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Effects of Functional Training on Physical Fitness and Navigation Skills of Maritime Students

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Abstract
Physical fitness and navigation skills are the keys for seafarers during maritime work and need to receive consideration for maritime students. This paper introduces a new training method that is functional training, into the physical education curriculum of maritime colleges. The functional training is expected to influence indirectly the physical fitness and navigation skills through its effects on maritime students. The research methods include literature, experiment and mathematical statistics. In the experiment, 66 maritime students in a maritime college in China have been chosen and divided into experimental group and reference group. During the 16-week experiment, the experimental group has been adopted functional training, while the reference group remains unchanged. The basic physical fitness, navigation skills and functional movement screen (FMS) scores of the experimental group before and after experiment have been evaluated, and then analyzed using SPSS27.0 software. There is no significant difference between the experimental group and the reference group in 50 m running, 1000 m running and solid ball throwing ($P>0.05$), but the experimental group has a greater improvement in performance. While, there are significant differences in rope throwing, 500 m swimming and FMS scores ($P<0.05$). The results show that the functional training has a good effect on improving the physical fitness and navigation skill level of maritime students, and would be potential in the physical fitness assessment and training planning of maritime students.

Keywords: Functional training, maritime students, physical fitness, navigation skills

1. Introduction

In recent years, the COVID-19 pandemic has posed a significant threat to human health, particularly impacting college students and exacerbating concerns regarding their physical and mental well-being [1]. Evidence suggests that the pandemic-induced disruptions have led to a decline in physical fitness among college students, with notable decreases in key indicators such as physical function, speed, endurance, and strength [2]. For instance, data from the Eighth National Student Physical Fitness and Health Survey in 2019 revealed that only a small percentage of students met the physical health standards, with minimal improvement observed among older students [3]. One study conducted at a maritime university in China indicated that a majority of maritime students exhibited suboptimal physical fitness levels, underscoring the need for targeted interventions [4].

The maritime industry presents unique challenges for its professionals, particularly in terms of physical demands and environmental hazards. Maritime students are required to possess exceptional physical and mental attributes, along with proficiency in water sports and navigation skills, to navigate the rigors of their future careers [5]. Despite the critical importance of physical fitness in maritime education, the existing educational framework in China faces several challenges, including outdated teaching methods, inadequate training content, and a lack of specialized programs [6]. Furthermore, the implementation of quasi-military management systems in some maritime colleges has not adequately addressed the core educational objectives related to physical fitness and navigation skills development [7].

To address these shortcomings, there is a pressing need for the reform and modernization of maritime physical education programs in China. Functional training, a methodology that targets specific weaknesses through tailored exercises, has shown promise in enhancing performance and reducing injury risks in various sports disciplines [8, 9]. However, its application in maritime education remains limited, presenting an opportunity for innovation and improvement [10]. Aligning with the international standards outlined in the STCW78/95 convention, the integration of functional training into maritime physical education holds potential for optimizing the overall fitness and skill levels of maritime students [11].

This study aims to investigate the efficacy of functional training in improving the physical fitness and navigation skills of maritime students through comparative experiments. By analyzing the current landscape of physical education and identifying areas for improvement, this research seeks to evaluate the feasibility and benefits of incorporating functional training into maritime education curricula. Ultimately, it is anticipated that such interventions will contribute to the holistic development of maritime students, better preparing them for the challenges of the shipping industry.

2. Literature Review

Currently, among the 14 undergraduate nautical colleges in China, the majority offer physical education courses that align with conventional student curricula, falling short of meeting the specialized training needs of maritime students. In contrast, Dalian Maritime University, Shanghai Maritime University, and Jimei University have pioneered maritime-specific physical education programs, focusing primarily on swimming supplemented by traditional ball sports like football, basketball, and volleyball. However, these initiatives still lack specialized maritime training components. Despite investments in reforming maritime physical education across colleges and universities, the outcomes remain marginal, with a significant proportion of maritime students failing to meet industry requirements [12]. Given these challenges, there is a critical need to overhaul maritime physical education courses by fostering a proactive sports attitude among students and introducing advanced training concepts and methodologies, particularly in navigation skills. This strategic approach aims to enhance both the physical fitness and practical navigational abilities of maritime students, ultimately striving to cultivate high-caliber navigation professionals capable of meeting the rigorous demands of the shipping industry.

Functional training has garnered significant attention in competitive sports and athletic rehabilitation, yet its application remains underexplored in maritime physical education. Originating from rehabilitation medicine in the United States, functional training was initially designed to aid patients in gradually restoring basic physical mobility. According to perspectives from the National Sports Medicine, functional training involves training the human movement chain, encompassing multidimensional movement trajectories through specialized exercises focused on acceleration, deceleration, and stability [13]. Gray Cook, a pioneer in functional training, emphasizes its core principle of identifying common elements across diverse movements [14]. Dong Delong and Wang Weixing further categorize functional training into endurance, strength, and speed training variants, aiming to address individual athletes' specific deficiencies comprehensively [15]. Additionally, Li Danyang highlights functional training as a form of resistance training that enhances strength and body balance using body weight and emphasizing proper posture during exercises [16]. In essence, functional training represents a paradigm shift from traditional training methods by simulating everyday activities and specific athletic movements. Despite its transformative potential, the integration of functional training into maritime physical education remains an untapped opportunity. This study proposes to explore the implementation of functional training within maritime education, aiming to enhance students' physical fitness and navigation skills. By leveraging its holistic approach and tailored exercises, functional training could play a pivotal role in preparing maritime students for the rigorous demands of their future careers.

In general, functional movement screening forms the cornerstone of functional training. This process involves assessing the motor control, stability, flexibility, and coordination deficiencies of research subjects through specific screening protocols. Based on the outcomes of these assessments, targeted functional training programs are designed to enhance overall physical function. The Functional Movement Screen (FMS), originally developed by Gray Cook in 1998 for high school and college athletes in Virginia, has evolved into a streamlined and quantifiable assessment tool following continuous refinement and practical application [17]. The FMS comprises seven standardized test items, including deep squats, hurdle steps, inline lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability tests. Notably, certain tests such as shoulder mobility, trunk stability push-up, and rotary stability incorporate pain-free movements to assess compensation and asymmetry in flexibility, balance, stability, and agility [18]. By quantitatively scoring performance across these test items, the FMS enables efficient identification of areas requiring corrective training interventions. Through targeted correction and functional exercise screening, the FMS aims to reduce the incidence of sports injuries among athletes and individuals, ultimately enhancing their overall physical preparedness.

Maritime students require proficiency in a range of essential sports skills rather than highly specialized ones. Functional training advocates for standardizing navigation majors by establishing a multi-sport model and introducing scientific training concepts. Fundamental navigation skills such as swimming and rope handling necessitate core physical attributes like flexibility, balance, stability, and agility. Functional training is instrumental in preventing sports injuries and enhancing both physical fitness and navigation prowess. Within maritime physical education, the FMS offers a quantitative evaluation method that assists educators in accurately assessing students' foundational physical fitness. Utilizing FMS results, educators can develop scientific and tailored functional training programs to enrich teaching content and effectively enhance students' athletic performance and physical well-being. This approach aligns with the objectives of cultivating high-quality maritime professionals and advancing reforms in maritime physical education courses.

3. Methodology

3.1 Literature research method

The theoretical framework of this study primarily relies on a

comprehensive literature review approach. Drawing from diverse sources including scholarly articles, journals, newspapers, magazines, and online databases, such as CNKI and Google Scholar, extensive knowledge was gathered on functional training and nautical sports curricula. This literature review spanned disciplines encompassing sports training, sports science, education, physical education, and statistics. The review aimed to explore the intersection between functional sports training and the enhancement of physical fitness and navigation skills among maritime students. By synthesizing existing research, this paper establishes a robust theoretical foundation for the integration of functional sports training into nautical sports curricula.

3.2. Statistical analysis

This study utilized SPSS 27.0 software as the primary tool for data analysis and statistical processing of relevant indicators from all test items. Comparative analysis was conducted between the experimental group and the reference group, both before and after the experiment.

3.3. Experimental method

This study employs a comparative experimental approach to assess the effectiveness of different training methods among two groups of students. The primary objectives include evaluating the impact of functional training on students' physical fitness and navigation skills in maritime education. Additionally, the study aims to explore the practical applications of functional training within the maritime physical education curriculum, offering enhanced instructional strategies. The experimental design incorporates a selection of physical fitness test indicators aligned with the latest National Student Physical Health Standards, encompassing assessments such as the 50-meter sprint, 1000-meter run, and shot put. The FMS is utilized to evaluate movement quality through standardized tests like deep squats, hurdle steps, shoulder mobility, and others, scored based on predefined criteria. Furthermore, navigation skills are assessed based on established standards, including a 500-meter swim and rope throwing.

3.4. Participants

This study focuses on assessing the impact of functional training on the physical fitness and navigation skills of maritime students. A total of 66 sophomore students majoring in navigation technology from a maritime college in China were randomly selected for the experiment, with 32 students assigned to the experimental group and 34 to the reference group. Given the specific requirements and gender considerations of seafaring professions, all participants were male and screened to ensure they were not obese, malnourished, or suffering from conditions such as heart failure or physical disabilities that would hinder exercise. To maintain experimental accuracy, students were instructed to maintain consistent extracurricular exercise levels prior to the experiment, ensuring comparable exercise frequency and intensity between the experimental and reference groups. Over a period of 16 weeks and under the supervision of qualified instructors, the experiment measured the subjects' physical performance, navigation skills, and FMS results. The findings were subsequently analyzed to assess the effectiveness of functional training in enhancing the targeted outcomes among maritime students.

4. Experimental Results

4.1. Effect of Functional Training on Physical Fitness

Speed quality pertains to the body's ability to move swiftly, reflecting muscle strength and coordination [18]. Table 1 reveals that initially, there was no significant difference in the 50-meter sprint between the experimental and reference groups, as indicated by a P-value above 0.05. However, following 16 weeks of instruction, the average 50-meter sprint time in the experimental group improved by 0.57 seconds, achieving statistical significance with a P-value below 0.05. In contrast, the reference group saw a modest improvement of 0.16 seconds, which was not statistically significant compared to the experimental group. These findings underscore the significant enhancement in lower limb explosive power due to functional training, surpassing traditional methods. This improvement is crucial for maritime students who may need to swiftly move heavy objects or engage in rescue operations during emergencies aboard ships.

Table 1: Comparison of 50 m run performance of students in two groups before and after experiment

	Experimental group (s)	Reference group (s)	T	P
Before experiment	8.77±1.09	8.81±1.03	–0.182	0.856
After experiment	8.20±1.03	8.65±1.03	–1.684	0.098
T	2.056	0.626		
P	0.044*	0.534		

Endurance quality refers to the ability to sustain exercise intensity over extended periods [18]. According to Table 2, after 16 weeks of training, the average 1000-meter run time in the experimental group decreased from 254.70 seconds to 248.6 seconds, marking an average improvement of 6.03 seconds. Conversely, the reference group's time decreased from 254.07 seconds to 251.03 seconds, with an average improvement of 3.04 seconds. Although both groups showed improvements, the difference was not statistically significant (P-values > 0.05). However, the experimental group demonstrated a notably higher increase in performance, suggesting that functional training effectively targeted and enhanced endurance quality compared to traditional methods.

Muscle strength quality denotes the ability of muscles to exert force against resistance during physical exertion. Enhancing strength involves factors such as muscle cross-sectional area, muscle fiber type, and CNS activation intensity, all crucial for overall physical performance improvement [19]. Strong muscle strength forms the foundation for enhancing physical fitness. The solid ball throw is selected as an indicator of physical fitness as it effectively measures upper limb strength, core stability, and lower limb coordination. Table 3 presents data indicating that after 16 weeks of training, the average solid ball throw distance in the experimental group increased by 0.4 meters, while the reference group showed an increase of 0.12 meters. Although the T-test results indicated

P-values above 0.05 for both groups, signifying no statistically significant difference, the experimental group demonstrated a more substantial improvement compared to the reference group. This suggests that functional training, compared to traditional methods, effectively enhances muscle strength quality among maritime students. The significant improvement in muscle strength quality through functional training is particularly beneficial for seafarers who often engage in tasks such as hull maintenance and ship equipment operations, which demand efficient physical strength. Adequate muscle strength reduces the risk of work-related injuries like muscle strains and sprains in high-risk maritime occupations. Therefore, integrating functional training into maritime sports education is essential to enhance seafarers' muscle quality, ensuring they possess the requisite strength for effective performance at sea.

Table 2: Comparison of 1000 m run performance of students in two groups before and after experiment

	Experimental group (s)	Reference group (s)	T	P
Before experiment	254.70±14.10	254.07±12.15	0.186	0.853
After experiment	248.67±13.06	251.03±11.10	–0.756	0.452
T	1.72	1.009		
P	0.091	0.317		

Table 3: Comparison of solid ball performance between two groups of students before and after experiment

	Experimental group (m)	Reference group (m)	T	P
Before experiment	6.68±1.89	6.69±1.94	–0.013	0.989
After experiment	7.08±1.81	6.81±1.89	0.564	0.575 *
T	–0.829	–0.242		
P	0.411	0.809		

4.2. FMS test indicators

The FMS serves as a valuable tool for assessing fundamental movement abilities and plays a crucial role in uncovering movement potential and preventing injuries [13]. Following 16 weeks of instruction, both the experimental and reference groups underwent FMS tests to evaluate changes in their movement capabilities. The scores before and after the experiment are detailed in Tables 4 and 5.

Table 4 and Table 5 highlight significant improvements in six key FMS indicators: deep squat, hurdle step, inline lunge, trunk stability push-up, rotational stability, and significant improvement in the straight leg raise for the experimental group compared to the reference group. These results indicate that functional training effectively enhances flexibility, stability, and coordination among college students, thereby reducing the risk of sports-related injuries. The substantial improvements observed underscore the positive impact of functional training on enhancing the functional movement abilities of maritime students.

Table 4: Comparison of FMS scores of experimental group students before experiment

FMS	Experimental group (m)	Reference group (m)	T	P
Squats	1.79±0.410	2.13±0.457	–5.520	0.000**
Hurdle racks	1.31±0.467	1.99±0.369	–9.799	0.009**
Front and back leg split squat	1.88±0.327	2.36±0.483	–7.341	0.000**
Shoulder joint flexibility test	2.18±0.386	2.40±0.494	–3.764	0.000**
Straight leg lift	1.93±0.471	2.19±0.398	–4.924	0.000**
Trunk stabilization push-ups	1.54±0.502	2.00±0.302	–6.464	0.000**
Rotational stability test	1.54±0.502	2.04±0.323	–7.794	0.000**

Table 5: Comparison of FMS scores between two groups of students after experiment

FMS	Experimental group (m)	Reference group (m)	T	P
Squats	2.13±0.547	1.82±0.386	4.287	0.000**
Hurdle racks	1.99±0.369	1.78±0.420	3.059	0.003**
Front and back leg split squat	2.36±0.483	1.93±0.531	4.934	0.000**
Shoulder joint flexibility test	2.40±0.494	2.28±0.454	1.456	0.148
Straight leg lift	2.19±0.398	2.01±0.476	2.360	0.020*
Trunk stabilization push-ups	2.00±0.302	1.64±0.483	5.149	0.000**
Rotational stability test	2.04±0.323	1.78±0.420	4.153	0.000**

4.3. The Effect of functional training on the navigation skills of Maritime Students.

Following 16 weeks of training, both the experimental and reference groups underwent reassessment in 500-meter swimming and heaving line tests, as detailed in Table 6 and Table 7. Table 6 reveals that the average time for the experimental group in the 500-meter swimming test decreased significantly from 991.70 seconds before the experiment to 916.90 seconds after. Similarly, the reference group improved from 973.70 seconds to 938.90 seconds. The T-test yielded highly significant P-values (< 0.01) for both groups, indicating substantial improvements. Table 7 shows that the heaving line performance of the experimental group increased significantly from 25.82 meters before the experiment to 27.45 meters after, with a P-value < 0.01, signifying a significant improvement. Moreover, the experimental group's improvement was notably higher than that of the reference group. These results underscore the

significant positive impact of 16 weeks of functional training on enhancing navigation skills. Effective navigation demands excellent physical coordination and balance, particularly in responding to unforeseen challenges. Functional training's diverse movement patterns enhance body coordination and flexibility, contributing to improved performance in maritime-specific skills.

Table 6: Comparison of 500 m swimming performance between the two groups before and after experiment

	Reference group （s）	Experimental group(s)	T	P
Before experiment	973.70±58.45	991.70±58.98	–0.592	0.568
After experiment	938.90±38.21	916.90±41.01	1.198	0.261
T	3.614	8.623		
P	0.006**	0.000**		

Table 7: Comparison of the scores of students heaving line before and after experiment

	Reference group （s）	Experimental group(s)	T	P
Before experiment	25.00±3.16	25.82±3.09	–0.554	0.592
After experiment	25.82±3.46	27.45±2.9	–1.161	0.273
T	3.105	5.285		
P	0.011*	0.000**		

5. Conclusion

This study examined the current status of physical fitness and navigation skills among maritime students, aligning with the demands of the shipping industry. It proposed the integration of functional training into the nautical sports curriculum to enhance the quality of maritime students. Through empirical research, it was found that the introduction of functional training led to significant and comprehensive improvements in the physical fitness and navigation skills of maritime students. The study innovatively tested the efficacy of functional training in nautical sports, an area where traditional methods prevail. Sixty-six navigation technology students from a maritime university in China participated in a 16-week experiment, divided into experimental and reference groups. Pre- and post-experiment assessments included physical fitness tests, FMS, and navigation skill evaluations, with statistical analysis comparing data before and after the experiment. Results demonstrated that the experimental group outperformed the reference group across all tests, indicating that functional training is more effective than traditional methods in improving speed quality, endurance quality, core stability, flexibility, and coordination. This validates the feasibility of integrating functional training into the nautical sports curriculum to meet reform objectives. Its innovative and diverse training methods effectively enhance physical fitness and navigation skills, reduce sports injuries, and promote overall physical health among maritime students. However, the study acknowledges several limitations, including the relatively small sample size of 66 participants and the short 16-week training period, which may not fully capture long-term training effects. Future research should consider expanding the sample size, extending the training duration, and exploring different training intensities and frequencies to further optimize the physical fitness and navigation skills development of maritime students. In conclusion, introducing functional training into the nautical sports curriculum represents a promising approach to cultivate high-quality maritime professionals equipped to meet the rigorous demands of the shipping industry.

6. Recommendations

Integration of Functional Sports Training: Maritime colleges should integrate functional sports training into their physical education programs to enhance students' overall physical fitness and sailing skills.

Personalized Training Plans: Tailor functional training plans based on individual differences in students' physical fitness and navigation skill levels to optimize training effectiveness.

Long-term Follow-up Studies: Conduct long-term follow-up studies to evaluate the sustained impact of functional training on students' physical fitness and proficiency in maritime operations throughout their careers.

Professional Development: Provide professional training for coaches and instructors at nautical colleges and universities in functional sports training to elevate teaching quality.

Interdisciplinary Collaboration: Foster interdisciplinary collaboration between nautical colleges and universities and experts in sports science, sports medicine, and related fields to innovate and refine functional sports training methodologies.

Implementing these recommendations can not only enhance the educational experience for maritime students but also ensure they are well-prepared physically and skillfully for the challenges of the maritime industry.

7. Future research

Future research endeavors should consider expanding the sample size, prolonging the training duration, and investigating various intensities and frequencies of training to comprehensively assess their effects on the physical fitness and navigation skills of maritime students. Additionally, conducting long-term follow-up studies will be crucial to continuously evaluate the enduring impact of functional training on maritime students. These studies aim to optimize training programs for achieving optimal results in enhancing both physical fitness and navigational competencies among maritime professionals.

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10. Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

11. Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

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