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RESEARCH ARTICLE

BREATH- HOLDING DRILLS ON OXYGEN UTILIZATION AND FATIGUE RESISTANCE AMONG SWIMMING ATHLETES

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Abstract

Swimming requires out standing cardiovas cularendurance,muscularstr ength,and efficien to xygenuse.To enhance performance and delay fatigue, athletes are exploring innovative training methods, with breath-holding drills gaining attention. Breath-holding, or voluntary apnea, can induce physiological adaptations beneficial to athletes, suchas improvin g anaerobic performance as shown by ameta-analysis. Controlled-frequency breath (CFB) training in swimming improves muscular oxyg en utilization and respiratory muscle strength. Recent studies have foun d that inspiratory muscle resistance training combined with strength training enhances gas exchange capacity and reduces inspiratory muscl e fatigue in artistic swimmers. The mammalian diving reflex, triggered by breath-holding and facial immersion in cold water, can slightly improve endurance. However, breath-holding techniques carry risks, like potential blackouts from hyperventilation before submersion.When used correctly, breath-holding drills can be beneficial, as respiratory muscle training improves swimming endurance. Systematic reviews indicate that apnea training leads to physiological adaptations, increasin g tolerance to high intensity efforts and improving recovery. In Southea st Asia, research on breath-holding drills among swimmers is emerging, with a study in Indonesia showing that specific breathing strategies can influence swimming velocity and efficiency.

Introduction:-

Breath-holding exercises have become a fundamental component of elite swimming training, offering potential benefits for oxygen utilization and fatigue resistance. These drills are designed to enhance an athlete's ability to tolerate low -oxygen conditions, improve respiratory efficiency, and increase endurance during high-intensity performances. Recent studies have explored thephysiological adaptations associated with breath -holding techniques, revealing promising outcomes interms of improved oxygen uptake and delayed muscle fatigue (Wirasak&Chansamorn, 2023). While traditional endurance training remains essential, integrating breath- holding drills into swimming regimens could provide competitive advantages for athletes aiming to optimize performance (Mahavong &Chantharasy, 2021).

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One of the primary benefits of breath- holding drills is the enhancement of oxygen utilization efficiency. Research conducted by Laksana and Prapawadee (2022) demonstrated that swimmers who regularly practiced controlled breath -holding exhibited increased arterial oxygen saturation levels, allowing them to maintain optimal performance for extended durations. Similarly, a study by Vannasith et al. (2023) found that exposure to intermittent hypoxia during training sessions improved hemoglobin concentration, facilitating greater oxygen transport to working muscles. These physiological adaptations contribute to a swimmer's ability to sustain high -intensity efforts while minimizing oxygen debt accumulation.

Beyond oxygen utilization, breath- holding drills have been shown to delay the onset of fatigue in swimming athletes. A study by Phoutthasinh and Khamphoumy (2020) assessed the impact of hypoxic training on collegiate swimmers, reporting significant improvements in muscular endurance and lactate threshold levels. Their findings indicated that breath- holding exercises condition the body to tolerate higher levels of carbon dioxide, thereby reducing early fatigue and extending an athlete's capacity to maintain peak performance (Sisombath & Bounleut, 2023).

The ability to delay fatigue is particularly advantageous in sprint and middle -distance events, where efficient energy utilization is crucial for success.

In addition to physical adaptations, breath -holding drills play a role in enhancing mental resilience and focus. According to Keovilay and Chanthone (2021), swimmers who engaged in hypoxic training reported reduced competition anxiety and improved breath control under pressure. This psychological advantage can be attributed to the body's ability to regulate stress responses more effectively when subjected to controlled oxygen deprivation. Furthermore, the study by Souphavady et al. (2024) found that athlete s who incorporated meditation- based breath-holding techniques demonstrated greatermental clarity and sustained focus during races, reinforcing the holistic benefits of these exercises.

While breath- holding training offers notable advantages, improper application can lead to potential risks, such as shallow water blackout. Research by Viravong and Phanousith (2022) emphasized the importance of structured progression and professional supervision when implementing hypoxic drills. Their study highlighted the need for individualized protocols based on an athlete's fitness level, as excessive breath -holding without proper recovery intervals could compromise safety. Additionally, Bounchanh and Khamxay (2023) noted that swimmers must be educated on the physiological signs of oxygen deprivation to prevent accidental loss of consciousness in water.

Optimal training frequency and duration for breath -holding exercises have been widely debated. A study by Xayavong et al. (2021) suggested that training sessions incorporating two to three hypoxic drills per week, with breath -holding durations not exceeding 30 seconds, produced measurable performance gains without inducing excessive stress. Conversely, research by Somchanh and Viengvilay (2023) warned against prolonged breath -holding beyond 45 seconds, which could lead to hypercapnia and negatively impact overall athletic output. These findings suggest that a balanced approach is necessary to maximize benefits while minimizing potential drawbacks.

Age and experience levels influence the effectiveness of breath- holding drills among swimmers. Young athletes tend to adapt more rapidly to hypoxic conditions compared to their senior counterparts. Research by Keomany et al. (2020) found that junior swimmers (ages 13 -18) demonstrated faster improvements in oxygen efficiency than older athletes, likely due to their greater respiratory plasticity and adaptability. However, research by Simmalavong and Oudomphonh (2024) indicated that experienced swimmers benefited from more refined breath- control techniques, which contributed to superior pacing and energy conservation during races.

Gender differences in response to breath -holding exercises have also been noted in recent studies. A study by Phetsamone and Saysamone (2023) found that female swimmers exhibited greater enhancements in oxygen retention and fatigue resistance

compared to male counterparts. This disparity was attributed to variations in lung volume, metabolic efficiency, and hormonal influences that affect endurance capacity. Additionally, research by Chanthavong and Phetdala (2022) suggested that female swimmers naturally adopted more conservative breathing strategies, which contributed to their sustained efficiency in breath- holding tasks

Integrating breath- holding drills with other training methodologies can amplify overall performance outcomes. Research by Panyathong and Inthavong (2023) demonstrated that swimmers who combined hypoxic training with high-intensity interval training (HIIT) achieved greater aerobic capacity improvements than those who practiced breath- holding in isolation. Similarly, a study by Vongphachanh and Soukaphone (2024) found that resistance training complemented breath- holding exercises by enhancing respiratory muscle strength, leading to prolonged breath retention and improved swimming stroke efficiency. Breath- holding drills present a valuable training strategy for improving oxygen utilization and fatigue resistance among swimming athletes. Research underscores the physiological, psychological, and strategic advantages of these exercises, while also highlighting potential risks that must be managed through structured implementation. Coaches and athletes should tailor breath -holding protocols to individual needs, considering factors such as age, gender, and experience level to optimize training outcomes. As advancements in sports science continue to evolve, further research into breath- holding techniques could unlock new possibilities for enhancing swimming performance in both competitive and recreational settings.

Statement of the Problem

This study will determine the breath- holding drills on oxygen utilization and fatigue resistance among swimming athletes at Guangdong Jiangmen Chinese Medical College in Jiangmen City, Guangdong Province, China.
The results of the study will be used as a basis for a lung capacity and respiratory muscle strengthening program.

Specifically, the study will answer the following questions:
1.Whatis the demographic profile of the athlete respondents in terms of:
1.1. sex;
1.2. age; and
1.3. number of years as a swimming athlete?

2.What is the assessment of the athlete respondents of their breath- holding drills on oxygen utilization in terms of:
2.1. breath- holding duration;
2.2. stroke efficiency and oxygen conservation;
2.3. heart rate recovery and oxygen debt;
2.4. CO_2 tolerance and mental control; and
2.5. efficiency in turns and underwaterphases?

3.Is there a significant difference in the assessment of the athlete respondents of their breath- holding drills on oxygen utilization when they are grouped according to their profile?
4.What is the self- assessment of the athlete respondents of their fatigue resistance in terms of:
4.1. stroke efficiency under fatigue;
4.2. breath control and oxygen utilization;
4.3. heart rate and recovery time;
4.4. speed maintenance over repeated sets; and
4.5. muscle endurance and power output?
5.Is there a significant difference in the self -assessment of the athlete respondents of their fatigue resistance when they are grouped according to their profile?
6.Is there a significant relationship between breath -holding drills on oxygen utilization and fatigue resistance among swimming athletes?
7.Based on the results of the study, what comprehensive tennis-specific fitness training program can be proposed?

Methodology:

Research Design

The study employs a descriptive, comparative, and correlational methodology, known for its clear definitions, thorough documentation, in-depth analysis, and refined understanding of contextual interactions. According to Nguyen and Phan (2024), descriptive research systematically investigates the essential characteristics, behaviors, and attributes of phenomena within their natural settings. The primary goal is to develop detailed profiles of specific entities or gain a deeper understanding of the current situation, providing a strong foundation for future research.
Building upon the work of Nguyen and Phan (2024), descriptive research is a pivotal tool in the social sciences and psychology, offering a detailed understanding of natural patterns and behaviors. This methodology enables the

collection of precise, impartial data on the beliefs, actions, andcharacteristics of target populations, contributing valuable insights into broader societal trends.

In addition, Tan and Lim (2023) emphasize the importance of comparative methods in identifying key variables that influence outcomes across diverse groups or settings. They argue that correlational analysis plays a critical role in uncovering potentialcausal relationships between variables, thereby enhancing the explanatory power of research designs. In this study, correlational analysis will be used to explore the relationships between specific demographic traits and relevant attitudes or behaviors, ai ding the development of theoretical frameworks and practical intervention strategies.

The descriptive- comparative- correlational methodology applied in this research provides a robust framework for examining the complex relationships between variables and their contexts. By merging the foundational principles from Nguyen and Phan (2024) with the methodological perspectives of Tan and Lim (2023), this approach strengthens the depth, validity, and reliability of the findings, paving the way for future studies and practical applications in related fields.

This study aims to investigate the swimming athletes' assessment of their breath- holding drills on oxygen utilization and their self- assessment of their fatigue resistance.

This research approach allows the researcher to numerically analyze, compare, and correlate the relationships amongst the dependent variables included in the study.

By utilizing this approach, the researcher will be able to findany significant difference or relationship in the swimming athleterespondents' assessment of their breath- holding drills on oxygen utilization and their demographic data such as sex, age, and number of years as swimming athlete. Also, the researcher will be able to find any significant difference or relationship in the swimming athletes' self- assessment of their fatigue resistance and their demographic data such as sex, age, and number of years as swimming athlete. The swimming athletes' assessment of their breath- holding drills on oxygen utilization and their self-assessment of their fatigue resistance will then be correlated.

All the above discussions on the descriptive research method will suit the nature of research that this present study would do; hence this method will be adopted.

Research Instrument

In gathering the needed data, the researcher will make researcher- made questionnaires on the swimming athlete respondents' assessment of their breath- holding drills on oxygen utilization and their self- assessment of their fatigue resistance.

The researcher will use face to face or onsite in administering this questionnaire.

The questionnaire will be composed of the following parts.

Part1–This section determines the demographic profile of the swimming athlete respondents.

Part2–This section determines the swimming athlete respondents' assessment of their breath -holding drills on oxygen utilization.

Part3–This section identifies the swimming athlete respondents' self- assessment of their fatigue resistance.

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