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Effect of foam rolling followed by cold water immersion on Muscle damage and Delayed Onset Muscle Soreness in youth Soccer Players

تأثير أسطوانة التدليك متبوعة بالغمر في الماء البارد على الضرر والإحساس بالألم العضلي لدى لاعبي كرة القدم شباب

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Abstract : The study aimed to know the effect of foam rolling followed by cold water immersion recovery on muscle damage and delayed onset muscle soreness(DOMS) in youth soccer players after high intensity effort, the study included 20 players of ESS team U19 category from the Algerian championship, the players were randomly divided into two groups 10 players per group (experimental and control), the experimental group used foam rolling followed by cold water immersion us recovery protocol, while the control group had no recovery protocol. firstly the players simulated yoyo test L1 the blood sample had been taken, before,1h,24h after to know the concentration of (CK) and the rate of recovery, also we used visual analogy scale(VAS) before, immediately, after 48h to know the effects of the method on muscle pain and delayed onset muscle soreness(DOMS). The results of this study showed that foam rolling followed by cold-water immersion recovery could be used as a useful way to decrease muscle damage and muscle soreness.

Keywords: foam roller(FR)- cold water immersion(CWI)- muscle damage- muscle soreness(DOMS)

الملخص : تهدف هذه الدراسة إلى معرفة تأثير تمارين أسطوانة التدليك متبوعة بالغمر في المياه الباردة على الضرر العضلي و الإحساس بالألم العضلي عند لاعبي كرة القدم بعد جهد بدني عالي الشدة، شملت الدراسة 20 لاعب من فريق وفاق سطيف - تحت 19 سنة – الناشط في البطولة الوطنية الجزائرية ، قسم اللاعبون عشوائيا إلى مجموعتين متساويتين 10 لاعبين في المجموعة التجريبية و 10 لاعبين في المجموعة الضابطة، في المجموعة التجريبية يقوم اللاعبون بتمارين أسطوانة التدليك متبوعة بالغمر في المياه الباردة كبروتوكول استرجاع، أما المجموعة الضابطة فلا يستخدم أفرادها أي بروتوكول استرجاع، أولا أخذت عينة الدم ثم قام اللاعبون بأداء اختبار Yoyo L1 ثم أخذت عينة دم بعد 1 ساعة و بعد 24 ساعة و ذلك لمعرفة تركيز الكرياتين كيناز مؤشر الضرر العضلي، كذلك استخدم سلم الإحساس

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بالألم العضلي قبل, بعد 1 ساعة و بعد 48 ساعة من الإختبار لمعرفة فعالية بروتوكول الإسترجاع في التخلص من الألم العضلي الناتج عن الجهد البدني عالي الشدة، توصلت الدراسة إلى أن دمج تمارين أسطوانة التدليك متبوعة بالغمر في المياه الباردة كطريقة استرجاع، لها فعالية في التخلص من الضرر العضلي و الإحساس بالألم العضلي بعد جهد بدني عالي الشدة لدى لاعبي كرة القدم.

- **الكلمات المفتاحية: أسطوانة التدليك-الغمر في الماء البارد-الضرر العضلي-الألم العضلي.**

Introduction and problematic of the study:

Physical training involves routinely exposing the body to workloads that are higher than usual in order to cause significant changes in the functions involved in performing the task (Meslem & Bouhal , 2022). Severe workloads, on the other hand, do not always boost performance in high-level athletes who train intensively (Mahdad , Mahdad , & Zaki , 2021). Indeed, after intensive training sessions, a complex combination of cerebral and peripheral responses can cause significant performance reductions. Only when adequate recovery is available will this performance drop be reserved. The state of exhaustion may become so severe if the recovery times are insufficient or not programmed properly. (Hausswirth and Mujika 2013 P 02). Soccer is one of the sports characterized by high-intensity exercise that causes muscle injury and connective tissue damage. Injury and inflammation cause pain that appears one to three days after anaerobic activity, a condition known as delayed onset muscle soreness (DOMS). After high-intensity exercise, muscle damage markers such as creatine kinase levels rise (CK). very often utilized ways for quick recovery (Hartono et al. 2019 P 01).

Foam rolling (FR) is a common technique utilized by athletes after training and competition. (Rey et al. 2019 P06). FR is a type of self-myofascial release (SMR) in which an individual applies direct pressure to the targeted musculature with a

tool. (Wiewelhove et al. 2019)(Romero-Moraleda et al. 2019 04). This technique is based on myofascial release (MR), a term that refers to a variety of manual treatment techniques in which a practitioner applies pressure to a muscle or fascia. (Ajimsha and Al-mudahka 2015). FR is helpful to both athletes and the general public, as it improves flexibility. (Junker and Stöggl 2019), enhancing muscle recovery and enhancing pre and post-exercise muscle performance (Cheatham et al. 2015). FR may also help with muscle stiffness and delayed onset muscle soreness, as well as increasing range of motion. (Hendricks et al. 2020).

In addition, one of the most effective healing strategies utilized after competition and training is cold-water immersion. (djamel, Khiat , & Kasmi , 2021), Cold water constricts arteries and reduces inflammation, lowering creatine kinase production from the muscle in this approach.,(Machado et al. 2016,Farkhari et al. 2021) immersion in cold water also generates hydrostatic pressure on the body, which leads blood to migrate from the lower sections of the body to the chest area, causing blood flow to eliminate chemicals from the metabolism more quickly. (Ascensão et al. 2011 P09,Pournot et al. 2011 P03). In addition to reducing inflammatory responses, muscular damage, oedema, and discomfort, immersion in cold water inhibits cell permeability through vasoconstriction. Because this strategy can help reduce oedema and inflammatory reactions caused by tissue damage after intensive and traumatic exercise, it may be a good way to reduce oedema and inflammatory responses caused by tissue damage.(Pointon et Duffield 2012), and the study of (Pooley et al. 2020) showed that CWI is beneficial recovery intervention for elite young soccer players following competitive soccer matches. Some studies makes combination between foam rolling and cold water immersion (Kumar, John, and Jimshad 2018) they found that there was a significant reduction in pain as

compared to improvement in ROM of the elbow when foam rolling was followed by CWI on body building athletes. In our study, we tried to make combination between foam rolling method and cold-water immersion method to know the effect of this new method on the rate of recovery on young soccer players.

Objectives

Although several studies had been conducting on the effect recovery methods on the rate of recovery or the improvement of performance, there are still many ambiguities about the combination between different recovery methods. Therefore, this study aimed to investigate the effects of foam rolling followed by cold-water immersion recovery on muscle damage and muscle soreness DOMS in young male soccer players after a simulated high intensity exercise.

Previous and similar studies

First study

Ravi kumar, anil T john, Jimshad T u; study entitled "effect of foam rolling followed by cryotherapy versus cryotherapy followed by foam rolling on pain and range of motion for delayed onset muscle soreness in amateur body builders" a comparative study. In department of physiotherapy, Bangalore, Karnataka, india, in 2018.

The study included 20 male and female amateur bodybuilders who underwent 6 months of resistance training, assessed inclusion and exclusion criteria, obtained informed consent, and obtained ethical approval from the institution. The subjects were divided into 2 groups, group A (n=10) received cryotherapy followed by foam rolling. Group B (n = 10) foam rolling followed by cryotherapy. Anterior-posterior measurement of pain measurement and goniometer measured ROM using VAS.The results showed that foam rolling and cryotherapy helped significantly reduce muscle pain. Whether cryotherapy and foam rolling

have a significant effect on increasing range of motion rather than pain relief(Kumar et al. 2018).

Second study

Hossein moradi, and amirabbas monazzami, study entitled "effect of cryotherapy and foam rolling recovery methods on performance and muscle damage induces in young male soccer players after simulated soccer match". Department of sport physiology, faculty of sport sciences, Razi University, Kermanshah, iran, in 2020.

For this study, 21 male subjects were selected and randomized into three recovery groups after a simulated football match. Foam roller recovery involves massaging different muscle groups with a foam roller. Cold water immersion recovery involves submerging the body up to the neck in cold water at 15°C. The object is inactive without active recovery. The variables aerobic power, explosive power, speed, lactate, dehydrogenase, and creatine kinase were measured using the Yoyo Recovery Test, Sargent Jump Test, 20m Speed Test, Lactate Meter, Elisa Test, respectively, and the two-way repeated-measures Anova test was used to determine Differences in confidence intervals. The results showed a significant difference in the muscle damage index between the foam roller recovery group and the control group 24 hours after the simulated football game. However, no significant differences in performance metrics were observed in-group comparisons with active recovery. Foam rolling recovery appears to act as a useful method to speed recovery compared to water immersion recovery by reducing the inflammatory response (Moradi and Monazzami 2020).

Third study

Sam Pooley, Owen Spinriff, matt Allen and Hannah Jayne Moir, entitled "comparative efficacy of active recovery and cold water immersion as post-match recovery interventions in elite youth soccer". Medical & sports science

department, Tottenham hotspur football club, Kingston University, London, UK, in 2019.

The researchers evaluated the effects of cold-water immersion (CWI) and active recovery (AR) on muscle recovery after competitive soccer matches in elite youth players (n=15). Participants in a controlled crossover design played nine competitive soccer games, three 80-minute games for each intervention (SS, CWI and AR). Muscular oedema, creatine kinase (CK), counter movement jump performance (CMJA), and felt muscle soreness (PMS) were measured before, immediately after, and 48 hours after the match, and the results were compared between time periods and interventions. At 48 hours after SS, all measures of muscle injury remained considerably increased relative to baseline. CMJA returned to baseline after AR and CWI at 48 hours post-match, but CK only returned to baseline after CWI at 48 hours post-match. When comparing AR and CWI to SS, there was a significant improvement in PMS at 48 hours post-match, with no significant differences between AR and CWI. When comparing CK and CMJA percentage changes to SS, AR and CWI showed considerable improvements. Both AR and CWI were found to be beneficial recovery therapies for elite young soccer players following competitive soccer matches, and both were found to be superior to SS.(Pooley et al. 2020)

Fourth study

Sharief Hendricks, hayd'n Hill, Steve den Hollander, Wayne Lombard, Romy parker. Study entitled "Effects of Foam Rolling on Performance and Recovery: A Systematic Review of the Literature to Guide Practitioners on the use of Foam Rolling". University of Cape Town, Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences, South Africa, in 2019.

Seven electronic databases were searched using a customized search strategy: Google Scholar, Science Direct, PubMed Central, PubMed, ISI Web of Science, Medline, and Scopus. The database search was restricted to British journals published between January 2006 and June 2019. Any study design was considered, including cross-over, repeated measurements, and randomized-control trials, as long as one of the interventions used a FR. Studies combining FR with other approaches were also taken into account, as long as one of the conditions was FR only. The findings demonstrate that FR can help to reduce muscle stiffness and increase range of motion, and that it should be used in conjunction with dynamic stretching and an active warm-up before a workout. Furthermore, a total of 90s-120s of FR appears to be the ideal dosage for achieving these flexibility benefits. Because FR reduced DOMS and enhanced PPT, it may help athletes recover faster from training. Future research on the impacts of FR should include actual controls or sham groups, as well as the athlete's FR experience.(Hendricks et al. 2020).

Fifth study

Ezequiel Rey, Alexis Padrón-Cabo, Pablo B. Costa, and Roberto Barcala-Furelos, study entitled" The Effects of Foam Rolling as a Recovery Tool in Professional Soccer Players". Faculty of Education and Sport Sciences, University of Vigo, Pontevedra, Spain, in 2017.

The purpose of this study was to see how effective FR (20 minutes of foam rolling exercises on quadriceps, hamstrings, adductors, gluteals, and gastrocnemius) and passive recovery (20 minutes of sitting on a bench) interventions on Total Quality Recovery (TQR), perceived muscle soreness, jump performance, agility, sprint, and flexibility 24 hours after a training session were. 18 professional soccer players took part in a randomized fully controlled trial design over the course of two experimental sessions. The first session's goal was

to collect each variable's pre-test values. Following the baseline assessments, the athletes engaged in a standardized soccer training session. All players were randomly assigned to the FR recovery group and the passive recovery group at the end of the training unit. To get the post-test values, a second experimental session was conducted. The results of the between-group studies revealed that FR had a significant impact on agility recovery and subjective muscular soreness at 24 hours after training as compared to the passive recovery group. To improve recovery between training loads, soccer coaches and physical trainers working with high-level players should employ an organized recovery session lasting 15 to 20 minutes based on FR exercises that might be performed at the end of a training session.(Rey et al. 2019)

Sixth study

Jakub Grzegorz Adamczyk, Karol Gryko, Dariusz Boguszewski, study entitled" Does the type of foam roller influence the recovery rate, thermal response and DOMS prevention?". Theory of Sport Department, Jozef Pilsudski University of Physical Education in Warsaw, Warsaw, Poland, in 2020.

This randomized trial included 33 active healthy males who were split into three groups of eleven: foam rolling with a smooth (STH) or grid roller (GRID) or passive recovery (PAS). For one minute, all of the participants did complete squat jumps. At rest (thermal imaging of skin temperature and blood lactate), immediately after exercise, immediately after recovery treatment, and after 30 minutes of rest, the subjects were examined (Tsk & LA). The Visual Analog Scale (VAS) was used to assess their pain levels 24 hours, 48 hours, 72 hours, and 96 hours following activity. Foam rolling appears to be useful for increasing lactate clearance and reducing DOMS, however the type of foam roller used has little effect on recovery time.(Adamczyk, Gryko, and Boguszewski 2020).

Seventh study

Soetanto Hartono, Achmad Widodo, Himawan Wismanadi and Gulbuldin Hikmatyar, study entitled" The Effects of Roller Massage, Massage, and Ice Bath on Lactate Removal and Delayed Onset Muscle Soreness". Surabaya State University, Faculty of Sport Sciences, Surabaya, Indonesia, 2019.

The objective of this study was to see if rolling massage, massage, and an ice bath may help with lactate elimination and delayed onset muscular pain. Thirty third-semester students from the Faculty of Sport Sciences were randomly allocated to one of three groups: roller massage, massage, or cold bath. After a 10-minute warm-up, all groups performed the Running-based Anaerobic Sprint Test (RAST). All students had their blood lactate measured using a blood lactate analyzer eight minutes after RAST. The roller massage group received 5 minutes of treatment with a foam roller, the massage group had 5 minutes of massage, and the ice bath group received 5 minutes of immersion in 10 degrees cold water, after which their blood lactate levels were re-examined. The data was analyzed using nonparametric Kruskal Wallis after the normality and homogeneity tests of roller massage. Despite the lack of significance, lactate removal appears to be the most effective in ice bath treatment when compared to massage and roller massage, and reduction in Delayed Onset Muscle Soreness (DOMS) appears to be the most effective in ice bath treatment when compared to massage and roller massage. The ice bath's vasoconstriction impact resulted in quicker lactate elimination, and physicality may possibly have a role. The ice bath's cooling impact has a strong analgesic effect(Hartono et al. 2019).

Followed Methodologies:

Participants

Thirty (20) young soccer players of E.S.Setif team under 19 years (U19) of the Algerian first professional championship(mean +SD: age = 18,16 ± 0,55 years,

height = 180,65 ± 5,82 cm, weight = 67,72 ± 6,70 kg, BMI = 20,58 ± 1,44 kg/m) the players were randomly divided into two groups of 10 players per group(experimental and control) the experimental group (EG) use foam rolling FR followed by cold water immersion CWI, and the control group (CG) in inactive recovery this mean the subjects had no activity.

Table 1. Demographic characteristic of the sample.

Variables	Mean ± SD
Age (years)	18,16 ± 0,55
Height (cm)	180,65 ± 5,82
Weight (kg)	67,72 ± 6,70
Body mass index (kg/m_2)	20,58 ±1,44

SD- standard deviation

Table 1 showed characteristic of the sample, Mean ± SD; age(18,16 ± 0,55), height(180,65 ± 5,82), weight(67,72 ± 6,70), Body mass index(20,58 ±1,44).

Table 2. Comparison between groups in pre-tests.

Variables	Groups	Pre-tests	P-value
CK	EG	37.50 ± 16.40	0.089
	CG	52 ± 11.9	
DOMS	EG	1.4 ± 0.56	0.999
	CG	1.4 ± 0.48	

EG - experimental group, CG - control group, P- probability

The table 2 shows that there are no statistically differences between the experimental group and control group in pre-tests. ($p>0.05$), this means that the sample is equivalent in the pre-tests.

Study variables

The study used two groups of teen participants each group, the sample tested pre-post test to determine the effect of the independent variable on the

dependent variable, the independent variable was FR followed by CWI, while the dependent variable was muscle damage and muscle soreness.

Research design and measurements

Creatine kinase (CK)

formerly known as creatine phosphokinase, is an intracellular enzyme present in greatest amounts in skeletal muscle, myocardium, and brain; smaller amounts occur in other visceral tissues(Cabaniss 1990), the appearance of creatine kinase (CK) in blood has been generally considered to be an indirect marker of muscle damage(Baird et al. 2012). This indicator used widely in sport to know the muscle damage and measure the rate of recovery after training sessions and competitions.

Visual analogy scale (VAS)

The Visual Analogue Scale (VAS) is a popular tool for the measurement of pain(Heller, Manuguerra, and Chow 2016), the subjects were asked to indicate their perceived level of muscle pain(soreness), the visual analogy pain scale consists of a 6 cm line with descriptors at each end.

Study Protocol

In the week preceding the study, anthropometric tests was taken(height, weight, BMI).The 5-10 ml blood sample was taken from the right arm vein(Moradi and Monazzami 2020), of each participant, before, after 1h, after 24h, also the pain and muscle delayed onset soreness were measured in three stages, before, after 1h, after 48h using the visual analogy scale(VAS) according to the perception of the players using 1 to 6 Scale(Hartono et al. 2019). The yoyo intermittent recovery test L1 used us an exercise induced muscle damage, when the blood sample and DOMS(VAS) was taking, the participant simulated yoyo intermittent recovery test L1, 1h after the test the blood sample and DOMS was taming again for the second time, than immediately the players performed the

recovery protocol; foam rolling FR followed by cold-water immersion CWI, in FR method the subjects performed five different exercises using a FR with 45s each position, for this purpose muscle groups(triceps sural, hamstrings, quadriceps, adductors, Gluteal muscles, abdominal muscles and spinal straightening muscles) were targeted(Junker and Stöggl 2019,Wiewelhove et al. 2019), than immediately the players immersed their bodies to the iliac crest in an ace-bath with a temperature of 6°C – 8°C for 8min(Bahnert, Norton, and Lock 2013), after 24h the same protocol of recovery was performed, the blood sample and VAS was taken again for the third time.

Statistical Analyses

The study used mean and standard deviation (SD) with all the value. Statistical analyses used SPSS program version 28, paired T-test used within group and independent T-test used between groups comparison.

Results

Table 3. Comparison of creatine kinase post-test 1h and post-test 24h.

Variables	Groups	Test	Mean ± SD	P-value
CK	EG	Post-test 1h	391.60 ± 33.51	0.001
		Post- test 24	215.19 ± 73.37	
	CG	Post-test 1h	397.58 ± 53.13	0.363
		Post- test 24	378.64 ± 40.99	

According to the results of CK post-test 1h and post-test 24h, the table 2 shows statistically significant decrease in muscle damage in EG after the recovery protocol FR followed by CWI. While CG shows no significant decrease in muscle damage. $p>0.05$

Figure 1. The change in CK sample in different stages.

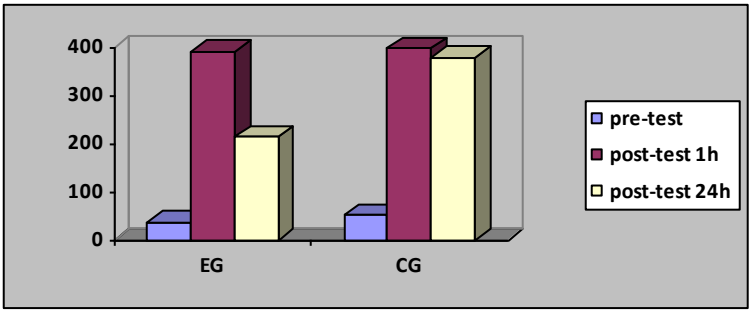

Table 4. Comparison of DOMS post-test 1h and post-test 48h.

Variables	Groups	Test	Mean ± SD	P-value
DOMS	EG	Post-test 1h	4.5 ± 0.8	0.001
		Post- test 48h	1.4 ± 0.48	
	CG	Post-test 1h	5.3 ± 0.96	0.081
		Post- test 48h	4.2 ± 0.88	

According to the results of DOMS post-test 1h and post-test 24h, the table 3 shows statistically significant decrease in muscle soreness in EG after the recovery protocol FR followed by CWI. While CG shows no significant decrease in muscle soreness. $p>0.05$

Figure 2. The change of DOMS in different stages

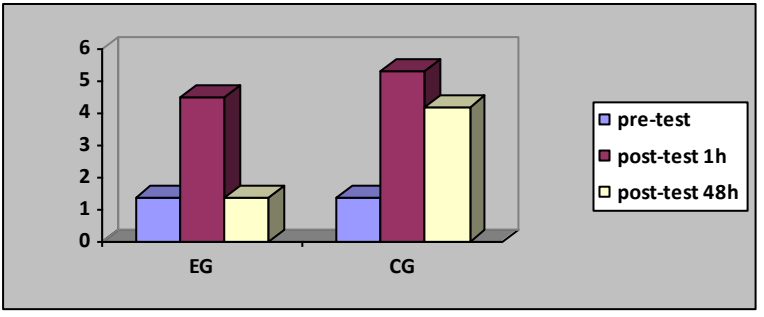

Table 5. Comparison between study tests in post-test 24h for Ck and 48h for DOMS.

Variables	Mean ± SD	P-value
CK	215.19 ± 73.37	0.001
	378.64 ± 40.99	
DOMS	1.4 ± 0.48	0.001
	4.2 ± 0.88	

Table 5 shows that there are statistically significant differences between experimental group and control group in post-tests 24h for CK and 48h for DOMS in favor of the experimental group for both CK and DOMS.

Discussion

As the most important finding of the present study, The use of foam rolling followed by a cold-water immersion recovery approach was found to be an effective way to accelerate recovery following simulated high-intensity exercise. In terms of our hypothesis. We claimed that in the FR method, the individuals completed five different exercises with a FR for 45 seconds in each position, with muscle groups (triceps sural, hamstrings, quadriceps, adductors, Gluteal muscles, abdominal muscles, and spinal straightening muscles) targeted.(Junker and Stöggl 2019,Wiewelhove et al. 2019), whether in CWI the players immersed their bodies to the iliac crest in an ace-bath with a temperature of 6°C – 8°C for 8min(Bahnert et al. 2013), after 24h the same protocol of recovery was applied again.

The result showed that recovery using foam rolling followed by cold-water immersion decrease CK the indicator of muscle damage compared to control group. The results of within-group comparison showed that the level of CK decrease after applying foam-rolling exercises followed by cold-water immersion protocol, also the comparison between groups shows an advantage in favor of experimental group (EG); this means that recovery method was effective in reducing muscle damage.

The findings of this study are in conformity with those of a previous study of (Moradi and Monazzami 2020) studies in terms of the effectiveness of foam rolling exercises and cold water immersion in reducing muscle damage.
Also an important finding of the present study that foam rolling followed by cold water immersion can be a useful method to reducing muscle soreness DOMS.

The data of the within-group comparison revealed that muscular soreness decreased after performing foam-rolling activities followed by cold-water immersion, and the comparison between groups revealed that the experimental group had an advantage., this means that the recovery method was effective in reducing muscle soreness.The results of the present study consistent with the results of (Kumar et al. 2018) studies in terms of the effectiveness of foam rolling followed by cold water immersion in decreasing muscle soreness DOMS.

Conclusion

This study found that foam rolling followed by cold water immersion recovery is an effective method for reducing muscle damage and muscle soreness (DOMS), improving the rate of recovery for youth soccer players after simulated high-intensity exercises. A combination of recovery methods may also be more effective for accelerating recovery.

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