

An Electromyography (EMG) Analysis After Pre-Cooling Between Male and Female in Recreational Runners

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ABSTRAK

Latar belakang: Menjaga suhu tubuh internal sangat penting untuk kinerja pelari. Ketidakmampuan dalam menurunkan suhu yang meningkat saat berlari dapat menyebabkan hipertermia, dan mengakibatkan kelelahan otot. Pre-cooling dapat menurunkan suhu inti, memungkinkan penyimpanan panas yang lebih besar selama latihan dan menunda kelelahan akibat panas, serta meningkatkan output motorik melalui penurunan aktivitas listrik dengan mendinginkan otot. Selain itu, ada sedikit penelitian yang membandingkan aktivitas listrik di otot antara perbedaan gender dalam menanggapi latihan berkepanjangan setelah pre-cooling. **Tujuan penelitian:** Untuk mengetahui perubahan aktivitas listrik sebelum dan sesudah rendaman air dingin (CWI) pada pelari pria dan wanita. **Metode:** Studi ini melibatkan 2 laki-laki dan 2 perempuan berusia 20 tahun yang merupakan pelari yang aktif dengan IMT normal. Hasil penelitian ini diukur menggunakan elektromiografi (EMG) yang dilakukan setiap 4 menit saat sesi lari 1 dan 2 (16 menit). **Hasil:** Aktivitas listrik (mV) subjek laki-laki menurun secara signifikan antara 8 ke 16 menit dan 16 ke 8 menit ($p=0.041$, $p<0.05$). Namun tidak pada subjek perempuan ($p>0,05$). **Kesimpulan:** Bahwa CWI sebagai pre-cooling berpengaruh menurunkan tingkat aktivitas listrik pada otot selama berlari pada kedua jenis kelamin.

Kata kunci: elektromiografi, aktivitas otot, rendaman air dingin, mini maraton, pelari jarak jauh.

ABSTRACT

Background: Maintaining internal body temperature is critical for the runner's performance. The inability to reduce the rising temperature may result in hyperthermia and muscle fatigue. Pre-cooling may lower core temperature, allowing for greater heat storage during exercise and delaying thermally-induced fatigue, as well as increased motor output through decrease electrical activity by cooling the muscles. Furthermore, there have been lack studies that compare electrical activity in muscle between gender differences in response to prolonged exercise after pre-cooling. **Objective:** The purpose of this study to investigate the changes in electrical activity pre and post cold water immersion (CWI) in male and female recreational runners. **Methods:** This case involved 2 males and 2 females aged 20 years old who are physically active runner with normal-weight BMI. The outcome was measured using electromyography (EMG) which was carried out every 4 minutes while 1st and 2nd running sessions (16 minutes). **Results:** Male subjects' electrical activity (mV) decreased significantly between 8 to 16 minutes and 16 to 8 minutes ($p=0.04$, $p<0.05$). But not in female subjects ($p>0.05$). **Conclusion:** It can be concluded that CWI as pre-cooling had an effect of lowering the electrical activity level in the muscle during running in both genders.

Keywords: electromyography, electrical activity, cold water immersion, gender, recreational runner.

INTRODUCTION

Running is one of the most popular and practiced sports worldwide. Running is also one of the most effective ways to boost physical health, but it comes with a high risk of injury, with rates ranging from 19 to 79%, especially in recreational and amateur runners (Gent et al. 2007).

Maintaining internal core body temperature is critical for runner performance, which occurs when heat production exceeds heat loss capacity, resulting in body temperature elevation. The inability to reduce the rising temperature may result in hyperthermia and muscle fatigue (Bongers et al. 2017).

Muscle fatigue was defined as a decrease in maximal force or power output in response to contractile activity. Fatigue was a defense mechanism that prevented homeostasis disorder, which put physical health at risk, particularly the brain, which was highly capable of increasing temperature. High body temperature appeared to have an effect on endurance performance while exercising under increasing thermal pressure (Sadri et al. 2014).

Pre-cooling may reduce the initial core temperature, allowing for more heat storage during exercise and delaying thermally-induced fatigue. Central mechanisms have also been proposed, in which afferent feedback from thermoreceptors signaling lower body temperatures and less central fatigue may allow for higher motor output through decreased electrical activity in the muscle (Stevens et al. 2016, Tyler et al. 2013). Furthermore, there have been lack studies that compare male and female responses to CWI as pre-cooling (Cheuvront and Haymes, 2001).

As a result, the current study aimed to examine the difference in electrical activity before and after CWI between gender differences of recreational runners. It was hypothesized that CWI would result a decrease in electrical activity compared to before it was applied.

MAIN TOPIC

Case report

This case involved 20 years old 2 males and 2 females who are an undergraduate student in Khon Kaen University, Thailand. They are both runners who have physically active lifestyle (1 to 3 times per week, for at least 6 months) with body mass index classified as normal-weight (18.5 - 24.9 kg/m²), no smokers, did not have the history of allergy or high sensitivity of cold exposure (Cameron, 2013), did not have a cardiovascular and pulmonary disease (such coronary disease, hypertension), for female were not in menstrual cycle period.

Before data collection, the subject was provided verbally consent and asked to sign the consent form by the researcher. This study was approved by Ethics Committee of Khon Kaen University (Ref. No: HE642206) and conducted at Physical Therapy research laboratory, Faculty of Associated Medical Sciences, Khon Kaen University, Thailand.

Measurement



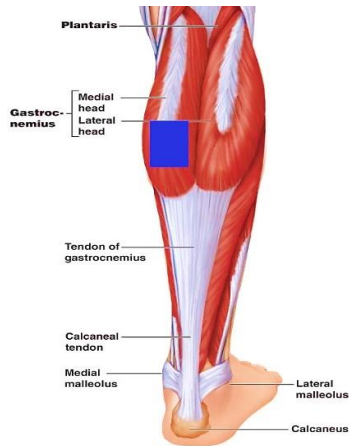


Figure 1. Surface Electromyography (EMG) and electrode placement

Electromyography (EMG) with surface electrodes was used in this study to measure electrical activity (Delsys Inc., Boston, USA). EMG data was collected from the dominant-side lower extremity muscle, the medial gastrocnemius. Bipolar surface electrodes were attached to the participant's skin at the distal muscle belly of the medial gastrocnemius muscle (Wang et al. 2014). The participant's skin was shaved and cleaned with alcohol before the electrode placement.

Intervention



Figure 2. Cold water immersion (CWI)

The subjects were immersed in cold water at their hip level by sitting in a plastic tub. They were immersed in 2 different temperatures of cold water, the first 3 minutes at 15-20°C for familiarization and the second 5 minutes at 8-10°C for the main CWI protocol. The CWI was given once, before the second running session. A glass thermometer was used to constantly monitor the temperature of the cold water.

Study protocol

There were 2 running sessions for this study. The subjects were instructed to do dynamic stretching for 5 minutes (3 sets of 30 seconds each of hip extensor/flexor, adductor/abductor with full extension of legs, trunk circles, and passive ankle rotation) and running on a treadmill (Bolzen EX, Australia) for 3 minutes prior to the main study. The subjects then ran on the treadmill for 16 minutes at their own average running speed of 7 km/h, and the first outcome measurement was taken (Jones et al. 2020). After the first running session, the subjects were asked to cool down using the same protocol as the warm-up, and then they were asked to rest for 30 minutes (Ryu et al. 2016). The following session was cold water immersion (CWI) application, and the final session was the second running session, which followed by the same protocol as the first running session and measured the second outcome. While they were running, the outcome was measured every 4 minutes. This research was carried out in a temperature-controlled (25°C) room.

Statistical analysis

The value was expressed as mean SD, and all statistical analysis was carried out using the SPSS version 28.0 with the level of significance set to 0.05. The Shapiro-Wilk test was used to ensure that all outcomes were normally distributed. ANOVA with repeated measures was used to compare changes within different genders over time. For multiple comparisons, the LSD post-hoc test was used.

RESULTS

This study included 4 subjects, 2 males and 2 females. Table 1 shows the significance difference in gender comparisons of some characteristics. Only the height characteristic differed significantly between male and female ($p=0.01$, $p<0.05$).

Table 1. Data characteristics subjects

Characteristics	Male n=2	Female n=2	p-value
Weight (kg)	65.0±1.4	49.0±5.7	0.06
Height (cm)	177.5±3.5	158.5±0.7	0.01*
BMI (kg/m ²)	20.7±0.4	19.5±2.1	0.52

Data are presented as means±SD. Independent sample t-test was used to analyze the differences between genders, * $p<0.05$.

Table 2 and Figure 3 show the electrical activity changes in both genders before and after CWI every 4 minutes for 16 minutes. Male subjects' electrical activity (mV) decreased significantly between 8 and 16 minutes and 16 to 8 minutes ($p=0.04$, $p<0.05$). Female subjects showed no significant difference ($p>0.05$) (Table 2).

Table 2. Gender comparison between before and after CWI every 4 minutes in twice measurements.

Time (min)	MALE		FEMALE	
	Before	After	Before	After
Baseline	1440.5	1478.5	1415	964.4
4	±518.3	±404.2	±561.3	±363.4
8	1413.2	1320.9	1427.8	845.7
12	±163.7	±355.9	±402.6	±126.4
16	1265.2	1172.3	1407.8	852.2
4	±202.2*	±319	±635.1	±100.3
8	1346.3	1145.8	1936.6	835.5
12	±69.5	±386.4	±1262.9	±132.5
16	1010.9	1297.4	1170.3	630.5
4	±351.3*	±480.0	±856.4	±16.1

Data are presented as means±SD. *significant difference $p<0.05$.

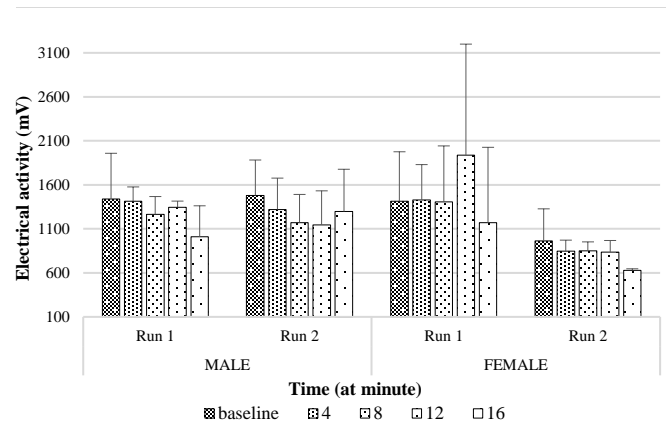


Figure 3. Electrical activity (mV) changes before and after CWI in every 4 minutes for 2 running sessions in male and female.

Prior to CWI, male and female subjects' electrical activity showed a similar result. However, after 5 minutes of immersion in cold water (8-10°C), it changed, and female subjects had lower electrical activity.

DISCUSSION

The purpose of this study was to see if there was a difference in electrical activity between male and female recreational runners before and after CWI. Male and female subjects showed different electrical activity results, with females showing a lower result almost all of the time than males. Many physiological parameters, including skeletal muscle ratio and subcutaneous fat thickness, differ by gender. Several previous studies have consistently identified estrogen as the most consistently identified source of these differences (Paredes-Ruiz et al. 2021).

There were no statistically significant differences between genders. Females, on the other hand, have lower electrical activity before and after CWI than males. Previous research found that testosterone may increase type II fibers, and that males have a high proportion of these fibers. Males and females have different body compositions in general; females have more

fat mass, whereas males have more muscle mass (Dhananjaya et al. 2017).

Cooling decreased nerve conduction velocity in motor neuron terminals as well as the number of acetylcholine molecules binding to the postsynaptic receptor, causing muscle contraction times to be delayed (Hurr, 2021). Temperature effects on metabolic rate and maximal rate of adenosine triphosphate (ATP) hydrolysis may explain changes in rate processes as temperature decreases. Slow contraction speed may be caused by delayed calcium release from the sarcoplasmic reticulum, decreased calcium sensitivity, and impaired kinetics of muscle fiber action potentials. Because fast twitch fibers are recruited at lower temperatures, accelerating fatigue, early fatigue defense mechanisms (via prolonged contractions) will be beneficial to fatigue resistance (Drinkwater, 2008).

In recreational runners, an increase in body temperature caused by strenuous activity has a negative impact on another physiological response during running activity. Elevated body temperature has been implicated as a contributing factor to poor performance during outdoor exercise (Junior et al. 2021). Pre-cooling had the primary effect on heat balance in that more heat was stored during activity, allowing for a slower rise in body temperature during exercise. Heat storage capacity was created by pre-cooling, which was used during the initial phase of exercise (Daanen et al. 2006).

Thermoregulatory responses should be monitored in all running time, also physical performance should be measured to compare the effect of before and after the CWI is applied. A comparison of all runner classifications in pre-cooling application is needed.

CONCLUSION

It can be concluded that CWI as pre-cooling had an effect of lowering the electrical activity level in the muscle during running in both genders. CWI as pre-cooling had a significant

positive effect on the electrical activity condition in the muscle, according to the results. Cold exposure prolongs muscle contractions, which is beneficial to muscle fatigue resistance caused by increased fast twitch fibers during running.

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REFERENCES

- Andersen JJ. 2019. The State of Running. <https://runrepeat.com/state-of-running>.
- Bongers CCWG, Hopman MTE, Eijssvogels TMH. 2017. Cooling Interventions for Athletes: An Overview of Effectiveness, Physiological Mechanisms, and Practical Considerations. *Temperature*. 4(1):60-78.
- Cameron MH. 2013. Physical Agents in Rehabilitation from Research to Practice Fourth Edition. Elsevier Saunders. Pennsylvania.
- Cheuvront SN, Haymes EM. 2001. Thermoregulation and Marathon Running Biological and Environmental Influences. *Sport Medicine*. 31(10), 743-762.
- Daanen HA, Es EM, Graff JL. 2006. Heat Strain and Gross Efficiency during Endurance Exercise after Lower, Upper, or Whole-Body Precooling in the Heat. *International Journal of Sports Medicine*. 27(5):379-388.
- Dhananjaya JR, Veena HC, Mamatha BC, et al. 2017. Comparative Study of Body Mass Index, Hand Grip Strength, and Handgrip

- Endurance in Healthy Individuals. *National Journal of Physiology, Pharmacy and Pharmacology*. 7(6):594-598.
- Drinkwater, Eric. 2008. Effects of Peripheral Cooling on Characteristics of Local Muscle. *Medicine and Sport Sciences*. 53, 74-88.
- Gent RN, Middelkoop M, Os AG, et al. 2007. Incidences and Determinants of Lower Extremity Running Injuries in Long Distance Runners: A Systematic Review. *British Journal of Sports Medicine*. 41(8), 469-480.
- Hurr, Chansol. 2021. Acute Local Cooling to the Lower Body during Recovery Does not Improve Repeated Vertical Jump Performance. *International Journal of Environmental Research and Public Health*. 18(9):5026.
- Jones AM, Kirby BS, Clark IE, et al. 2020. Physiological Demands of Running at 2-Hour Marathon Race Pace. *Journal of Applied Physiology*. 130(2), 369-379.
- Junior JR, Prado DM, Sena AF, et al. 2021. Physiological Responses during the Long-distance Race in the Warm Environment in Runners: A Pilot-study. *The Journal of Sports Medicine and Physical Fitness*. 61(6).
- Paredes-Ruiz MJ, Jodar-Reverte M, Gonzalez-Moro IM, et al. 2021. Effects of Gender on Oxygen Saturation of Thigh Muscles during Maximal Treadmill Exercise Testing. *Sport Mont*. 19(1).
- Ryu JH, Paik IY, Woo JH, et al. 2016. Impact of Different Running Distances on Muscle and Lymphocyte DNA Damage in Amateur Marathon Runners. *The Journal of Physical Therapy Science*. 28, 450-455.
- Sadri K, Khani M, Sadri I. 2014. Role of Central Fatigue in Resistance and Endurance Exercises: An Emphasis on Mechanisms and Potential Sites. *Sportlogia*. 10(2), 65-80.
- Stevens CJ, Kittel A, Sculley DV, et al. 2016. Running Performance in the Heat is Improved by Similar Magnitude with Pre-Exercise Cold-Water Immersion and Mid-Exercise Facial Water Spray. *Journal of Sports Sciences*. 35(8), 1-8.
- Tyler CJ, Sunderland C, Cheung SS. 2013. The Effect of Cooling Prior to and during Exercise on Exercise Performance and Capacity in the Heat: A Meta-analysis. *British Journal of Sports Medicine*. 49(1).
- Wang L, Hong Y, Li JX. 2014. Muscular Activity of Lower Extremity Muscles Running on Treadmill Compared with Different Overground Surfaces. *American Journal of Sports Science and Medicine*. 2(4), 161-165.