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Original Scientific Article

Determining the Efficacy of Providing Ice Compression for Fitness Enhancement After Speed Endurance Exercise on Reducing Heart Rate, IL-6, and Fatigue Index in Football Athletes

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Abstract

Objectives. This study aimed to investigate the effects of Ice Compression For Fitness (ICEFIT) on reducing heart rate, Interleukin-6 (IL-6) levels, and fatigue index in soccer athletes after performing speed endurance training.

Materials and methods. A total of 34 male students from the Football Coaching Department at the State University of Surabaya (Indonesia), aged 18-20 years, with a normal BMI, at least 10 years of football training experience, and no injuries in the past 6 months, were selected as research subjects and were given ICEFIT treatment for 4 weeks. Data collection was conducted by measuring heart rate, IL-6 levels, and fatigue index at both the pre- and post-intervention stages. Data analysis techniques included using the parametric paired sample t-test and independent sample t-test, with a significance level of 5 %.

Results. The results showed that ICEFIT significantly reduced heart rate, IL-6 levels, and fatigue index in soccer athletes after speed endurance training ($p \le 0.05$). Furthermore, marked reductions in heart rate, IL-6 levels and fatigue index were observed between the groups ($p \le 0.05$).

Conclusions. These findings demonstrate that ICEFIT is effective in reducing heart rate, IL-6 levels, and fatigue index in soccer athletes after speed endurance training.

Keywords: ICEFIT, proinflammatory cytokine, soccer athletes, speed endurance training.

Introduction

Football, known as the most popular sport worldwide, is a large ball game played by two teams, each consisting of 11 players, led by a referee and two assistant referees, with one substitute or backup referee (Lepschy et al., 2018; Irfan et al., 2020). The official rules stipulate that football is played for a total of 90 minutes, divided into two halves of 45 minutes each, with a 15-minute halftime break in between (Dolci et al., 2020). Football is a sport that utilizes both aerobic and anaerobic energy systems, although the predominant energy system used is anaerobic (Evangelos et al., 2016). The anaerobic system is required during high-intensity sprints performed in technical and tactical tasks, such as defense and attack, while the aerobic system ensures continuity in high-intensity anaerobic efforts and accelerates recovery processes (Stojmenović & Stojmenović, 2023).

Throughout a half, football players are constantly moving, with or without the ball. Players moving without the ball perform tasks involving jogging, running, acceleration, sprinting, maximal sprints, high-intensity acceleration, and deceleration (Leontijević et al., 2019). Players controlling or attacking with the ball exhibit skills such as passing, first touch, controlling, dribbling, heading, and shooting (Kusuma et al., 2023). The pace of football games has been

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steadily increasing, making it one of the highest-intensity sports today (Rivilla-García et al., 2019). In fact, the intensity of football matches has risen significantly in top leagues such as the English Premier League (EPL) (Barnes et al., 2014).

As the intensity and duration of football games increase, training programs that emphasize the anaerobic energy system are required, one of which is speed endurance training. Speed endurance training is part of high-intensity interval training (HIIT), characterized by sustained periods of intense activity interspersed with short active recovery periods (Ramírez et al., 2017). Despite being demanding for athletes, research has found that speed endurance training positively impacts both anaerobic and aerobic capacities (Ramírez et al., 2017).

However, the significant effects of anaerobic training can pose negative risks to the body if not addressed properly. High-intensity anaerobic training will linearly increase heart rate (D'Unienville et al., 2022) and, if prolonged, can lead to fatigue (Güler et al., 2020). Fatigue results from lactic acid accumulation, which reduces muscle contraction ability and athletic performance (Sari et al., 2019; Zubaida et al., 2023). Selain Additionally, lactic acid production in working muscles correlates with the release of Interleukin-6 (IL-6) (Robson-Ansley et al., 2004). Research indicates that high-intensity exercise in humans and intramuscular lactate injections in rats closely correlate with systemic IL-6 release. This supports the connection between exercise intensity, lactate production, and IL-6 release during strenuous activity (Nash et al., 2023). Dengan The relationship between lactic acid production and IL-6 release helps explain why IL-6 secretion increases during high-intensity exercise and glycogen depletion (Smith, 2000).

Recovery is critical for football players. Recovery refers to the process of restoring the body's metabolic functions to normal after strenuous activity, enabling the individual to be ready for future tasks (Fahmi & Ashadi, 2019). Recovery is critical for football players. Recovery refers to the process of restoring the body's metabolic functions to normal after strenuous activity, enabling the individual to be ready for future tasks (Carling et al., 2018; Handoko & Bagaskoro, 2021; Marqués-Jiménez et al., 2017).

Given the importance of recovery in football, interventions that can accelerate the recovery process are essential, one of which is cold water or ice treatment. Research has shown that cold water immersion during halftime significantly slows muscle fatigue and reduces lactic acid levels in football players (Panyakham & Pariwat, 2022). A study by Fakhro et al. (2022) also found that cold water immersion is highly effective in improving recovery from exercise-induced muscle damage (EIMD). Additionally, cold water immersion has been shown to reduce muscle damage markers in the blood after simulated match training in football players (Roonkiani et al., 2020).

Based on the explanation above, football predominantly relies on anaerobic energy systems, requiring training programs that improve anaerobic capacity. As football is a sport that demands continuous high-intensity activity over long periods, players are prone to fatigue, characterized by increased heart rate, elevated IL-6 levels, and a high fatigue index. These conditions hinder football players' performance, making recovery crucial to preparing them for subsequent activities. If left unaddressed, athletes may not be able to perform optimally. Therefore, a modality that accelerates the recovery process in soccer athletes is necessary. This study will use an intervention called Ice Compression For Fitness (ICEFIT). This ICEFIT intervention is designed to help soccer athletes recover their heart rate, IL-6 levels, and fatigue index after speed endurance training.

Materials and Methods

Study Design

This study employed a true-experimental method with a randomized control group pretest-posttest design. A total of 34 male students from the Football Coaching Department at Universitas Negeri Surabaya, aged 18-20 years, with normal BMI, at least 10 years of football training experience, and no injuries in the last 6 months, were selected as research subjects. Informed consent was obtained before the initial data collection from all subjects. All procedures applied in this study were approved by the Health Research Ethics Committee of the Faculty of Medicine, Ciputra University [No: 107/EC/KEPK-FKUC/III/2024].

Programs of Speed Endurance Training for Soccer

The speed endurance training applied in this study involved repeated high-intensity sprints aimed at achieving anaerobic conditions, combined with technical drills for passing and dribbling. The speed endurance training was conducted for 4 weeks with three sessions per week. During weeks 1 and 2, the training consisted of 8 repetitions, with a total sprint distance of 80 meters and a 1:2 work-to-rest ratio (estimated workout time of 96 seconds and rest interval of 192 seconds per repetition). In weeks 3 and 4, the training also included 8 repetitions, with a total sprint distance of 80 meters, but the work-to-rest ratio was changed to 1:1 (estimated workout time of 96 seconds and rest interval of 96 seconds per repetition).

Ice Compression For Fitness (ICEFIT) Procedure

The ICEFIT procedure was applied during the training intervals (3 minutes in weeks 1 and 2; 1.5 minutes in weeks 3 and 4). Ice was applied in the form of an ice pack at a temperature of 15 °C and placed on the back of the subject's neck. The ice compression was administered 7 times per training session over 12 training sessions.

Data Collection

Data collection was conducted by measuring heart rate using Polar (Polar H10 Sensor, Inc., USA) (Pranoto et al., 2023a). The fatigue index was measured using the Running-Based Anaerobic Sprint Test (RAST), in watts/sec, and calculated using the formula: Maximum power – minimum power ÷ total time for the 6 sprints. Meanwhile, IL-6 levels were analyzed using commercial ELISA Kits (Cat. No.: E-EL-H6156; Human IL-6 ELISA Kit; Elabscience Biotechnology Inc., Houston, TX 77079, USA) (Pranoto et al., 2023b).

Statistical Analysis

Normality tests were conducted using the Shapiro–Wilk test, followed by parametric paired sample t-tests to assess differences within each group. Independent sample t-tests were applied to evaluate differences between groups. Effect size was evaluated using Cohen's d. Data were considered significantly different between groups if $p \leq 0.05$.

Results

The analysis of the general characteristics of the study subjects showed no significant differences between the groups, as presented in Table 1. The results of the analysis of heart rate, IL-6 levels, and fatigue index before and after the ICEFIT intervention are shown in Figures 1-3. The analysis of the differences in heart rate, IL-6 levels, and fatigue index between the control group (CON) and the ICEFIT group is presented in Table 2.

Table 1. General characteristics of study subjects

Parameters	CON (n = 17)	ICEFIT (n = 17)	p-value
Age (years)	21.47 ± 0.79	21.06 ± 0.89	0.168
Height (m)	1.68 ± 0.07	1.71 ± 0.03	0.162
Weight (kg)	65.59 ± 7.79	67.18 ± 6.12	0.513
Body Mass Index (kg/m2)	23.33 ± 1.61	22.93 ± 1.75	0.493
Training Experience (years)	10.12 ± 2.18	10.29 ± 2.52	0.828

Note: CON: Control group; ICEFIT: Ice compression enhancement for fitness group

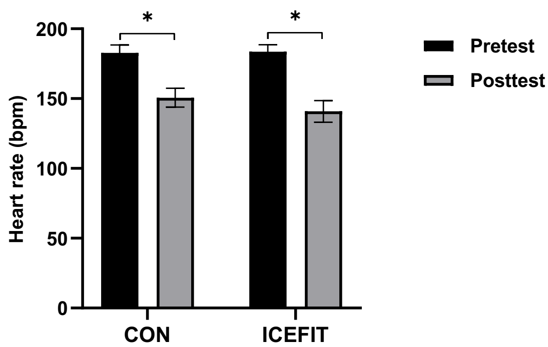

Fig. 1. Average heart rate in each group. Description: (*) Indicates a significant difference from the pretest ($p \leq 0.05$)

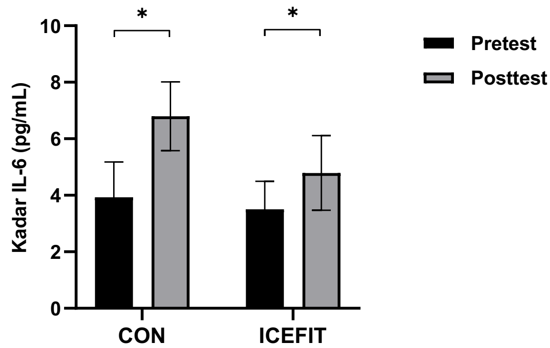

Fig. 2. Average IL-6 levels in each group. Description: (*) Indicates a significant difference from the pretest ($p \leq 0.05$)

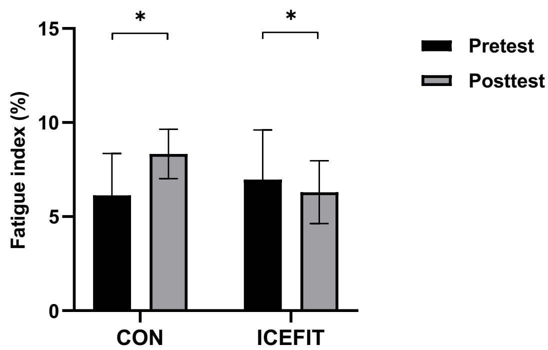

Fig. 3. Average fatigue index in each group. Description: (*) Indicates a significant difference from the pretest ($p \leq 0.05$

Discussion

The main findings of this study indicate that ICEFIT intervention significantly modulates post-exercise inflammatory response, heart rate recovery, and fatigue index in athletes after high-intensity speed endurance training. Specifically, athletes who received the ICEFIT treatment experienced lower increases in IL-6 levels, faster heart rate recovery, and more controlled fatigue compared to the control group.

The reduction in IL-6 levels aligns with previous research showing that cryotherapy and compression can mitigate

Table 2. Differences in heart rate, IL-6 levels, and fatigue index between groups

Parameters	CON (n=17)	ICEFIT (n=17)	Effect size	p-value
Pre-Heart rate (bpm)	182.67 ± 5.69	183.51 ± 5.03	-	0.652
Post-Heart rate (bpm)	150.63 ± 6.75	140.89 ± 7.74*	1.341	0.000
Δ-Heart rate (bpm)	-32.04 ± 8.81	-42.62 ± 8.12*	1.249	0.001
Pre-IL-6 (pg/mL)	3.93 ± 1.25	3.51 ± 0.99	-	0.279
Post-IL-6 (pg/mL)	6.79 ± 1.22	4.79 ± 1.32*	1.574	0.000
Δ-IL-6 (pg/mL)	2.86 ± 1.99	1.28 ± 0.86*	1.031	0.006
Pre-Fatigue index (%)	6.14 ± 2.23	6.97 ± 2.64	-	0.328
Post-Fatigue index (%)	8.33 ± 1.31	6.29 ± 1.67*	1.359	0.000
Δ-Fatigue index (%)	2.19 ± 2.83	-0.67 ± 2.36*	1.098	0.003

Description: (*) Significant at CON ($p \leq 0.05$). (-) No observed effect size. Effect size was evaluated using Cohen's d. The p-value was applied using independent sample t-tests inflammatory responses (Sánchez-Ureña et al., 2018; Minett & Costello, 2015). Inflammation is a natural response to intense physical activity and is often accompanied by the release of pro-inflammatory cytokines such as IL-6 (Fujii & Shibata, 2023). However, the role of cryotherapy in controlling systemic inflammation remains debated (Kusmierczyk et al., 2024). While some studies suggest that cryotherapy reduces muscle soreness and local inflammation, its effects on systemic markers like IL-6 are inconsistent (White & Wells, 2013; Elvianasti et al., 2023). The reduction in IL-6 observed in this study may be attributed to the specific combination of cold exposure and compression provided by ICEFIT, which enhances lymphatic drainage and reduces metabolic waste, thereby limiting muscle damage and inflammation following high-intensity exercise.

Regarding heart rate recovery, our findings are consistent with those of Roberts et al. (2015), who found that cold water immersion after resistance exercise reduced cardiac output and stroke volume due to peripheral vasoconstriction. This vasoconstriction helps preserve core body temperature by diverting blood flow from the periphery, a process that may also reduce cardiovascular strain on the heart post-exercise (Moore et al., 2022). Vaile et al. (2011) demonstrated that various forms of cryotherapy, including cold water immersion, accelerate cardiovascular recovery after high-intensity exercise, supporting our conclusion that ICEFIT facilitates faster heart rate recovery. This is further corroborated by Xiao et al. (2023), who found that cooling interventions like ICEFIT improve heart rate variability and promote faster cardiovascular recovery by reducing overall physiological stress. The faster heart rate recovery in the ICEFIT group may be due to a combination of reduced metabolic activity in cooled muscles and improved circulation efficiency through vasoconstriction and blood flow centralization.

The more controlled fatigue index observed in the ICEFIT group is consistent with studies showing that cold water immersion enhances muscle recovery and delays the onset of fatigue (Machado et al., 2016). Fatigue during high-intensity exercise is often associated with the accumulation of metabolic waste, including lactate, and muscle damage (Güler et al., 2020). By lowering muscle temperature, ICEFIT likely slows enzymatic activity and metabolic processes that contribute to fatigue, while compression facilitates the removal of waste products (Minett & Costello, 2015). However, since fatigue was not completely prevented in the ICEFIT group, this suggests that while ICEFIT helps manage fatigue, it may not be sufficient on its own to fully counteract the neuromuscular and metabolic fatigue associated with repeated high-intensity exercise (Horgan et al., 2023).

The modulation of IL-6 levels suggests that ICEFIT may reduce the inflammatory response triggered by muscle damage and metabolic stress. The cryotherapy element likely reduces the influx of pro-inflammatory cytokines by decreasing blood flow to muscle tissue, while compression enhances the clearance of these inflammatory markers through the lymphatic system (Dalgaard et al., 2020; Singh et al., 2017). Furthermore, lowering muscle temperature may slow enzymatic processes related to inflammation and muscle damage (White & Wells, 2013). However, the statistically insignificant reduction in IL-6 in the ICEFIT group suggests that while beneficial, ICEFIT may need to be combined with other recovery modalities or longer recovery periods to produce a more pronounced effect on systemic inflammation.

The improvement in heart rate recovery may also be linked to the vasoconstriction induced by cold exposure, which redirects blood flow to the body's core, reducing cardiovascular strain post-exercise (Roberts et al., 2015). Compression likely enhances this effect by preventing excessive muscle tissue swelling, allowing for more efficient circulation and faster heart rate recovery. This combination supports the notion that ICEFIT improves cardiovascular recovery by optimizing blood flow and reducing the metabolic load on the heart after intense exercise (Xiao et al., 2023).

The partial control over the fatigue index observed in the ICEFIT group reflects its role in reducing muscle soreness and improving functional recovery. However, fatigue is influenced by a variety of factors, including metabolic, muscular, and neural systems (Wan et al., 2017). While ICEFIT may address some of the metabolic factors contributing to fatigue, such as lactate accumulation, it may not fully mitigate neuromuscular fatigue or psychological stress arising from prolonged high-intensity exercise (Güler et al., 2020; Horgan et al., 2023). This suggests that while ICEFIT provides significant recovery benefits, additional interventions or longer recovery times may be needed to fully alleviate fatigue.

These results suggest that ICEFIT could be a valuable recovery tool for athletes in high-intensity sports such as soccer. Its ability to reduce IL-6 levels and enhance heart rate recovery offers significant benefits for athletes who need to recover quickly between training sessions or competitions. Coaches, sports scientists, and athletic trainers may consider incorporating ICEFIT into broader recovery strategies, especially for sports involving repeated high-intensity efforts. The potential of ICEFIT to enhance recovery could translate into improved athletic performance by allowing faster physiological recovery between training efforts. However, this study has several limitations. First, the relatively small sample size may affect the generalizability of the results. Larger-scale studies are needed to confirm these findings in different athletic populations. Second, although IL-6 was measured as a primary marker of inflammation, adding other markers such as C-reactive protein (CRP) or tumor necrosis factor-alpha (TNF-α) would provide a more comprehensive understanding of ICEFIT's impact on inflammation. This study also did not account for individual variations in cold sensitivity, which could influence the results. Finally, the optimal intensity and duration of the ICEFIT intervention remain unclear, as different temperatures and compression levels may produce varying effects on recovery outcomes.

Future research should focus on larger sample sizes and include a range of inflammatory and recovery markers to better understand the physiological effects of ICEFIT. Longitudinal studies investigating the cumulative effects of ICEFIT over a competitive season would also be valuable, as they could assess its long-term benefits and potential adaptive effects. Additionally, further exploration into the optimal temperature, compression levels, and duration of ICEFIT for different sports and athlete types will help refine its practical application. Comparing ICEFIT to other established recovery modalities, such as active recovery or massage, could also provide insights into its relative effectiveness.

Overall, this study's findings underscore the potential of ICEFIT as an effective recovery intervention for athletes after high-intensity exercise. The treatment significantly improved heart rate recovery and reduced inflammatory responses, as indicated by IL-6 levels. Furthermore, while ICEFIT helped control fatigue increases, it did not fully prevent it. These findings support the use of ICEFIT in practical settings to enhance athletic recovery, although further research is needed to optimize its use and better understand its effects across different sports and individual responses. Continued investigation into the mechanisms underlying ICEFIT's effects will be essential for developing more targeted and efficient recovery protocols in the future.

Conclusion

Based on the results of this study, ICEFIT was proven to significantly reduce heart rate, Interleukin-6 (IL-6) levels, and fatigue index in soccer athletes after performing speed endurance training. Moreover, there were significant differences between the group receiving ICEFIT and the control group in terms of reductions in these three variables. This demonstrates that ICEFIT is effective in aiding recovery and reducing fatigue following intense exercise in soccer athletes.

Conflict of Interest

The authors declare that they have no competing interests.

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References

Lepschy, H., Wäsche, H., and Woll, A. (2018). How to be Successful in Football: A Systematic Review. *The Open Sports Sciences Journal, 11*(1), 3-23. https://doi.org/10.2174/1875399X01811010003

Irfan, M., Yenes, R., Irawan, R., and Oktavianus, I. (2020). Kemampuan teknik dasar sepakbola. *Jurnal Patriot, 2*(3), 720-731. https://doi.org/10.24036/PATRIOT.V2I3.664

Dolci, F., Hart, N. H., Kilding, A. E., Chivers, P., Piggott, B., and Spiteri, T. (2020). Physical and Energetic Demand of Soccer: A Brief Review. *Strength and Conditioning Journal, 42*(3), 70-77. https://doi.org/10.1519/SSC.0000000000000533

Evangelos, B., Lefteris, M., Aristotelis, G., Ioannis, G., and Natalia, K. (2016). Aerobic and anaerobic capacity of professional soccer players in annual macrocycle. *Journal of Physical Education and Sport ® (JPES), 16*(2), 527-533. https://doi.org/10.7752/jpes.2016.02083

Stojmenović, D., & Stojmenović, T. (2023). Physiological parameters of professional football players in teams of various levels. *Pedagogy of Physical Culture and Sports, 27*(5), 361-367. https://doi.org/10.15561/26649837.2023.0502

Leontijević, B., Janković, A., and Tomić, L. (2019). Attacking Performance Profile Of Football Teams In Different National Leagues According To Uefa Rankings For Club Competitions. *Facta Universitatis, Series: Physical Education and Sport,* 697. https://doi.org/10.22190/FUPES180404062L

Kusuma, K. C. A., Artanayasa, I. W., Sudiana, I. K., Yudi, A. A., Kusuma, C. A., and Yudi, A. A. (2023). Enhancing anaerobic endurance in football players: A comparative study of 3-a-side and 5-a-side small-sided games. *Journal Sport Area, 8*(3), 318-327. https://doi.org/10.25299/sportarea.2023.vol8(3).13150

Rivilla-García, J., Calvo, L. C., Jiménez-Rubio, S., Paredes-Hernández, V., Muñoz, A., Tillaar, R. Van Den, & Navandar, A. (2019). Characteristics of Very High Intensity Runs of Soccer Players in Relation to their Playing Position and Playing Half in the 2013-14 Spanish La Liga Season. *Journal of Human Kinetics, 66*(1), 213. https://doi.org/10.2478/HUKIN-2018-0058

Barnes. C.Archer, D. T., Hogg, B., Bush, M., and Bradley, P. S. (2014). The evolution of physical and technical performance parameters in the english premier league. *International Journal of Sports Medicine, 35*(13), 1095-1100. https://doi.org/10.1055/S-0034-1375695

Ramírez, J. M., Núñez, V. M., Lancho, C., Poblador, M. S., & Lancho, J. L. (2017). A speed-endurance training to improve aerobic, anaerobic capacity, and fat oxidation of four groups of athletes. *Medicina Dello Sport, 70*(3), 266-281. https://doi.org/10.23736/S0025-7826.17.02861-7

D'Unienville, N. M. A., Nelson, M. J., Bellenger, C. R., Blake, H. T., and Buckley, J. D. (2022). Heart-Rate Acceleration Is Linearly Related to Anaerobic Exercise Performance. *International Journal of Sports Physiology and Performance, 17*(1), 78-82. https://doi.org/10.1123/IJSPP.2021-0060

Güler, Ö., Aras, D., Akça, F., Bianco, A., Lavanco, G., Paoli, A., and Şahin, F. N. (2020). Effects of Aerobic and Anaerobic Fatigue Exercises on Postural Control and Recovery Time in Female Soccer Players. *International Journal of Environmental Research and Public Health, 17*(17), 1-11. https://doi.org/10.3390/IJERPH17176273

Sari, R. M., Harahap, N. S., Siregar, N. S., and Rispandi, M. (2019, October). The Effect of Massage to Decrease Lactic Acid Levels after Anaerobic Physical Activity. *Proceedings of The 5th Annual International Seminar on Trends in Science and Science Education,* AISTSSE 2018. https://doi.org/10.4108/EAI.18-10-2018.2287364

Zubaida, I., Prama, D., Cde, D., Anugrah, M., and Triprayogo, R. (2023). Revitalizing performance: Exploring the influence of sports massage and PNF stretching on lactic acid recovery in females futsal athletes. *Journal Sport Area, 8*(3), 310-317. https://doi.org/10.25299/sportarea.2023.vol8(3).13712

Robson-Ansley, P. J., De Milander, L., Collins, M., and Noakes, T. D. (2004). Acute interleukin-6 administration impairs athletic performance in healthy, trained male runners. *Canadian Journal of Applied Physiology, 29*(4), 411-418. https://doi.org/10.1139/H04-026

Nash, D., Hughes, M. G., Butcher, L., Aicheler, R., Smith, P., Cullen, T., and Webb, R. (2023). IL-6 signaling in acute exercise and chronic training: Potential consequences for health and athletic performance. *Scandinavian Journal of*

Medicine & Science in Sports, 33(1), 4-19. https://doi.org/10.1111/SMS.14241

Smith, L. L. (2000). Cytokine hypothesis of overtraining: A physiological adaptation to excessive stress? *Medicine and Science in Sports and Exercise, 32*(2), 317-331. https://doi.org/10.1097/00005768-200002000-00011

Fahmi, H., & Ashadi, K. (2019). The Comparation of Sport Massage and Hydrotherapy Cold Water to Physiological Recovery. *JUARA: Jurnal Olahraga, 4*(2), 196-209. https://doi.org/10.33222/juara.v4i2.566

Carling, C., Lacome, M., McCall, A., Dupont, G., Le Gall, F., Simpson, B., and Buchheit, M. (2018). Monitoring of Post-match Fatigue in Professional Soccer: Welcome to the Real World. *Sports Medicine (Auckland, N.Z.), 48*(12), 2695. https://doi.org/10.1007/S40279-018-0935-Z

Handoko, A., & Bagaskoro, C. (2021). Effect Of Recovery Time After Match On Muscle Explosive Power On Football Athletes. Saintika Medika, 17(1), 12-18. https://doi.org/10.22219/SM.VOL17.SMUMM1.12092

Marqués-Jiménez, D., Calleja-González, J., Arratibel, I., Delextrat, A., and Terrados, N. (2017). Fatigue and Recovery in Soccer: Evidence and Challenges. *The Open Sports Sciences Journal, 10*(1), 52-70. https://doi.org/10.2174/1875399X01710010052

Panyakham, A., & Pariwat, P. (2022). Effect of cold water immersion during half time on body recovery in soccer player. *Journal of Physical Education and Sport, 22*(3), 749-756. https://doi.org/10.7752/jpes.2022.03094

Fakhro, M. A., AlAmeen, F., & Fayad, R. (2022). Comparison of total cold-water immersion's effects to ice massage on recovery from exercise-induced muscle damage. *Journal of Experimental Orthopaedics, 9*(1), 1-8. https://doi.org/10.1186/S40634-022-00497-5/FIGURES/4

Roonkiani, S. K., Ebrahimi, M., & Majelan, A. S. (2020). Effect of cold water immersion on muscle damage indexes after simulated soccer training in young soccer players. *Biomedical Human Kinetics, 12*(1), 236-241. https://doi.org/10.2478/BHK-2020-0030

Pranoto, A., Rejeki, P. S., Miftahussurur, M., Setiawan, H. K., Yosika, G. F., Munir, M., Maesaroh, S., Purwoto, S. P., Waritsu, C., & Yamaoka, Y. (2023a). Single 30 min treadmill exercise session suppresses the production of pro-inflammatory cytokines and oxidative stress in obese female adolescents. *Journal of basic and clinical physiology and pharmacology, 34*(2), 235-242. https://doi.org/10.1515/jbcpp-2022-0196.

Pranoto, A., Cahyono, M. B. A., Yakobus, R., Izzatunnisa, N., Ramadhan, R. N., Rejeki, P. S., Miftahussurur, M., Effendi, W. I., Wungu, C. D. K., & Yamaoka, Y. (2023b). Long-Term Resistance-Endurance Combined Training Reduces Pro-Inflammatory Cytokines in Young Adult Females with Obesity. *Sports (Basel, Switzerland), 11*(3), 54. https://doi.org/10.3390/sports11030054.

Sánchez-Ureña, B., Rojas-Valverde, D., and Gutiérrez-Vargas, R. (2018). Effectiveness of two cold water immersion protocols on neuromuscular function recovery: A tensiomyography study. *Frontiers in Physiology, 9*(JUN), 1-7. https://doi.org/10.3389/fphys.2018.00766

Minett, G. M., & Costello, J. T. (2015). Specificity and context in post-exercise recovery: It is not a one-size-fits-all approach. *Frontiers in Physiology, 6*(APR), 140555. https://doi.org/10.3389/FPHYS.2015.00130/BIBTEX

Fujii, W., & Shibata, S. (2023). Mineralocorticoid Receptor Antagonists for Preventing Chronic Kidney Disease Progression: Current Evidence and Future Challenges. *International Journal of Molecular Sciences, 24*(9), 7719. https://doi.org/10.3390/IJMS24097719

Kusmierczyk, J., Wiecek, M., Wojciak, G., Mardyła, M., Kreiner, G., Szygula, Z., & Szymura, J. (2024). The Effect of Physical Activity and Repeated Whole-Body Cryotherapy on the Expression of Modulators of the Inflammatory Response in Mononuclear Blood Cells among Young Men. *Journal of clinical medicine, 13*(9), 2724. https://doi.org/10.3390/jcm13092724

White, G. E., & Wells, G. D. (2013). Cold-water immersion and other forms of cryotherapy: Physiological changes potentially affecting recovery from high-intensity exercise. *Extreme Physiology and Medicine, 2*(1), 1-11. https://doi.org/10.1186/2046-7648-2-26/TABLES/1

Elvianasti, M., Lufri, L., Zainul, R., Festiyed, F., Diliarosta, S., Zidny, R., & Damaiana, M. A. (2023). Exploring Indigenous Knowledge of Traditional Martial Art "Silat Beksi" to Identify Contents and Contexts for Science Learning in Biology Education. *Pegem Journal of Education and Instruction, 13*(2), 371-385. https://doi.org/10.47750/PEGEGOG.13.02.40

Roberts, L. A., Muthalib, M., Stanley, J., Lichtwark, G., Nosaka, K., Coombes, J. S., & Peake, J. M. (2015). Effects of cold water immersion and active recovery on hemodynamics and recovery of muscle strength following resistance exercise. *American Journal of Physiology - Regulatory Integrative and Comparative Physiology, 309*(4), R389-R398. https://doi.org/10.1152/ajpregu.00151.2015

Moore, E., Fuller, J. T., Buckley, J. D., Saunders, S., Halson, S. L., Broatch, J. R., & Bellenger, C. R. (2022). Impact of Cold-Water Immersion Compared with Passive Recovery Following a Single Bout of Strenuous Exercise on Athletic Performance in Physically Active Participants: A Systematic Review with Meta-analysis and Meta-regression. *Sports medicine (Auckland, N.Z.), 52*(7), 1667-1688. https://doi.org/10.1007/s40279-022-01644-9

Vaile, J., O'Hagan, C., Stefanovic, B., Walker, M., Gill, N., & Askew, C. D. (2011). Effect of cold water immersion on repeated cycling performance and limb blood flow. *British Journal of Sports Medicine, 45*(10), 825-829. https://doi.org/10.1136/BJSM.2009.067272

Xiao, F., Kabachkova, A. V., Jiao, L., Zhao, H., & Kapilevich, L. V. (2023). Effects of cold water immersion after exercise on fatigue recovery and exercise performance--meta analysis. *Frontiers in Physiology, 14*(January), 1-15. https://doi.org/10.3389/fphys.2023.1006512

Machado, A. F., Ferreira, P. H., Micheletti, J. K., de Almeida, A. C., Lemes, Í. R., Vanderlei, F. M., Netto Junior, J., & Pastre, C. M. (2016). Can Water Temperature and Immersion Time Influence the Effect of Cold Water Immersion on Muscle Soreness? *A Systematic Review and Meta-Analysis. Sports Medicine, 46*(4), 503-514. https://doi.org/10.1007/S40279-015-0431-7/FIGURES/6

Horgan, B. G., Tee, N., West, N. P., Drinkwater, E. J., Halson, S. L., Colomer, C. M. E., Fonda, C. J., Tatham, J., Chapman, D. W., & Haff, G. G. (2023). Acute Performance, Daily Well-Being, and Hormone Responses to Water Immersion After Resistance Exercise in Junior International and Subelite Male Volleyball Athletes.

Journal of Strength and Conditioning Research, 37(8), 1643-1653. https://doi.org/10.1519/JSC.0000000000004428

Dalgaard, F., Xu, H., Matsouaka, R. A., Russo, A. M., Curtis, A. B., Rasmussen, P. V., Ruwald, M. H., Fonarow, G. C., Lowenstern, A., Hansen, M. L., Pallisgaard, J. L., Alexander, K. P., Alexander, J. H., Lopes, R. D., Granger, C. B., Lewis, W. R., Piccini, J. P., & Al-Khatib, S. M. (2020). Management of atrial fibrillation in older patients by morbidity burden: Insights from get with the guidelines-atrial fibrillation. *Journal of the American Heart Association, 9*(23). https://doi.org/10.1161/JAHA.120.017024

Singh, D. P., Lonbani, Z. B., Woodruff, M. A., Parker, T. J., Steck, R., & Peake, J. M. (2017). Effects of topical icing on inflammation, angiogenesis, revascularization, and myofiber regeneration in skeletal muscle following contusion injury. *Frontiers in Physiology, 8*(MAR), 236597. https://doi.org/10.3389/FPHYS.2017.00093/BIBTEX

Wan, J. J., Qin, Z., Wang, P. Y., Sun, Y., & Liu, X. (2017). Muscle fatigue: general understanding and treatment. *Experimental & molecular medicine, 49*(10), e384. https://doi.org/10.1038/emm.2017.194

Визначення ефективності застосування льодової компресії з метою покращення стану фізичної підготовленості щодо зниження частоти серцевих скорочень, рівня ІЛ-6 та індексу втоми спортсменів-футболістів після виконання вправ, спрямованих на розвиток швидкісної витривалості

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 2 табл., 3 рис., 41 джерело.

Мета дослідження. Метою цього дослідження було вивчити вплив льодової компресії для покращення стану фізичної підготовленості (ICEFIT) на зниження частоти серцевих скорочень, рівнів інтерлейкіну-6 (ІЛ-6) та індексу втоми у спортсменів-футболістів після виконання тренувань на розвиток швидкісної витривалості.

Матеріали та методи. Загалом 34 студенти чоловічої статі з факультету підготовки футбольних тренерів Державного університету Сурабаї (Індонезія) віком 18-20 років з нормальним показником індексу маси тіла, щонайменше 10-річним досвідом футбольних тренувань та відсутністю травм за останні 6 місяців були відібрані в якості суб'єктів дослідження та проходили курс лікування ICEFIT протягом 4 тижнів. Збір даних проводився шляхом вимірювання частоти серцевих скорочень, рівнів ІЛ-6 та індексу втоми як на перед-, так і на післяінтервенційному етапах дослідження. Методи аналізу даних включали використання параметричного t-критерію парних вибірок та t-критерію для незалежних вибірок з рівнем значущості 5 %.

Результати. Результати дослідження показали, що застосування льодової компресії для покращення стану фізичної підготовленості сприяло значному зниженню частоти серцевих скорочень, рівнів ІЛ-6 та індексу втоми спортсменів-футболістів після виконання тренувань на розвиток швидкісної витривалості ($p \leq 0,05$). Крім того, спостерігалося суттєве зниження частоти серцевих скорочень, рівнів ІЛ-6 та індексу втоми між групами ($p \leq 0,05$).

Висновки. Отримані дані демонструють ефективність застосування ICEFIT з метою зниження частоти серцевих скорочень, рівнів IL-6 та індексу втоми спортсменів-футболістів після проведення тренувань на розвиток швидкісної витривалості.

Ключові слова: ICEFIT, прозапальний цитокін, спортсмени-футболісти, тренування на розвиток швидкісної витривалості.

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