenges in sailing, a unilateral sport, is the potential for asymmetrical development of the dominant limb's muscles. This asymmetry in the upper limbs can influence the asymmetry in the lower limbs, leading to imbalances that may affect performance and increase the risk of injury. Previous studies have indicated a need for comprehensive training programs that address these imbalances by focusing on both limbs equally to ensure optimal performance and reduce injury risks[11–15].

In sailing, there are several Olympic racing classes, including Windsurfing, Optimist, and Laser. Each class demands specific physical and technical skills, highlighting the importance of tailored training programs. However, existing research often lacks a detailed examination of the specific muscular demands and endurance requirements for each class. This gap in the literature suggests a need for further studies to identify the unique training needs and strategies for athletes in different sailing classes[16,17].

Overall, while there is some understanding of the importance of isometric endurance and muscle symmetry in sailing, more research is needed to explore the specific demands of each sailing class and to develop targeted training programs. This would help in addressing the current gaps in knowledge and provide a more comprehensive understanding of the physical requirements for sailing sports.

The purpose of this study is to ascertain and compare the young sailing athletes' performance metrics, including muscle endurance, muscle strength, power, balance, and flexibility, across various sailing classes.

Material and Methods

Participants

Based on the G Power program's power analysis and the dominant side hand grip test's mean and standard deviations from the reference study, it was determined that 36 participants in total—12 in each of the three research groups—should be included in the study at a significance level of 0.05, an effect size of 0.628, and a reliability level of 90%[18].

26 males and 14 females in all from Laser (14 athletes; 16±2.04 years), optimist (13 athletes; 11.5±1.1 years), and windsurfing (13 athletes; 13,6±2.1 years), sailing classes were participated in the current study (Table 1). The athletes were randomly selected from the Galatasary sailing club and the athletes were divided into three groups according to their sailing class. The starting and finishing time of the study is between December and January 2022.

Table 1. Sailor's demographic information

	Windsurfing (Mean ± SD) n=14	**Optimist (Mean ± SD) n=13**	**Laser (Mean ± SD) n=13**	**Total (Mean ± SD) n=40**
Age (year)	13,6±2.1	11.5±1.1	16±2.04	13.65±2.56
Height (cm)	160±10.6	149.8±8.0	169±6.6	159.9±11.7
Body weight (kg)	50.4±9.9	39.6±5.6	62.2±6.1	50.7±11.9
Body mass index (BMI) (kg/m²)	19.4±2.7	17.6±2.02	21.5±1.2	19.5±2.6

The inclusion criteria are;

- athletes who are professional sailing athletes,
- not possessing any physical ailments that might obstruct the test procedures,
- being between the ages of 8-20
- being an athlete competing in the Laser, Optimist, or Windsurfing classes.

The exclusion criteria are;

- any musculoskeletal issue that inhibits the athlete's ability to execute the performance tests,
- disability within the last 1 year

Instruments

To assess the strength, balance, endurance, and flexibility parameters of sailors, performance tests were conducted. Prior to the testing, each participant's demographic information, height, weight, Body Mass Index (BMI), and the dominant hand and leg were documented. The dominant hand and leg were determined by asking participants to indicate their preferred hand for tasks such as writing and handling the sail, and their preferred leg for tasks such as balancing on the boat. Asymmetry was measured using a symmetry index, which compared the performance of the dominant and non-dominant sides during the tests comparisons to identify any significant differences in strength, power, balance, endurance, and flexibility between the dominant and non-dominant sides.

Strength and Power Measurements

1. Hand Grip Test: The Jamar handgrip dynamometer measured maximum isometric hand-grip strength. Subjects squeezed the device firmly for three seconds, with a 15-second break between each trial. A 3-minute rest period was allowed when switching hands (Figure 1)[19].

2. Vertical Jump Test: The athlete starts a step back from the wall and jumps as high as possible, using their arms and legs for propulsion. The difference between the standing reach and leap height is used to calculate the score[20].

3. Standing Long Jump Test (Broad Jump Test): Participants attempt to jump as far as they can while landing on both feet without falling backward. The measurement is taken from the take-off line to the nearest contact point on landing (Figure 2)[21].

4. Single-Leg Side Jump Test: Athletes stand on one leg and jump sideways between two parallel tape strips placed 40 cm apart on the floor. They are instructed to perform as many successful jumps as possible within a 30-second period[20].

Core Muscle Endurance Measurement

5. Sit-up Test: Starting in an upright position, athletes lower their backs until their shoulder blades touch the ground, then raise themselves back up. The test lasts for one minute, and the score is based on the number of correct repetitions completed[20,21].

6. Plank Test: Athletes strive to maintain an elevated position for as long as possible. They support themselves on their elbows, forearms, and toes, ensuring their back remains straight and hips don't drop (Figure 3).

7. Rotary Stability Test: Athletes capable of executing straight unilateral movements, with their knees and elbows aligned with the platform, are awarded 3 points. Those who can perform straight diagonal movements, maintaining alignment of their knees and elbows with the platform, receive 2 points. Athletes unable to execute straight diagonal movements are given 1 point. Those experiencing any pain during the test are allocated 0 points (Figure 4)[22].

Balance and Flexibility Measurements

8. Y Balance Test: For each leg, the three movements are performed in anterior, posteromedial, and posterolateral directions. The score is calculated by dividing the total score attained in the anterior, posterolateral, and posteromedial regions by 3 times the leg length, and then multiplying the result by 100[23].

9. Straight Leg Raise Test: The athlete assumes a position lying on the back with legs extended and hips in a neutral position. Once the leg has achieved its maximum range of flexion, the goniometer is positioned at the femoral head, with one arm of the goniometer parallel to the ground and the other arm directed towards the malleolar region of the fibula. In the assessment of angles, a measurement of 75 and above is deemed normal, while grade I and grade II shortening are determined by angles ranging from 74 to 61 and 60 or below, respectively.

10. Sit and Reach Test: Athletes sit with the measuring stick between their legs, extending their arms forward as far as possible while maintaining the position for two seconds. The greatest length achieved is recorded.

11. Total Body Rotation Test: The athlete is positioned an arm's length away from the wall. They are then instructed to turn to the right side and extend their fist as far as possible, along with a measuring stick, maintaining this position for 2 seconds. Subsequently, the athlete is asked to perform the same movement to the left side. Measurements are taken for both sides, and each score is documented by calculating the average of the two sides[22].

12. Shoulder Elevation Test: Athletes hold a long stick and lift it as high as possible while lying face down on a flat surface. The score is calculated by dividing the achieved score by the arm length and then multiplying the result by 100 (Figure 5).

13. Shoulder Flexibility Test: The athlete is directed to lift the fingers of their second arm, with the palm facing outward, as high as possible in an attempt to touch or overlap the middle fingers of both hands. If the fingertips touch, no points are awarded. If the fingertips fail to touch, the distance between them is recorded as a "negative score." Conversely, if the fingertips do overlap, the extent of this overlap is measured and noted as a "positive score"[24].

Symmetry Index (SI): The formula for quantifying asymmetry in strength and flexibility is:

$$SI = \frac{Xr - Xl}{\frac{1}{2}(Xr + Xl)} \times 100\ \%$$

Here, Xr and X1 represent measurements from the right and left sides, respectively. An SI of 0 indicates perfect symmetry. A positive SI means the right side is stronger or more flexible, and a negative SI indicates the left side is dominant. Asymmetry is significant if SI exceeds 10%[25].

Statistical Analysis

Upon concluding the study, the data gathered from the three groups were analyzed using the Kruskal-Wallis H test within the SPSS software.Comparisons between 2 groups were analyzed with the Mann Whitney U test (IBM Corp. (2020). IBM SPSS Statistics for Windows (Version 27.0) [Computer software]. IBM Corp.).

The Kruskal-Wallis H test was used to compare outcome measures among the three different sailing classes (Windsurfing, Optimist, and Laser). This non-parametric test determines whether there are statistically significant differences in the median values of the outcome measures across the three groups.

The Mann-Whitney U test was employed for pairwise comparisons to analyze the differences between sailing classes. Specifically, it was used to: Compare the outcome measures between male and female athletes to identify any significant gender-based differences, the dominant and non-dominant sides within each individual to assess asymmetry, conduct pairwise comparisons between the sailing classes (e.g., Windsurfing vs. Optimist, Windsurfing vs. Laser, and Optimist vs. Laser) to identify which groups differed from each other.

The analysis of asymmetry data involved calculating the SI for each participant and then using the Mann-Whitney U test to compare the asymmetry indices between different groups (e.g., boys vs. girls, different sailing classes). This helped determine if there were statistically significant differences in asymmetry between the groups.

Results

The Kruskal-Wallis analysis comparing the three sailing classes revealed a statistically significant difference in the Jamar hand grip test results for both the right and left hands, with p-values less than 0.001. Among the groups, the Laser class demonstrated the highest average hand grip strength, as detailed in Table 2.

Table 2. Strength performance tests comparisons between sailing classes

	Windsurfing (Mean ±SD) N=14	Optimist (Mean ±SD) N=13	Laser (Mean ±SD) N=13	P
Hand Grip Test R (kg-f)	61.07 ± 20.58	41.53 ± 8.98	86.15 ± 23.99	**0.000**
Hand Grip Test L (kg-f)	61.42 ± 19.84	40.76 ± 9.09	83.07 ± 20.26	**0.000**
Vertical Jump Test (cm)	37.82 ± 13.74	29.23 ± 7.63	39.11 ± 10.85	0.068
Standing Long Jump Test (cm)	177.39 ± 37.31	158.38 ± 17.48	193.15 ± 23.33	**0.003**
Single Leg Jump Test (n)	32.14 ± 11.27	22.07 ± 7.04	24.23 ± 9.04	**0.041**
Sit-Up Test (n)	18.42 ± 2.34	17.30 ± 1.97	20 ± 4.50	0.239
Plank Test (s)	162.71 ± 89.01	149.69 ± 81.63	143.69 ± 76.20	0.915
Rotary Stability Test –R (score)	3.0 ± 0	2.92 ± 0.27	2.92 ± 0.27	0.575
Rotary Stability Test –L (score)	2.71 ± 0.46	2.92 ± 0.27	2.61 ± 0.50	0.188
Y Balance Test –R	122.44 ± 8.50	126.83 ± 12.48	113.20 ± 9.08	**0.006**
Y Balance Test –L	116.82 ± 9.05	124.03 ± 11.87	105.63 ± 8.37	**0.000**
Straight Leg Raise Test –R	88.28 ± 9.35	92.69 ± 7.83	81.73 ± 12.24	0.114
Straight Leg Raise Test –L	87.32 ± 8.12	91.42 ± 9.36	84.11 ± 14.37	0.286
Shoulder Flexibility Test- R	7.35 ± 5.47	4 ± 7.38	1.34 ± 11.44	0.402
Shoulder Flexibility Test-L	2.67 ± 7.37	-0.19 ± 7.98	-.269 ± 10.36	0.612
Sit and Reach Test	7.42 ± 9.92	6.76 ± 8.25	10 ± 14.49	0.938
Shoulder Elevation Test (cm)	19.42 ± 8.18	18.69 ± 6.18	17.15 ± 6.69	0.752
Total Body Rotatiton Test-R	59.47 ± 18.08	49.20 ± 15.62	43.40 ± 14.66	0.052
Total Body Rotatiton Test-L	52.19 ± 22.92	44.67 ± 15.96	43.62 ± 14.08	0.587

R: Right; L:Left; p<0.05; p<0.001

The analysis of the Standing long jump test results indicated a significant difference among the groups (p=0.003), with the highest mean value once again observed in the laser group.

There is a significant difference between the groups according to the results of the single-leg jump test (p=0.041) and the highest average is in the windsurfing group.

The evaluation revealed no statistically significant differences between the groups regarding vertical jump (p=0.068), sit-up (p=0.239), plank (p=0.915), and rotary stability test for both right (p=0.575) and left (p=0.188) sides. Moreover, the analysis found no significant difference between the groups in terms of straight leg raise for both right (p=0.114) and left (p=0.286), shoulder flexibility for both right (p=0.402) and left (p=0.612), shoulder elevation (p=0.752), sit and reach (p=0.938), and total body rotation test for both right (p=0.052) and left (p=0.587) results.

Based on the Y balance test results, a significant difference was observed between the groups on both the right (p=0.006) and left sides (p<0.001), with the optimist group displaying the highest average values. Furthermore, the Mann-Whitney U analysis revealed that the group of boys exhibited a greater percentage of asymmetries in the hand grip and straight leg raise tests. Additionally, boys performed better in several other outcome measures, including the vertical jump test, single leg jump test, standing long jump test, and sit-up test. Asymmetry data was analyzed using the symmetry index (SI) to compare the performance of the dominant and non-dominant sides, with significant differences identified through the Mann-Whitney U test.

In terms of Symmetry Index (SI) for hand grip values, the laser class exhibits a higher asymmetry percentage at 46%. The optimist and windsurf classes have similar asymmetry percentages, with 26% for the optimist class and 28% for the windsurf class. Regarding SI straight leg raise values either laser class has a greater asymmetry percentage. Optimist and windsurf class has similar asymmetry percentages (31% versus 30%) (Table 3). Boys have a greater asymmetry percentage than girls both the hand grip and straight leg raise test. Based on gender, a significant difference was observed in favor of men in several tests: the hand grip test for the right hand (p=0.013), vertical jump test (p=0.007), single leg jump test (p=0.025), standing long jump test (p=0.001), and sit-up test (p=0.003) (Table 4).

Table 3. Symmetry Index (SI) Comparison for Hand Grip Strength and Straight Leg Raise Tests

Test	Class	Asymmetry Percentage
Hand Grip Test	Laser	46
	Optimist	26
	Windsurf	28
Straight Leg Raise Test	Laser	46
	Optimist	31
	Windsurf	30

Table 4. Gender Comparison for Various Performance Tests

Test	Gender	Mean ± SD	p
Hand grip test (kg-f)	Male	70.38 ± 27.05	**0.013**
	Female	48.92 ± 17.34	
Vertical jump test (cm)	Male	39.09 ± 11.59	**0.007**
	Female	28.67 ± 8.68	
Single leg jump test (n)	Male	28.84 ± 10.63	**0.025**
	Female	21.57 ± 7.26	
Standing long jump test (cm)	Male	187.71 ± 29.7	**0.001**
	Female	155.21 ± 18.63	
Sit-up test (n)	Male	19.57 ± 3.37	**0.003**
	Female	16.71 ± 1.99	

The windsurfing class outperformed the optimist class in the single-leg jump test ($p=0.018$). Group 3 (laser class) had a significant advantage over group 2 (optimist class) in the vertical jump test ($p=0.021$) and standing long jump test ($p<0.001$). Group 2 (optimist class) achieved the highest score on the Y balance test for both the right ($p=0.006$) and left ($p=0.001$) lower limbs compared to group 3 (laser class). The windsurfing class demonstrated higher scores on the Y balance test for both the right (p=0.012) and left (p=0.004) lower limbs compared to laser group. In the total body rotation assessment, the windsurfing class had a higher score on the right side compared to the laser class (p=0.021), while there was no significant difference on the left side of the trunk rotation between the windsurfing and laser classes (p=0.343).

Discussion

The findings of this study confirmed studies hypotheses. As outlined in studies first hypothesis, there was no significant difference in certain performance parameters between sailing classes. Specifically, no significant differences were observed between the groups in performance tests such as the plank and sit-up tests, which assess static and dynamic core endurance.

Significant differences in strength and balance parameters exist between sailing classes, as hypothesized. Particularly, variations were observed in the Jamar hand grip test, with the laser, windsurfing, and optimist classes displaying the highest values. These differences may be attributed to variations in mean age among the groups. The vertical jump test, standing long jump test, and single-leg jump test also exhibited significant differences between classes. The laser class achieved the highest values in the vertical and standing long jump tests, followed by the windsurfing and optimist classes. Similarly, the windsurfing class had the highest values in the single-leg jump test, followed by the laser and optimist classes. Additionally, the Y balance test proved to be a distinctive measure among the groups, with the optimist, windsurfing, and laser classes displaying the highest values.

In a 2021 study by Caraballo Isabel and colleagues, 68 young elite Spanish sailors aged between 9 and 19 years were categorized into four groups: Windsurfing, Optimist, Laser, and 420 classes. Consistent with these findings, sailors in the Laser class demonstrated higher levels of upper and lower limb strength in this study too. This congruence in grip strength and lower limb strength results between this study and the existing literature underscores the reliability and validity of these findings within the domain of competitive sailing[12]

In a 2015 study by Callewaert et al., 47 young male sailors were divided into optimist and laser classes. They conducted performance tests including sit-up, standing long jump, side jump, hand grip, and sit and reach tests. Similar to this study, the laser class achieved higher scores in all these tests. However, in this study, the laser class had higher scores specifically in the hand grip, standing long jump, and sit and reach tests compared to other sailing classes[26].

Taking this into account alongside other research outcomes, it suggests that individuals in the laser group achieve these elevated performance test scores due to both their anthropometric characteristics and the distinct, high-intensity training regimens specific to this group.

In a 2020 study by Caraballo et al., similar to this studies, three sailing classes were examined: windsurfing, optimist, and laser. The study included 33 sailors and conducted the hand grip test and straight leg lift test[1]. In terms of the straight leg lift test, the SI % values ranked optimist, windsurfing, and laser, whereas in this study, the ranking was laser, optimist, and windsurfing. Regarding the hand grip test, the SI % order was windsurfing, laser, and optimist in their study, whereas in this studies, it was laser, optimist, and windsurfing. This study found higher SI values in the laser group. In terms of gender, women exhibited higher SI % in the hand grip test variable, while boys had slightly higher SI % in straight leg lifts. In this study, both the hand grip test and straight leg lift tests showed higher SI % in favor of boys. Possible factors contributing to these differences include genetics, developmental status, and variations in training methods.

In alignment with study findings, a study carried out by Pan in 2022 also included vertical jump and sit and reach tests. The outcomes of these assessments closely match those of the laser group in study investigation and are notably higher. Furthermore, similar to this study, Pan's research found that the vertical jump and sit and reach test results for the laser group surpassed those of the other groups[19].

In a study of 29 Spanish male laser-class athletes (16-23 years old), their age, height, and BMI were similar to this study (Table 1). The study concluded that these characteristics are advantageous for the hiking maneuver and directly impact sailing performance. This study supports these findings, as the laser group, with similar characteristics, performed the best[12].

A study conducted in Turkey in 2020 included 23 sailors aged 15-17, but the sailing class was not specified. Various tests, similar to study, were used to assess physical performance. However, the lack of information about specific sailing classes was considered a limitation[27]. In this study, we aimed to compare different sailing classes and highlight the differences.

In a Singaporean study from 2006, 55 laser sailors (37 males, 18 females) with an average age of 20 and height of 165 cm were assessed. Their vertical jump test results were 24 cm for women and 34 cm for men[28]. In this study, which included younger and shorter athletes (average age 13.65, height 160 cm), the vertical jump results were 28 cm for women and 39 cm for men. This indicates that study participants, despite their lower age and height averages, exhibited higher lower extremity strength compared to Singaporean sailing athletes.

Another study included 22 experienced sailors from various countries, with an average age of 18.8 years, who had been sailing for at least 3 years. These participants were categorized into two groups: those experiencing low back pain and those without it. This research utilized the passive straight leg raise test to assess flexibility, similar to this study. In the pain-free group, the flexibility was measured at 61.6 degrees for the right side and 61.8 degrees for the left side. In contrast, this study found the straight leg lift test results to be 87.9 degrees on the right side and 88.2 degrees on the left side, indicating greater flexibility among this study's participants. Moreover, the diverse nationality of sailors in the Brazilian study suggests a less homogeneous group compared to study, which might explain some of the differences in findings[29].

Upon reviewing the literature, it's evident that there are limited studies focused on various sailing classes. In this context, this research holds significant value for country and contributes importantly to the international literature. Through the performance tests conducted on professional sailing athletes as part of this study, we identified differences in the parameters of strength, endurance, flexibility, and balance among sailing athletes based on gender and sailing class.

Each sailing class possesses distinct physical, anthropometric, and performance characteristics, which are influenced by factors such as age, gender, sport-specific training, and the demands of the sport itself. This differentiation underscores the importance of tailored training and development programs for athletes in each sailing class to optimize their performance and health.

The study's strengths include its comprehensive assessment of various physical attributes (core endurance, balance, muscle strength, and flexibility), which provides a detailed understanding of the physical demands on young elite sailors. By including athletes from windsurfing, optimist, and laser classes, the research highlights the specific requirements and performance profiles unique to each class, aiding in the development of tailored training programs. The random selection of participants from a reputable sailing club, combined with clear inclusion/exclusion criteria, ensures a representative sample, enhancing the reliability and validity of the findings. Additionally, the use of standardized and widely accepted performance tests ensures comparability with existing literature, facilitating broader interpretation and relevance. However, the lack of a control group limits the ability to compare the performance of young elite sailors with non-sailors or athletes from other sports. Future research should incorporate control groups and explore longitudinal effects of tailored training programs on performance and injury prevention in different sailing classes.

Conclusion

This findings reveal significant differences in hand grip strength, standing long jump, single-leg jump, and Y balance test results among the different sailing classes, indicating that each class has distinct physical demands. The Laser class showed the highest mean values in hand grip and standing long jump tests, while the Windsurfing class excelled in the single-leg jump test, and the Optimist class performed best in the Y balance test. These results suggest that tailored exercise programs focusing on the specific needs of each class can enhance performance. Expanding research within the field of physiotherapy for sailing is crucial for further identifying and optimizing performance parameters in sailing athletes. In study subsequent research, we plan to incorporate targeted exercise practices and follow-up evaluations to address these specific needs. Normative values from existing literature provide a benchmark for comparison, ensuring the relevance and value of this study's outcomes for developing sport-specific training and rehabilitation programs in sailing.

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