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"The Impact of Training Conditions and Microclimate on Injury Prevention and Performance Enhancement in Athletes"

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***Abstract**: This article examines the internal and external microclimatic conditions in training facilities to prevent injuries among athletes during their training and ensure the protection of their labor. The study focuses on the locomotor system and the loads placed on it. Observations of athletes' activities, alongside measurements of the facility's microclimate, formed the basis of the research.*

Keywords: labor protection, sports, injury, timing, microclimate, warm-up exercises, athlete, risk factors, skill.

Introduction

In occupational safety, several principles and methods are implemented, and from these, research-based recommendations and tools have emerged [1]. Occupational safety encompasses the technical, organizational, and management principles essential for ensuring safety in a structured and systematic manner [1,2]. These principles include replacing harmful technology with safer alternatives, using safe equipment, and enhancing labor processes. One technical principle, for instance, involves creating barriers between individuals and hazardous sources. Organizational principles focus on reducing people's exposure to hazardous environments and promoting health and rehabilitation. The management principles emphasize selecting the right personnel, enhancing professional knowledge, and fostering both moral and material incentives [2]. To reduce the risk of injuries and maintain the health of athletes, it is essential to implement legal, socio-economic, organizational, sanitary-hygienic, treatment, and rehabilitation measures [3]. Even minor causes can lead to significant sports injuries, which can prevent athletes from competing for months, regardless of whether surgery is required. A well-planned exercise routine enhances athletic performance and facilitates the smooth transition between different phases of physical activity, preparing the body both before and after major motor activities [3.4].

Objectives and Methods

The primary objective of this study is to examine the internal and external microclimatic conditions of training facilities and their impact on the physical well-being and injury risk of athletes. Specifically, the research focuses on how microclimatic factors such as temperature and humidity, as well as the structure of
training sessions, influence the performance, injury prevention, and overall health of athletes. This study also aims to evaluate the effectiveness of warm-up exercises in preparing athletes for strenuous activity and preventing injuries, particularly to the musculoskeletal system[4].

In sports science, strength training is recognized as a key factor in improving physical performance and minimizing injury risks. A wide variety of exercises are now incorporated into sports programs to enhance strength, power, and endurance. Athletes in team sports such as football, basketball, and hockey, often rely not only on physical strength but also on technical skills to perform well. For example, football requires athletes to master complex maneuvers like kicking, passing, trapping, jumping, running, and abruptly changing direction[5]. This diversity of movements demands a high level of physical fitness and coordination. Hence, strength training plays a critical role in enhancing these abilities, allowing athletes to perform more efficiently and reduce injury risk during intense gameplay [6].

Moreover, strength training not only improves aerobic capacity but also aids in the rapid recovery of muscle tissues post-exercise. The increased intensity and frequency of modern sports training, however, also raise the risk of injuries. Each sport has its own specific set of injuries, often related to the particular demands of the activity. For instance, athletes in sports such as boxing, wrestling, and gymnastics experience injuries that primarily affect their joints, muscles, ligaments, and bones. In skiing and equestrian sports, concussions and fractures are common due to the nature of these high-impact activities [6,7].

The study also focuses on how microclimatic conditions inside training facilities, such as air temperature, humidity, and ventilation, affect the overall training outcomes and health of athletes. It has been found that a rise in muscle temperature due to warm-up exercises results in enhanced muscle elasticity, reduced stiffness, and a lower risk of injuries. When muscle temperature increases by 10°C, chemical activities and metabolic rates within the muscles intensify by up to three times[7]. This acceleration in metabolic processes leads to better oxygen delivery to muscles, improves coordination between muscles, and facilitates quicker muscle relaxation and contraction cycles. These physiological changes collectively improve an athlete's performance and delay the onset of fatigue [7, 8].

Through systematic observations, the study employs various instruments and techniques to gather data on microclimatic parameters, as well as athlete performance and injury occurrences. The chronometric method is used to record the time spent by athletes in different stages of training (warm-up, special exercises, and competitions). Additionally, a thermohygrometer is utilized to monitor air temperature and humidity levels in the gym over a specific period[9].

Research Findings

The results of this study shed light on the importance of maintaining optimal environmental and training conditions for athletes. It was observed that the overall training session for judo lasted 97 minutes, broken down into four main stages: a 15-minute warm-up, 10 minutes of special exercises, 50 minutes of battle or competition, and 10 minutes of waiting time between sessions. During these sessions, athletes began sweating approximately 8 to 10 minutes after the start of training, which indicates the initiation of thermoregulation in response to physical exertion. This finding highlights the importance of structuring warm-up exercises to properly activate the athletes' physiological systems before the main activity [10].

Similarly, the sambo training sessions lasted 85 minutes, with 34 minutes allocated for warm-up, 16 minutes for special exercises, 35 minutes for competition, and 10 minutes for waiting between sessions. In both cases, it was noted that athletes begin sweating around 8 to 10 minutes into their training, which correlates with the activation of the body's cooling mechanisms through perspiration. This confirms that proper warm-up exercises play a crucial role in preparing athletes for highintensity activities and minimizing the risk of injury.

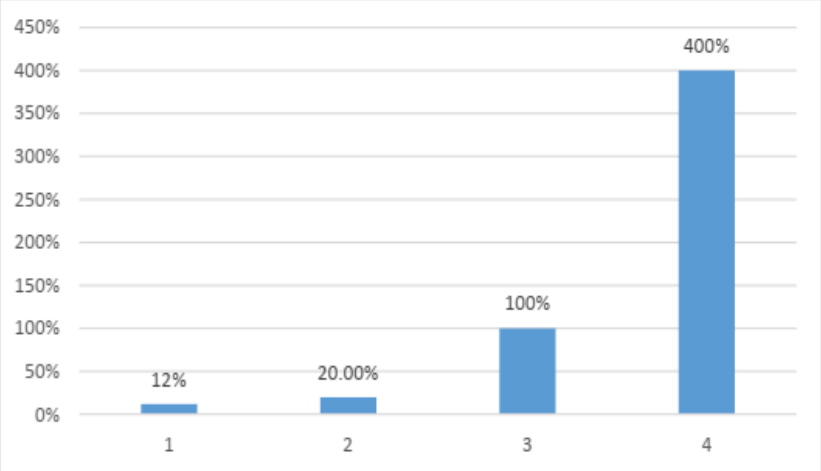
The environmental conditions within the training facility were measured using the RHT20 thermohygrometer. The maximum recorded air temperature in the gym was 28.1°C, while the minimum was 8.1°C. Relative humidity fluctuated between 12.0% and 56.8%, with an average of 29.95%. According to the established standards of microclimate for production rooms (SanQvaN № 0324-16), these values indicate that the gym's conditions do not meet the necessary sanitary and hygienic requirements. The low humidity levels, in particular, increase the risk of dehydration among athletes, as large amounts of water are lost through perspiration and respiration during training [11].

The results also revealed that a 20-minute general warm-up exercise was insufficient to fully warm up the athlete's body. As the ambient conditions in the gym did not adequately support the body's thermoregulation processes, athletes were at a higher risk of sustaining injuries due to insufficient preparation of their muscles and connective tissues. The low relative humidity in the gym (significantly below the recommended 40-60%) compounded this problem by accelerating water loss, which further reduced the athletes' ability to maintain optimal physical performance during their training sessions. Sweating is the first sign of heat regulation in the body, and inadequate preparation can lead to overheating, fatigue, and increased injury risk.

Furthermore, it was found that a mere increase in muscle temperature by 30°C resulted in a significant improvement in work capacity, especially in speedstrength exercises. Work efficiency in these exercises increased by 32-44%, and muscle contraction force improved by 4%. Additionally, the latent period of muscle contraction decreased by 7%, further enhancing athletic performance. Such physiological benefits underscore the necessity of a well-structured warm-up routine, especially in sports that involve rapid movements, such as wrestling, football, and judo [12].

If the outdoor air temperature is below -10°C and the wind speed exceeds 7 m/s, ventilation of the hall is conducted for 1-1.5 minutes when there are no students present. During long breaks and between shifts, ventilation lasts for 5-10 minutes. When the air temperature reaches +14°C, the sports hall must be ventilated. All of these measures are part of occupational safety in sports[13,14].

If we consider the energy expenditure of a single athlete in a sports hall, even with slight muscle activity like sitting, metabolism increases by 12% compared to walking, by 20% when standing, by 100% during slow walking, and by 400% during running.



1. compared to walking, 2. standing, 3. during slow walking,
4. during running

Figure 1

Chronometric analysis of judo and sambo training sessions demonstrated that the duration of warm-up exercises directly influences the athletes' performance and injury rates. A poorly designed warm-up regimen leads to insufficient preparation, which increases the likelihood of muscle strain, ligament injuries, and other musculoskeletal issues during competition. Thus, it is critical to adapt the warm-up duration based on the athlete's experience level, the intensity of the sport, and environmental factors like temperature and humidity [14]. The study confirms that regular monitoring of training facility conditions, along with adjustments in warmup routines, can substantially improve athlete performance while reducing injury risks.

Discussion

A comprehensive warm-up is essential for preparing the athlete's body, increasing muscle temperature, improving mobility, and preventing injuries. Increased muscle temperature facilitates better movement efficiency and accelerates recovery processes. Specifically, a 10°C rise in muscle temperature leads to a 4% increase in muscle contraction force, while a 30°C rise significantly decreases muscle contraction time. Chronometric results from judo and sambo exercises revealed that the training program did not fully warm up the athletes, contributing to their increased risk of injury. Moreover, the gym's microclimatic conditions were insufficient for optimal training. A 20-minute warm-up did not adequately prepare the athletes, and the gym's low relative humidity further contributed to significant water loss during exercise.

Conclusion

1. Injuries vary based on an athlete's skill level, gender, and age, with 18-22-
year-old football and wrestling athletes experiencing the highest injury rates.

2. Hand, wrist, knee, and foot injuries were found to be most common, particularly among female wrestlers, who are 1.5 to 2 times more likely to suffer such injuries than male wrestlers. Two-thirds of wrestlers do not use protective gear.

3. The gym's training program and sanitary conditions do not meet the established standards, resulting in inadequate preparation and higher injury risks for athletes.

4. Insufficient warm-up time and low relative humidity contribute to water loss during exercise, increasing the likelihood of dehydration and injuries.

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