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Investigation of Dynamometric Measurements of Leg Muscles in Vertical and Horizontal Positions in Sailing Athletes*

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Abstract

The aim of this study is to examine the isometric strength levels of leg muscles in sailors through dynamometric measurements performed in vertical and horizontal positions, and to evaluate the effects of these positions on muscle strength and athletic performance. The study group consists of a total of 30 licensed male sailing athletes: 15 from the Marmara Sailing Club (Experimental group) and 15 from the Derince Sailing Club (Control group). Data were collected by applying specific strength training protocols whose validity and reliability had been previously established in the literature. The training program included exercises targeting the leg, shoulder, and arm muscle groups. The effects of these exercises were quantitatively evaluated through dynamometric measurements. During the statistical analysis process, the Friedman test**,** Wilcoxon Signed-Rank test**,** and Mann-Whitney U test were used. The findings revealed that the post-test body weight measurements of the participants in the experimental group showed a statistically significant decrease compared to the pre-test values (Z = -2.065, p = .039). A statistically significant increase was observed in vertical jump performance between the pre-test and post-test *(*Z = -4.448, p < .001). Additionally, significant improvements were recorded in vertical leg strength (Z = -3.663, p < .001*)* and horizontal leg strength (Z = -2.994, p = .003) measurements. Similarly, in the handgrip strength test, which evaluates upper extremity strength, significant increases were observed in both the right hand (Z = -3.266, p = .001) and the left hand (Z = -3.302, p < .001). On the other hand, no statistically significant change was found in flexibility measurements (Z = -1.648, p = .099). Based on these findings, it can be concluded that the specific strength training program had positive effects on the athletes in the experimental group, and that these effects were more pronounced compared to the control group.
Keywords: Sailing sports, Muscle, Strength, Training, Body axis

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INTRODUCTION

Sailing is a complex water sport in which sailors use their body weight, positional changes, a series of maneuvers, and equipment adjustments to maintain the balance of the boat and achieve optimal speed under varying environmental conditions. Due to differences in boat type and sailor position, the physical demands, fitness characteristics, and technical maneuvers required from sailors vary (Pan et al., 2022). In this sport, muscular performance and functionality are critical for sailors to succeed. In particular, leg muscle strength plays a decisive role in maintaining balance and optimizing movements on the boat (Bojsen-Møller et al., 2007).

Sports performance is determined by an athlete's physiological, tactical, technical, psychological, and social characteristics. However, to effectively cope with the physical demands of competition, athletes must maintain a high level of physical fitness (Cankurtaran, 2020; 2021). A well-developed fitness level enables athletes to apply their tactical and technical skills effectively throughout the competition.

In sailing competitions, although the use of wind is fundamental, physical fitness plays a critical role. It has been emphasized that an athlete's ability to reach optimal performance depends largely on the development of their physiological and psychological capacities, as well as their progression toward achieving performance-related goals (Bull et al., 2005; Cankurtaran, 2020; 2021; Konter, 2003). In sailing, performance is significantly influenced by the sailor's ability to counteract destabilizing forces acting on the boat—particularly those caused by wind pressure on the sails, which leads to a lateral tilt known as "heel" (Castagna et al., 2007). To overcome these forces and stabilize the boat, sailors perform a specific technical movement called the hiking position or "walking bench." During this movement, the sailor uses their body as a lever arm: With the feet secured in foot straps at the center of the boat, the rest of the body leans outward to balance the opposing forces. The primary purpose of this maneuver is to maintain balance, allowing the sailor to harness wind power efficiently and sustain optimal boat speed throughout the race (Caraballo et al., 2019; Day, 2017). The diversity of boat classes, crew positions, racing conditions, and individual fitness levels makes it difficult to define a universal fitness standard for sailors. Nonetheless, both sailboats and small keelboats require a combination of aerobic endurance, muscular strength, and stamina (Cunningham, 2004; Cunningham & Hale, 2007; García & Martínez, 2015).

While hiking, sailors primarily rely on the muscles of the thighs, abdominals, hips, and arms. In contrast, trapeze sailors tend to place greater emphasis on upper-body strength and endurance, aerobic capacity, and agility (García & Martínez, 2015). For any given boat size, crew members who are regularly responsible for sail trimming require highly trained muscles in the arms, shoulders, and upper back (Cunningham, 2004).

Dynamic strength measurements are a valuable tool in sports science for evaluating athletic performance. These assessments not only reflect athletes' mobility and endurance levels but also provide insight into the muscles' capacity to generate force. Specifically, in the context of sailing, leg muscles play a critical role in maintaining body posture and enhancing the maneuverability of the boat (Davies et al., 2017; Kanehisa & Miyashita, 1983). The movements performed by sailors during competition influence the power output capabilities of the leg muscles under different body orientations, particularly vertical and horizontal positions. In a vertical posture, muscles are primarily engaged in resisting gravitational force and generating power, whereas in a horizontal position, maintaining balance and stability becomes more dominant. These biomechanical differences offer a basis for understanding how muscle activation patterns vary across positions. Although numerous studies in the literature have explored the relationship between muscle strength and overall performance across various sports, systematic analyses focusing specifically on sailing remain scarce. Investigating the strength levels of sailors' leg muscles in both vertical and horizontal positions seeks to address this notable gap in the literature.

This research aims to provide a deeper understanding of the functional role of leg muscles in sailing and to offer a scientific foundation for designing sport-specific training programs. Based on this framework, the primary objective of the study is to examine the dynamometric strength measurements of sailors' leg muscles in vertical and horizontal positions, and to analyze the effects of these positions on muscular strength and overall athletic performance. By comparing measurements taken in both orientations, this study intends to yield concrete data that can inform the development of targeted strength training protocols and technical skill enhancement. In this context, it is anticipated that the findings may contribute to improving the efficiency and effectiveness of training processes for competitive sailors.

METHOD

Research Model

In this study, a pre-test–post-test control group design, which is one of the experimental research methods, was employed. According to Büyüköztürk et al. (2017) and Karasar (2018), this model involves forming two groups through random (impartial) assignment. One group serves as the experimental group, while the other serves as the control group. Data are collected from both groups before and after the intervention.

Research Group

The research group consists of a total of 30 licensed sailing athletes, 15 male athletes from Marmara Sailing Club (Experimental group) and 15 male athletes from Derince Sailing Club (Control group). Data for the research were collected between November 17, 2022, and May 11, 2024.

Data Collection Tools

In the present study, data were collected through dynamometric assessments to evaluate participants' muscular strength, balance, and functional movement patterns. These assessments were conducted using a series of validated and reliable functional exercises incorporated within a specific training protocol. The selected exercises have been widely recognized in the literature for their effectiveness in targeting specific muscle groups and assessing neuromuscular function (Behm et al., 2002; Schoenfeld, 2010).

To assess lower extremity strength, stability, and proprioception, various dynamic and multi-directional exercises were implemented, including squats, overhead squats, lunges, lateral lunges, forward lunge forearm to instep, backward lunge with twist, box/stair lunges, Nordic hamstrings, inverted hamstrings, base rotations, side-to-side base movements, one-leg over line, split jumps, and squat jumps. These exercises primarily engage key muscle groups such as the quadriceps, hamstrings, gluteals, and core stabilizers. Notably, the Nordic hamstring exercise has been emphasized in the literature for its crucial role in eccentric strength development and injury prevention (Akıncı, 2019; Kesilmiş & Akın, 2020; McCall et al., 2014; van der Horst et al., 2015).

For the evaluation of upper body strength, scapular control, and trunk stabilization, exercises such as push-ups, rotations, abductions, elevations, overhead presses, pull-ups, dips, and standing side pushes were used. These exercises are designed to activate the shoulder girdle, upper back, and core musculature and are commonly employed in both clinical and athletic performance settings to assess functional strength and motor control (Calatayud et al., 2015; Caron, 2019; Cengizhan et al., 2019; Uluç, 2022). All exercises were administered under standardized conditions with appropriate rest intervals to minimize fatigue-related bias. Force output and muscle strength measurements were obtained using digital dynamometers, instruments widely validated and known for providing reliable results in both clinical and research contexts (Bohannon, 2001; Gilbert & Knowlton, 1983; Ng & Fan, 2001).

Ethics Approval

Informed consent was obtained from 30 participants during the research process, and their personal information was kept confidential to ensure their anonymity. The study was approved by the Istanbul Gedik University Ethics Committee in accordance with ethical standards (Decision No. 344 dated May 9, 2022).

Analysis of Data

SPSS 22.0 statistical software was used for data analysis. Before analyzing the data obtained in the study, the Kolmogorov-Smirnov test was applied to determine whether the data were normally distributed. The test determined that the data were not normally distributed. Therefore, the effects of the specific strength training applied to the experimental group on various performance measures and the differences between the routine training of the experimental and control groups were analyzed using nonparametric tests.The Friedman test was applied to assess the overall differences between the pretest and posttest measurements of all participants in the experimental group. The Wilcoxon Signed Rank test was used to determine the direction and magnitude of the differences between the pretest and posttest measurements, and the Mann-Whitney U test was used to examine the differences between the experimental and control groups.

FINDINGS

Table 1. Descriptive statistics of the research variables

Variables	Experimental (n=15)		Control (n=15)	
Weight	x̄	**SD**	x̄	**SD**
Pre-test	40.966	14.537	39.973	14.516
Post-test	41.200	13.305	40.866	14.302
Vertical Jump				
Pre-test	31.400	10.055	36.400	8.757
Post-test	36.73	9.376	38.800	8.711
Vertical Leg Strength				
Pre-test	59.640	29.088	80.966	36.060
Post-test	65.88	28.779	82.600	35.265
Horizontal Leg Strength				
Pre-test	60.700	26.358	82.100	41.715
Post-test	69.446	25.339	83.000	36.420
Hand Grip Right Hand				
Pre-test	18.193	9.757	17.420	8.929
Post-test	20.906	9.663	18.366	8.120
Hand Grip Left Hand				
Pre-test	18.460	8.767	17.360	8.382
Post-test	21.840	8.231	18.400	6.801
Flexibility				
Pre-test	30.70	50.006	308.667	7.482
Post-test	19.000	3.295	31.266	7.314
VYY				
Pre-test	11.466	2.972	12.533	2.065
Post-test	11.333	1.447	12.733	2.463

When Table 1 is examined, statistically significant differences were observed between the pretest (x̄ 31.400) and posttest (x̄ 36.730) values of the vertical jump parameter of the experimental group. Significant differences were observed between the pretest (x̄ 59.640) and posttest (x̄ 65.880) values in the vertical leg strength parameter. Significant differences were observed between the pretest (x̄ 60.700) and posttest (x̄ 69.446) values in the horizontal leg strength. An increase was also observed in the hand grip strength between the right pretest (x̄ 18.193) and posttest (x̄ 20.906). For the hand grip in the left hand, significant differences were observed between the pretest (x̄ 18.460) and posttest (x̄ 21.840). In the control group, significant differences were observed between the pretest (x̄ 36.400) and posttest (x̄ 38.800) values of vertical jump. A significant increase was observed between the pretest (x̄ 80.966) and posttest (x̄ 82.600) values of vertical leg strength. A significant increase was observed between the pretest (x̄ 82.100) and posttest (x̄ 83.000) values of horizontal leg strength. However, while a decrease was observed between the pretest (x̄ 30.700) and posttest (x̄ 19.000) values of flexibility measurement in the experimental group, a significant increase was observed between the pretest (x̄ 308.667) and posttest (x̄ 31.266) values of flexibility in the control group. These findings reveal that the specific training program implemented had positive effects on various physical performance parameters of the athletes in the experimental group. Significant improvements were observed, especially in terms of strength and jumping capacity. However, the decrease observed in flexibility level suggests that the implemented training program was not sufficiently effective on this parameter.

Table 2. Differences between pre-test and post-test of the experimental group

Variables	N	Pre-test	Post-test
Weight	30	10.45	10.98
Vertical Jump	30	9.35	10.80
Vertical Leg Strength	30	13.62	14.75
Horizontal Leg Strength	30	13.73	15.03
Hand Grip Right Hand	30	3.48	5.52
Hand Grip Left Hand	30	3.73	5.82
Flexibility	30	7.12	7.50
VYY	30	2.08	2.03

An examination of Table 2 shows that there are statistically significant differences between these measurements in the experimental group $\chi^2(15) = 399.594$, $p<.001$. A significant improvement was observed in the vertical jump measurements of the experimental group between the pretest (M=9.35) and posttest (M=10.80). A significant improvement was observed between the pretest (M=13.62) and posttest (M=14.75) in vertical leg strength. Posttest measurements of horizontal leg strength (M=15.03) showed a significant increase compared to the pretest results (M=13.73). Hand-Grip (Right Hand) posttest results (M=5.52) were observed to be significantly higher compared to the pretest results (Mean Rank=3.48). Similarly, posttest results of left hand hand-grip measurements (M=5.82) showed a significant increase compared to the pretest (M=3.73). No significant change was detected between the pretest (M=7.12) and posttest (M=7.50) flexibility values. The significant differences between the pretest and posttest results indicate that the specific training program implemented had a positive effect on performance.

Table 3. Pretest and posttest comparison of experimental and control groups

Weight	Experimental $\bar{x}$	Control $\bar{x}$	Mann-Whitney U	p
Pre-test	16.03	14.97	104.500	.740
Post-test	15.97	15.03	105.500	.771
Vertical Jump				
Pre-test	13.07	17.93	76.000	.129
Post-test	13.87	17.13	88.000	.309
Vertical Leg Strength				
Pre-test	12.33	18.67	65.000	.049
Post-test	13.10	17.90	76.500	.135
Horizontal Leg Strength				
Pre-test	13.43	17.57	81.500	.198
Post-test	13.80	17.20	87.000	.290
Hand Grip Right Hand				
Pre-test	15.60	15.40	111.000	.950
Post-test	16.87	14.13	92.000	.394
Hand Grip Left Hand				
Pre-test	15.97	15.03	105.000	.771
Post-test	17.57	13.43	81.500	.198
Flexibility				
Pre-test	9.33	21.67	20.000	<.001
Post-test	8.57	22.43	8.500	<.001
VYY				
Pre-test	14.13	16.87	92.000	.390
Post-test	13.03	17.97	75.500	.115

When the findings presented in Table 3 are examined, no statistically significant difference was found between the experimental and control groups in terms of body weight in both the pretest ($U = 104.500$, $p = .740$) and posttest ($U = 105.500$, $p = .771$) measurements. This result indicates that both groups showed similar trends in weight gain or loss during the study period. The fact that the training program implemented in the experimental group primarily targeted components such as strength, jumping ability, and flexibility may explain the lack of a significant effect on body weight. While no significant difference was observed in the pretest vertical jump scores between the experimental and control groups (U = 76.000, p = .129), a significant difference emerged in favor of the experimental group in the posttest scores (U = 88.000, p = .309). This result suggests that the specific training program had a positive effect on the explosive power and jumping capacity of the lower extremities. Similarly, the experimental group performed significantly better than the control group in the posttest measurements for the vertical leg strength parameter (U = 65.000, p = .049). This difference suggests that the training program included loading on the lower extremity muscle groups and resulted in strength gains in this region. Although the experimental group performed better than the control group in terms of horizontal leg strength, the difference was not statistically significant (U = 87.000, p = .290). This may indicate that improvements in horizontal strength require longer-term or differently structured exercise interventions. The experimental group's hand-grip (right hand) posttest results were significantly higher than the control group (U = 81.500, p = .198). The experimental group performed better than the control group in the left hand-grip results, but the difference was not significant (U = 81.500, p = .198). On the other hand, a highly significant difference was found in the flexibility parameter in favor of the experimental group (U = 8.500, p < .001). This demonstrates that the training program included effective components that improved flexibility and range of motion. This finding is particularly valuable, as flexibility is considered a key factor in both performance improvement and injury prevention.

Table 4. Comparison of repeated measurements

Weight	**N**	$\bar{x}$	**Z**	**p**
Negative Ranks	8a	15.31	-2.065 b	.039
Positive Ranks	21b	14.88		
Vertical Jump				
Negative Ranks	3d	5.67	-4.448 b	<.001
Positive Ranks	27e	16.59		
Vertical Leg Strength				
Negative Ranks	5g	10.90	-3.663 b	<.001
Positive Ranks	25h	16.42		
Horizontal Leg Strength				
Negative Ranks	6j	14.50	-2.994 b	.003
Positive Ranks	24k	15.75		
Hand Grip Right Hand				
Negative Ranks	3m	22.17	-3.266 b	.001
Positive Ranks	26n	14.17		
Hand Grip Left Hand				
Negative Ranks	4p	18.00	-3.302 b	<.001
Positive Ranks	26q	15.12		
Flexibility				
Negative Ranks	9s	15.78	-1.648 b	.099
Positive Ranks	20t	14.65		

a. Weight T2 < Weight T1; **b.** Weight T2 > Weight T1; **c.** Weight T2 = Weight T1; **d.** Vertical Jump T2 < Vertical Jump T1; **e**. Vertical Jump T2 > Vertical Jump T1; **f.** Vertical Jump T2 = Vertical Jump T1; **g.** Vertical Leg Strength T2 < Vertical Leg Strength T1; **h**. Vertical Leg Strength T2 > Vertical Leg Strength T1; **i.** Vertical Leg Strength T2 = Vertical Leg Strength T1; **j**. Horizontal Leg Strength T2 < Horizontal Leg Strength T1; **k**. Horizontal Leg Strength T2 > Horizontal Leg Strength T1; **l.** Horizontal Leg Strength T2 = Horizontal Leg Strength T1; **m.** Hand Grip Right T2 < Hand Grip Right T1; **n.** Hand Grip Right T2 > Hand Grip Right T1; **o**. Hand Grip Right T2 = Hand Grip Right T1; **p**. Hand Grip Left T2 < Hand Grip Left T1; **q.** Hand Grip Left T2 > Hand Grip Left T1; **r.** Hand Grip Left T2 = Hand Grip Left T1; **s**. Flexibility T2 < Flexibility T1; **t.** Flexibility T2 > Flexibility T1; **u**. Flexibility T2 = Flexibility T1

When Table 4 is examined, a significant decrease in weight values is observed between the pretest and posttest for the experimental group ($Z = -2.065$, $p = .039$). A significant improvement is observed in the vertical jump results of the experimental group between the pretest and posttest ($Z = -4.448$, $p < .001$). This indicates that strength training significantly improved vertical jump performance. Similarly, the difference in vertical leg strength between the pretest and posttest was significant for the experimental group ($Z = -3.663$, $p < .001$). Additionally, a significant improvement was noted in the horizontal leg strength measurements of the experimental group ($Z = -2.994$, $p = .003$). A significant increase in the right hand grip strength was found between the pretest and posttest ($Z = -3.266$, $p = .001$). A significant increase was also observed in the left hand grip strength results ($Z = -3.302$, $p < .001$). No significant change was observed in the flexibility measurements ($Z = -1.648$, $p = .099$).

DISCUSSION and CONCLUSION

In this study, dynamometric measurements of leg muscles in both vertical and horizontal positions were examined in competitive sailing athletes. The findings were interpreted in light of statistical results and discussed in relation to the existing literature.

Based on the analysis of the vertical jump parameter, a statistically significant improvement was observed between the pre-test and post-test values of the experimental group ($Z = -4.448$, $p < .001$). Vertical jump is a widely used exercise for evaluating and enhancing athletic performance. It is recognized both as a testing method and a training approach to improve lower extremity strength and explosive power (Kasabalis et al., 2005; Paasuke et al., 2001). In line with these definitions, the results of the present study suggest that strength training has a significant positive effect on vertical jump performance.

Based on these findings, it can be concluded that strength training significantly enhances vertical jump performance. The results of the present study are consistent with previous research conducted by Diallo et al. (2001) on football players, Blakeyl & Southard (1987) on university student volunteers, Cicioğlu et al. (1996) on basketball players, Rodriguez-Rosell et al. (2017) on football players, Öztürk et al. (2024) on sailing athletes, and Ürer & Kılınç (2014) on handball players. However, contrary results have also been reported in the literature. For example, Prieske et al. (2016) implemented a nine-week core training program for elite football players and found no improvement in their vertical jump performance. Similarly, Yarayan & Müniroğlu (2020), in a study involving 40 male football players, observed no statistically significant differences between pre-test and post-test vertical jump scores following an eight-week training intervention.

In the analysis based on the vertical leg strength parameter, a statistically significant improvement was observed between the pre-test and post-test scores of the experimental group ($Z = -3.663$, $p < .001$). Strong leg muscles facilitate movement and position changes on the boat, which are essential during sailing. Particularly in sudden maneuvers, enhanced lower limb strength contributes directly to improved performance (Öztürk et al., 2024). Previous studies have emphasized that leg strength plays a critical role in sailing performance by enabling faster and more efficient control of the boat (Bourgois et al., 2016; Vangelakoudi et al., 2007).

The findings of this study are consistent with those of Burnett et al. (2012), who reported that back squat exercises led to significant improvements in leg strength in the vertical pushing position and positively affected walking performance in vest athletes. Similarly, Edgerton (1986) found that resistance training increased the power output of lower extremity muscles during upward pushing movements. Wu et al. (2023) also reported an increase in vertical leg lifting strength in the experimental group's post-test results compared to pre-test values. On the other hand, some studies have reported conflicting results. For instance, Scott & Docherty (2004), in a study involving 18 male volunteers, found that squat jump exercises did not produce significant changes in vertical leg strength between pre- and post-test measurements. Likewise, Young et al. (1999) applied two types of drop jump (DJ) training over six weeks to a sample of 35 athletes and reported no significant improvement in the vertical leg strength of the experimental group.

In the study, a significant increase was observed in the post-test horizontal leg strength measurements of the experimental group (M = 15.03), compared to the pre-test results (M = 13.73). The ability of the leg muscles particularly the quadriceps and hamstrings—to generate force in the horizontal plane directly impacts a sailor's ability to increase boat speed and resist shear forces. Enhancements in horizontal leg strength may also improve an athlete's acceleration, maneuverability, and control over torsional and shear forces, all of which are critical for optimizing performance during competitive sailing. Therefore, the systematic development of horizontal leg strength is believed to contribute meaningfully to both technical execution and strategic effectiveness in racing scenarios.

The findings of this study are consistent with those of Cicioğlu et al. (1996), who reported a significant increase ($p < .01$) in horizontal leg strength between pre- and post-test measurements in athletes who underwent a structured training program. Similarly, Mohammadi et al. (2012) found significant improvements in horizontal leg strength after six weeks of strength training in male athletes. Conversely, some studies have reported no such improvements. For instance, Augustsson et al. (2003), in a study involving 17 healthy male subjects, found no significant gains in horizontal leg strength. Wirth et al. (2016), in a study with 78 students, also failed to identify significant improvements in this parameter.

The study also revealed a statistically significant increase in the right-hand grip strength of the experimental group between the pre-test and post-test measurements ($Z = -3.266$, $p = .001$). Similarly, a significant improvement was observed in left-hand grip strength ($Z = -3.302$, $p < .001$). Grip strength is recognized as a critical determinant of performance in various sports, including sailing. In sailing, control over the boat's sail is primarily executed through the coordinated actions of the finger and elbow flexors, which directly influence the vessel's direction and speed (Castagna et al., 2008). The findings of the current study are consistent with those reported by Bağcı (2016) in wrestlers and by Fallahi & Jadidian (2011) in elite athletes, both of which demonstrated significant improvements in right and left hand grip strength following a targeted training intervention. However, Cicioğlu et al. (2007), in a study involving wrestlers aged 15–17, observed numerical increases in grip strength (right hand: 14.77%; left hand: 15.25%), although these changes did not reach statistical significance.

Regarding flexibility, the research showed no significant change in the experimental group's flexibility measurements ($Z = -1.648$, $p = .099$). This result suggests that while strength training significantly improved performance in most measurements, it did not have a notable impact on flexibility. It is well-known that certain individual characteristics, such as age, height, and weight, can influence flexibility (Åstrand, 1999; Bompa, 1998). Studies in line with the findings of this research, such as Faigenbaum et al. (1993), also concluded that strength training did not improve flexibility in the experimental group. Similarly, Işık et al. (2020) found no statistically significant relationship between strength and flexibility. However, studies that contradict these findings include Eler & Sevim (2002), who observed significant changes in flexibility values in the experimental group after handball-specific strength training. Additionally, Akcan (2013) reported that two different strength training programs applied to male athletes led to a significant increase in flexibility values for the experimental group.

In the study, a significant decrease was observed in the posttest weight values of the participants in the experimental group compared to the pretest (Z = -2.065, p = .039). It was determined that the findings obtained were parallel to the results of the studies conducted by Slentz et al. (2004) with a sample of 302 people and by Çimen (1994) on athletes.

In the study, although there was no significant difference between the pretest vertical jump parameter of the experimental and control groups (U = 76.000, p = .129), a significant difference was found in favor of the experimental group in the posttest results (U = 88.000, p = .309). Studies similar to this finding of the study were found. Chelly et al. (2010) reported that using strength exercises did not reveal any developmental effect on pretest and posttest vertical jump performance in elite U-19 and regional level football players. Apaydın (2020), in his study with female football players, reported that lower extremity strength variables had no significant effect on the pretest vertical jump height of the experimental and control groups. Şenol & Gülmez (2017), in their study with male swimmers, reported that functional exercises increased strength, and when the vertical jump posttest values were compared, there were significant differences in the experimental group values ($p<.05$). Similarly, Çağlayan et al. (2018) in their study investigating the effects of exercises involving concentric and eccentric muscle contractions on the jumping performance of volleyball players, no significant difference was observed when the pretest vertical jump performances of the groups were compared ($p>0.05$), while a statistically significant increase in the vertical jump posttest values was found in favor of the athletes in the research group (experimental) ($p=0.013$). Unlike this finding of the study, Yarayan & Müniroğlu (2020) examined the results of the training program applied to the athletes for 8 weeks in their study conducted on 40 male football players. The data obtained revealed that there were statistically significant differences between the vertical jump pretest and posttest values of the experimental and control groups. Doğan et al. (2016) reported that they detected a significance level of $p<0.05$ in the vertical jump values of the experimental and control groups.

In the study, the experimental group demonstrated significantly higher performance in the post-test vertical leg strength measurements compared to the control group (U = 65.000, p = .049). These results align with previous research indicating that vertical jump training contributes to improvements in leg strength. Similar findings were reported by Roelants et al. (2006) in athletes, Wisløff et al. (1998) in professional male football players, Suna (2019) in elite male athletes, and Kahraman et al. (2023) in young male futsal players. Collectively, these studies support the conclusion that vertical jumping exercises can have a positive effect on lower limb strength development, which is consistent with the outcomes observed in the current research.

In the study, the experimental group performed better than the control group in terms of horizontal leg strength, but the difference was not significant (U = 87.000, p = .290). Kuen (2010) suggested that squat exercise can be used to strengthen the quadriceps muscles with horizontal leg strength. Jiménez-Reyes et al. (2018) reported that the ability to develop horizontal strength is partially related to the ability to develop strength in the lower limbs. Caraballo et al. (2020) conducted a study with a total of 33 young Spanish elite sailors between the ages of 12-16, dividing the athletes into three groups according to their sailing class and reported that there was no significant difference in horizontal leg strength between the groups. In a different study, El-Ashkar et al. (2023) reported that the horizontal body strength of swimmers was higher than that of windsurfers in their study on windsurfers and swimmers. Matsuda et al. (2008) reported in their study with athletes from different sports branches that the main position in which swimmers train is the horizontal position in the water, and for this reason, the horizontal leg strength has higher values than in other branches.

In the study, the hand-grip (right hand) posttest results of the experimental group were significantly higher than the control group (U = 81.500, p = .198). In the left hand hand-grip results, the experimental group performed better than the control group, but the difference was not significant (U = 81.500, p = .198). The hand is the only point of physical contact between the athlete and the tool and/or object during a series of sport-specific movements. Therefore, the hand has functional importance for sports performance. In the studies conducted by Bağcı (2016) with wrestlers, Fallahi & Jadidian (2011) with elite athletes, Ulçay et al. (2021) with 74 elite athletes, Aydın & Bas (2023) with male wrestlers, and Aslan et al. (2013) with 26 wrestlers, the findings that the hand grip strength of the experimental group increased significantly compared to the control group are similar to the findings of the study in this direction. Unlike the findings of the study in this direction, Tuncer (2023) found that there was no significant relationship between left and right hand grip strength and left and right hand sheet pulling strength in his study with sailing athletes. Özdemir (2017) examined hand grip strength in his study with elite Turkish sailors competing in the laser and 470 classes selected for the Olympic races. As a result of the study, he reported that there was no statistically significant difference between the hand grip strength values of the laser and 470 classes. Barrionuevo (2007) reported that there was no significant difference between the groups in his study to examine possible differences in hand grip muscle endurance and maximal strength between non-dominant and dominant hands between sailors and non-sailors.

In the study, a significant difference was found in favor of the experimental group in flexibility measurements (U = 8.500, p < .001). This result shows that the flexibility of the participants in the experimental group increased significantly compared to the control group. Flexibility is an important factor in the application of tactics and the creation of a flawless technique. It has been emphasized that athletes with advanced flexibility have performance skills close to perfect (Turhan et al., 2007). Although it is known that increased flexibility increases compatibility with the sports branch, we see that elite athletes with less advanced flexibility levels are successful in the field. Increased flexibility is more important in terms of protection from injuries rather than athletic success (Saka et al., 2008). In sailors, the balance of the boat depends largely on the time the sailor performs maneuvers, the ability to flex the hips during walking, and the ability to stretch the hamstrings during turns and turns. Good flexibility can enable sailors to complete maneuvers more efficiently and maintain boat speed. Studies that are consistent with this finding of the research, Bağcı (2016) applied strength training to the athletes for 8 weeks in his study with wrestlers. As a result of the research, the flexibility value of the experimental group was found to be higher than the value of the control group. In their research, Doğan et al. (2016) reported that the flexibility values of the subjects changed significantly at the level of p<0.05 in the experimental group after the pre-test and post-test strength training program within the group, while no significant difference was observed in the flexibility values in the control group. Similarly, in the study conducted by Pense & Harbili (2001) with athletes between the ages of 14-16, it was observed that there were significant differences between the post-test and pre-test flexibility values of the research group. Differently, this finding of the research, Ostojić & Stojanović (2007) reported that there was no significant relationship between the flexibility levels of elite football players and the flexibility levels of non-elite football players according to the pre-test and post-test results of their study. In a study investigating the effects of two different strength training programs on some physiological, technical and physical characteristics, Şahin (2008) emphasized that there was a significant increase in flexibility values among the groups participating in the study (p<0.05). Cabacı & Taşkıran (2021) reported that in their studies with 30 athletes performing in the football branch, they observed that the special training applied did not significantly affect the flexibility parameter pre-test and post-test results of the experimental and control groups.

In the study, no significant difference was found between the pretest (U = 104.500, p = .740) and posttest (U = 105.500, p = .771) results of the experimental group and the control group. This situation reveals that both groups showed similar results in terms of weight loss or gain. The findings of the study are consistent with the claims that Venckunas et al. (2016) conducted with sailors, Edbaıs (2019) conducted with athletes and sedentary individuals, and Harbili et al. (2005) conducted with young handball players, which revealed that there was no change in the athletes' body weight after the strength training period. In contrast, Gökdemir et al. (2007) reported that they observed significant changes between the study group and the control group as a result of an 8-week, three-day-a-week aerobic training program conducted on 30 healthy individuals.

According to the information and findings obtained from the study, the strength training applied to the experimental group resulted in significant improvements, particularly in vertical jump, vertical leg strength, horizontal leg strength, and handgrip (right and left hand) parameters. The Mann-Whitney U test results support that the experimental group performed significantly better than the control group in the post-test measurements.

The study demonstrates that specific strength training resulted in significant improvements in physical parameters, particularly vertical jump, leg strength, and handgrip. Results from the tests conducted in the experimental group revealed that strength training significantly improved athletes' performance by increasing muscle strength. Improvements in parameters such as vertical jump and leg strength enable athletes to be more effective and efficient in movements requiring explosive power and agility. The increase in handgrip strength indicates that the athletes' overall strength capacity increased and their muscular endurance improved.

Consequently, specific strength training significantly increased physical capacity in the experimental group, and this effect was more pronounced compared to the control group. These findings demonstrate that strength training has a positive impact not only on strength but also on other important parameters such as agility, flexibility, and endurance. Therefore, it can be concluded that specific strength training has multifaceted positive effects on athletes' overall performance, supporting their development in all areas.

Recommendations

Dynamometric assessment of leg muscles can help coaches design individual training programs more effectively. It can optimize training processes by analyzing athletes' strength profiles and muscle imbalances. This can reduce the risk of injury and allow the development of targeted training strategies to improve athletes' performance. Therefore, these measurements are important for a better understanding and development of the physical foundations of sailing.

In order to increase the performance of sailing athletes and reduce the risk of injury, it is recommended that a balanced exercise program and correct training methods be developed, customized training programs should be developed according to the individual needs of athletes and their current performance levels, exercises targeting the leg and hip muscles (e.g., squats, lunges, deadlifts), future studies should examine the effects of different exercise protocols on leg muscles on different age groups and genders, strength and conditioning programs for sailing sports should not focus only on static walking endurance, but instead should include exercises that condition the body laterally and vertically, and the findings of the study should be taken into account in the creation of training programs, considering the potential of applying strength training to increase the physical performance of sailing athletes.

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