Thus, it should be noted that holding events is an effective incentive for systematic sports, promotion of the development of physical culture and sports in the country. Raising the level of students' motivation to play sports, participate in competitions, thirst for victory, increase work capacity, mood and stress resistance.

Events are used to prepare for the next, more important competition; selection, detection of sports data and sports training; quality control of educational and training work; promotion of sports, promotion of ideas of physical education and sports. Receiving bonuses in the form of victories and additional points for receiving a scholarship. Encouraging a physically developed, healthy and immune-resistant organism of those doing the exercises.

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PHYSIOLOGICAL AND DYNAMOMETRIC CHARACTERISTICS OF SAILORS IN THE ILCA YACHT CLASS: REVIEW

Sailing, as a sport, encompasses a wide array of boat classes and racing formats, demanding comprehensive physical fitness and rigorous training regimens. This study delves into the physiological and dynamometric characteristics of yachting techniques and effective training methods for sailors to optimize their performance. The research combines diverse methodologies, including literature analysis, physiological measurements, and the evaluation of methodological quality using the Methodological Index for Non-Randomized Studies (MINORS). By leveraging these approaches, the study sheds light on the intricate interplay between environmental factors, physiological demands, and the performance of sailors in competitive sailing contexts. The findings emphasize the importance of tailored training methodologies in enhancing athletes' physical capabilities and improving their competitive edge in sailing competitions.

Keywords: ILCA, sailing, hiking; physical requirements; electromyography

Савченко К. Ю., Русанова О. М. **Фізіологічні, динамометричні характеристики яхтсменів у класі яхт ilca: огляд літературних джерел.** *Вітрильний спорт охоплює широкий спектр перегонів в різних класах яхт що вимагають високого рівня фізичної підготовленості спортсменів. З використанням у тренувальному процесі режимів навантаження високої інтенсивності. Це дослідження висвітлює фізіологічні та динамометричні особливості вітрильного спорту та ефективні методи тренувань яхтсменів з метою підвищення спеціальної працездатності. Для вирішення поставлених завдань дослідження використовувалися різноманітні методи: включаючи аналіз літератури, фізіологічні методи дослідження, квизначення та оцінювання методологічної якості наукових публікацій за допомогою Методологічного індексу нерандомізованих досліджень (MINORS). Використовуючи ці методи за результатами дослідження систематизовані фактори вливу навколишнього середовища, фізіологічних характеристик на результатами яхтсменів в умовах змагальної діяльності. Результати досліджень доводять важливість індивідуалізованих тренувальних програм для підвищення рівня розвитку фізичних якостей та їхньої конкурентоспроможності.*

Ключові слова: *ILCA, вітрильний спорт, відкренювання, фізичні вимоги, електроміографія*

IntroductionGiven the nuanced interplay between wind forces and the mechanics of yacht maneuvering, there emerges a compelling avenue for future research that delves into the intricacies of competitive sailing (Schutt, 2017). This calls for a comprehensive exploration utilizing contemporary research methodologies tailored to examine the impact of wind strengths and different course conditions on the load distribution experienced by sailors. Such an investigation holds promise in deepening our understanding of the multifaceted challenges inherent in competitive sailing, thereby fostering advancements in training techniques and performance optimization strategies. (Pan & Sun, 2022)

Studies by (Legg, Mackie & Smith, 1999; Winchcombe, Goods, Binnie, Doyle, Fahey-Gilmour & Peeling, 2021; Callewaert, Geerts, Lataire, Boone, Vantorre & Bourgois, 2013; Blackburn, 2000) have shed light on the escalating intensity of

loads experienced during both training and competitive sailing activities, particularly within the realm of ILCA dinghy racing. Furthermore, investigations led by (Callewaert, Geerts, Lataire, Boone, Vantorre & Bourgois, 2013; Blackburn, 2000) have underscored the pivotal influence of varying wind forces on the loads encountered during yacht openings, further complicating the dynamics of competitive sailing.

Competitive sailing in dinghies, particularly within the International Laser Class Association (ILCA), has garnered significant attention in recent research conducted by (Legg, Mackie & Smith, 1999; Winchcombe, Goods, Binnie, Doyle, Fahey-Gilmour & Peeling, 2021; Callewaert, Geerts, Lataire, Boone, Vantorre & Bourgois, 2013; Blackburn, 2000). This body of research emphasizes the crucial role of the opening technique in achieving successful competitive performance. Essential to this process is the physical conditioning of key muscle groups involved in enduring the isometric contractions during this maneuver, including the quadriceps and abdomen, alongside the hamstrings, lateral, lumbar, and back muscles, as well as the joints of the lower body (ankle, knee, and hip) (Bourgois, Callewaert, Celie, De Clercq & Boone, 2016).

Methods. This manuscript was developed and formatted in accordance with the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Data Sources and Search: A comprehensive search strategy was devised to identify all pertinent studies assessing performance in sailing. Our systematic search encompassed the Web of Science, PubMed, and Google Scholar databases, with the publication period limited to 1979 through August 2023. Inclusion and exclusion of studies were determined by two researchers through collaborative consultation, employing specific search terms and Boolean operators ("sailing" OR "laser" OR "quadriceps"). Additionally, referenced studies were manually scrutinized to meet our inclusion criteria.

Study Selection: The criteria for inclusion in our analysis required that the study must measure the ratio as an outcome, and the participants must represent dinghy sailing. We only included studies in the English language. Excluded studies comprised systematic reviews, meta-analyses, study protocols, books. No age restrictions were imposed on the participants, encompassing both male and female respondents, including elite and non-elite athletes.

Data Extraction and Quality Assessment:

After meticulous selection, two researchers jointly extracted data, documenting key variables such as authors, publication year, participant characteristics, and gender. To assess the quality of the included studies, the Methodological Index for Non-Randomized Studies (MINORS) was employed. Any discrepancies were resolved through consensus, with a MINORS score of ≥10 serving as the inclusion criterion.

Results. In the studies of recent years, the authors have presented the determinants and prognostic criteria for the effectiveness of yachtsman's competitive activity (table 1).

The investigation of the hiking technique reveals it to be a bilateral and multi-joint submaximal quasi-isometric movement employed by dinghy sailors to optimize boat speed and prevent capsizing (Bourgois, Dumortier, Callewaert, Celie, Capelli, Sjogaard, Clercq & Boone, 2017). A higher level of sailing proficiency is linked, in part, to a reduced rate of neuromuscular fatigue during hiking, which is strongly correlated (approximately 60%) with increased maximal isometric quadriceps strength.

In support of the "Quasi-isometric" concept, Spurway (2007) conducted an in-depth review of studies on the physiology of hiking. His findings indicate unambiguous physiological markers, including elevated heart rate beyond oxygen supply requirements, heightened blood pressure (especially diastolic), and pronounced hyperventilation, all suggestive of the isometric nature of the movement in sailors. They also pointed out the interest that many authors had created (Blackburn, 1994; Vangelakoudi, Vogiatzis & Geladas, 2007) surrounding the knowledge of the produced effort intensity, analyzing parameters like VO2, lactate and blood pressure amongst others or blood flow (Cunningham & Hale, 2007) in order to demonstrate that this position is not only static or isometric but also dynamic. Moreover, they make reference to studies that analyze the energetic system involved in the technique (Cunningham & Hale, 2007). The studies have shown that it is almost a completely dynamic movement that the aerobic system uses. This goes against what was previously thought when it was considered a static and anaerobic movement.

The use of physiological and EMG indicators has been instrumental in understanding the demands placed on the body during this activity **(**Callewaert, Geerts, Lataire, Boone, Vantorre & Bourgois, 2013; Vangelakoudi, Vogiatzis & Geladas, 2007**)**.

Research suggests that physical fitness and muscular strength significantly impact the performance of Olympic class sailors (Bojsen-Møller, Larsson, Magnusson & Aagaard, 2007). Additionally, indicators such as strength- and speed-oriented motor coordination, as well as isometric knee-extension strength endurance, are crucial in assessing the performance of young optimist and dynamic youth sailors (Callewaert, Boone, Celie, De Clercq & Bourgois, 2015).

Notably, maximal isometric quadriceps strength plays a pivotal role in determining sailing performance and mitigating neuromuscular fatigue during upwind sailing emulation (Bourgois, Callewaert, Celie, De Clercq & Boone. 2016). Stepwise regression analysis further suggests that better sailing proficiency is significantly associated with a lower decrease in mean power frequency (MPF), which is itself predicted by higher maximal isometric quadriceps strength.

The research incorporated various protocols including those established by Blackburn in 1994 and 2000, and the ones devised by Bahchevanski and Levski in 2017, to comprehensively analyze the physiological and electromyographic (EMG) responses associated with hiking techniques. Moreover, the study was complemented by the pioneering work of a mathematical model proposed by Putnam in 1979, which provided insights into the various positions involved in sailing dinghy hiking.

Table 1

Systematized data are presented in the table below

M. Bernardi et al. (1990)	We studied the isometric efforts of MVC. yachtsmen in offshore racing, which can be attributed to aerobic exercise

S. Legg et. al. (1997)	31 athletes of the elite New Zealand Olympic sailing team (including Laser) and 108 athletes from other countries: New Zealanders had greater strength endurance in the shoulders and arms, but less in the legs
H. Mackie et. al. (1999)	11 New Zealanders in the Europe, Laser, Finn and 470 classes; the effort; in the opening belt reached 73-87% of predMVC, with peak forces exceeding 100% predMVC
S. Legg et. al. (1999)	The 19 elite New Zealanders spent the most time on opening (29-66%). The longest continuous activity: opening with trimming on maneuvering (9-18 seconds)
P. Cunningham, T. Hale (2007)	6 elite men in the Laser class; age 19.7 years, s = 1.82; height - 181 centimeters, s = 0.03; body weight - 78.0 kilograms, s = 4.1 La peak, mmol·l^{-1} - 4.47 mmol·l^{-1} (at 30 minutes of simulated exercise) Heart rate, beats-min^{-1} - 156 beats-min^{-1}; VO2 peak, l-min^{-1} - 4.32 l-min^{-1} (s ¼ 0.16) Simulation of opening: VO2, l·min^{-1}- 2.51 l·min^{-1} (s ¼ 0.24) VO2 peak, l·min^{-1}- 2.58 l·min^{-1} (s ¼ 0.25) for 5 min
A.Vangelakoudi et. al. (2007)	In 8 nationally ranked Greek athletes; isometric endurance (160 s, s = 50) and opening time (1381 s, s = 1354) were (P < 0.05) longer than in 8 amateurs (101 s, s = 29 and 565 s, s = 367,); and fatigue index: (42%, s = 5), and (49%, s = 6), respectively
N. Spurway (2007)	The MVC measurement of isometric endurance indicates that physiological, not just volitional, limits are reached during opening
M. Callewaert et. al. (2013)	10 boys of the national level in the Laser Radial class: age 18.5 years ± 2.0; height 180.9 centimeters ± 4.7; body weight 72.3 ± 4.8 kilograms, body fat (%) 13.8 ± 3.0 Heart rate, beats-min^{-1} - 179 ± 9 beats·min^{-1}; peak power, W - 336 (± 33) W La peak, mmol·l^{-1} - 11.6 (± 1.5) mmol·l^{-1} VO2peak, ml·min^{-1}·kg^{-1} - 57.1 ± 4.2 ml·min^{-1}·kg^{-1} 72.3 ± 4.8 kg
J. Bojsen-Møller et. al. (2015)	Opening yachts of Olympic classes requires the ability to withstand prolonged quasi-isometric contractions, significant maximum strength, especially in the knee extensors, hip flexors, and abdominal and lower back muscles
S. Lopez et. al. (2016)	9 Optimist class sailors: age 12.7 ± 0.8 years, height 153 ± 9 centimeters, 41 ± 6 kg during training on the water 46-48% of VO2peak
R. Buchardt et. al. (2017)	MVC and hMVC were measured in 12 national-level athletes, strength decreased in both 10-minute periods (430 ± 131 vs. 285 ± 130 N, P < 0.001 and 369 ± 74 vs. 267 ± 97 N, P < 0.001, respectively) and a correlation (r2 = 0.619, P < 0.01) was observed between hMVC and regatta results
Bourgois J.G. et. al. (2017)	EMG during opening: quadriceps are engaged at an intensity of 30-40% of MVC, sometimes exceeding 100%. Better sailing level is partially determined by a lower rate of neuromuscular fatigue during hiking and for ≈60% predicted by a higher maximal isometric quadriceps strength
I. Caraballo et. al. (2019)	29 athletes in the Laser class - 17 ± 3 years old; height 172.4 ± 6.4; kg 66.4 ± 10.1; BMI 22.3 ± 3.3; body fat % 23.2 ± 12.1; Seventy-six percent of the performance can be estimated using the following equation: 311.971 + (−1.089 × height) + (−1946 × age) + (−1.537 × thigh length). Performance in the Laser class will be determined by the tactics (age and sailing experience) and the morphological

	characteristics of the sailor (height and sitting height).
C. Winchcombe et. al. (2021)	11 elite athletes in the class ILCA (age: 23.2 ± 3.4, weight: 82.6 ± 2.3, height: 182 ± 5) Heart rate, beats per minute^{-1}: on maneuvering: 159 ± 11 beats-min^{-1} full courses: 147 ± 15 bpm-1 gyroplane: 156 ± 16 bpm
G. Erkan et. al. (2021).	instant monitorization of blood pressure parameters during the hiking position is critically important while evaluating the performance
D. Pan et. al. (2022)	38 Chinese yachtsmen in the Laser class, participants of the National Championship: Age (years) 20.55 ± 3.8; Height (cm) 182.08 ± 5.04; Weight (kg) 76.26 ± 4.69; BMI 23.01 ± 1.34 The regression equation is possible to explain 65.5% of the performance of the sailors in Laser = 90.963-1.33 × sailing experience-0.461 × bench press-0.018 × cycling peak power out

Many studies have pointed to physical fitness as a crucial factor in successful racing that determines the efficiency of hiking (Erkan, Onur, Caner & Tolga, 2021; Bourgois, Dumortier, Callewaert, Celie, Capelli, Sjogaard, Clercq & Boone, 2017). This has been proven, among other things, by earlier studies (Aagaard, Beyer, Simonsen, Larsson, Magnusson & Kjaer, 1998; Tan, Aziz, Spurway, Toh, Mackie, Xie, Wong, Fuss & Teh, 2006).

Better sailing level is partially determined by a lower rate of neuromuscular fatigue during hiking and for ≈60% predicted by a higher maximal isometric quadriceps strength (Bourgois, Dumortier, Callewaert, Celie, Capelli, Sjogaard, Clercq & Boone, 2017).

It has been shown that covering the distance against the wind is the most physiologically demanding part of the race (Winchcombe, Goods, Binnie, Doyle, Fahey-Gilmour & Peeling, 2021). It has been proven that sailing the course on different courses to the wind and at different wind speeds gives different boat speeds (Pan & Sun, 2022).

Wind intensity applies an external stimulus to the sailor, thereby contributing to the internal load on the sailor. (Walker, 2020).

Therefore, an interesting area of research in the future may be the study of competitive activity using modern research methods and a modern methodology appropriate to this study. Which will involve studying the load on each course depending on the course in relation to the wind and its different strength.

Conclusions.

The article highlights the physiological and dynamometric features of sailing and effective methods of training yachtsmen in order to improve special performance. These methods systematize the factors of environmental influence, physiological characteristics on the results of yachtsmen in competitive activity. The results of the research prove the importance of individualized training programs for improving the level of development of physical qualities and their competitiveness.

Prospects for further research

Necessary implantation of provisions in the process of improving the physical training of qualified athletes in sailing class Laser yachts

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