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THE EFFECTIVENESS OF COLD IN POST-EXERCISE RECOVERY IN SPRINT KAYAKING

◦ ARTIGO CIENTÍFICO ORIGINAL ◦

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ABSTRACT

Study design: Prospective observational cohort study.

Background and aims: In kayak sprint competitions the athletes often do several races in a brief period of time with a small period to recover. High performance training also involves daily training sessions with high volume and intensity. Cold is used in sports as a quick and easy recovery method therefore the goal of the current study is to analyze the impact of a cooling vest in the recovery of elite sprint kayakers using blood lactate concentrations, Borg's RPE scale, subjective measurements and thermography, which is a non-radiating and contact-free technology used to monitor skin temperature.

Methods: Ten elite sprint kayakers (21.63 ± 2.85 years old; height, 177.9 ± 7.33 cm; body mass, 75.18 ± 7.33 kg; 10.19 ± 4.65 % fat mass) completed, in kayak ergometer, on two days apart the same protocol except for the active rest, in which, randomly, in one of them used a cold vest (Inuteq Siku PAC® & H2O®). Each moment was performed in a room with controlled temperature (20.93°C to 21.22°C) and humidity (66.04% to 68.90%) and consisted in 15 min of acclimatization, warm-up, 5 times 5 min (at 75% maximal average power (MAP) in 4 min test), 15 min of active rest at 40% MAP, 15 min of passive rest and finally a 500 m maximal test. On both moments it was determined the blood lactate concentration, the core temperature assessed by urine temperature, skin temperature above *latissimus dorsi* muscle using thermography and it was asked the rating of perceived exertion (Borg's RPE Scale) and recovery (0 to 10 scale with 10 representing completely recovered).

Results: There was no significant difference between the performance in 500 m maximal test in the two moments. However, the athlete's subjective perception of recovery was significantly higher with vest ($p<0.01$). The blood lactate concentration was significantly lower after the active recovery using the cold vest ($p<0.05$) as well as skin temperature ($p<0.01$) and core temperature 15 minutes after the active rest ($p<0.05$).

Conclusions: The results suggest that the use of a cooling vest during active recovery after training or competition can improve recovery. It can be interesting to test it in on-water situation.

KEYWORDS: THERMOGRAPHY; COLD; KAYAK SPRINT; RECOVERY; WATER SPORTS.

RESUMO

Desenho do estudo: estudo observacional, tipo coorte prospectivo.

Introdução e objetivos: Nas competições de canoagem de velocidade, os atletas realizam várias provas com pouco tempo de recuperação. O treino de alta competição inclui, também várias sessões de treino diárias com um grande volume e elevada intensidade. A utilização do frio como um método de recuperação de rápida e fácil utilização é vasta. Assim, este estudo tem como objetivo analisar as alterações provocadas pelo uso do frio através da termografia de infravermelhos, uma tecnologia que permite, de forma não invasiva, avaliar alterações na temperatura da pele.

Materiais e métodos: Dez canoístas de elite (idade, 21,63 ± 2,85 anos; estatura, 177,9 ± 7,33cm; massa corporal, 75,18 ± 7,33kg; % massa gorda, 10,19 ± 4,65%) completaram, em kayak ergómetro, em dois dias separados, o mesmo protocolo com exceção da recuperação ativa, no qual, de forma randomizada, num dos momentos utilizaram um colete de frio (Inuteq Siku PAC® & H2O®). Ambos os momentos de estudo foram realizados numa sala com temperatura (20,93°C a 21,22°C) e humidade (66,04% a 68,90%) controladas. O protocolo consistia em 15 min de aclimatização, aquecimento, 5 séries de 3 min (a 75% da potência máxima média (PMM) num teste de 4 min), 15 min de recuperação ativa a 40% da PMM, 15 min de descanso passivo e, um teste de simulação de prova de 500m. Em ambos os protocolos do estudo, foi avaliada a temperatura no músculo latissimus dorsal, bilateralmente, com termografia de infravermelhos em 5 momentos, foi feita a medição da concentração de lactato sanguíneo, da temperatura central através da temperatura da urina e inquirida, antes da realização da série de simulação de prova, a perceção subjetiva de recuperação (escala de 0 a 10, em que 10 indica recuperação total).

Resultados: Não houve diferenças estatisticamente significativas entre os testes de simulação nde prova de 500m. Contudo, a perceção subjetiva de recuperação foi significativamente mais alta aquando do uso de colete ($p<0,01$). A concentração de lactato sanguíneo foi significativamente mais baixa após a recuperação ativa com colete do que sem colete ($p<0,05$) bem como a temperatura central antes da série de simulação ($p<0,05$). A temperatura da pele após a recuperação ativa com colete foi significativamente menor aquando do uso do colete ($p<0,01$).

Conclusões: Os resultados sugerem que o uso de um colete de frio durante a recuperação ativa após uma competição ou treino pode acelerar o processo de recuperação. Poderá ser interessante testar a eficácia deste método em condições reais de treino ou provas.

PALAVRAS-CHAVE: TERMOGRAFIA; FRIO; KAYAK DE VELOCIDADE; RECUPERAÇÃO; DESPORTOS AQUÁTICOS.

LIST OF ABBREVIATIONS

AR – Active recovery/rest

BD – Body density

BLC – Blood lactate concentration

CWI – Cold water immersion

IRT – Infrared thermographic imaging

LL – Left *latissimus dorsi*

MAP – Maximal average power

RL – Right *latissimus dorsi*

TS – Training session

RPE – Rate of perceived exertion

ROI – Region of interest

SD – Standard deviation

INTRODUCTION

Canoe sprint takes place on a flatwater course and races are contested by two types of boat, canoe (C) and kayak (K). Kayak paddlers compete seated with a double-bladed paddle. The Olympic debut was in Berlin 1936 with nine men's events. At international level male athletes started in 2017 to compete in 500 m in K4, a boat of four athletes. European and World Championship take place every year during summer months, normally in north hemisphere and often under hot weather conditions, which can affect athletes' performance[1,2]. During these competitions athletes do 2 to 4 races a day with a brief time to recover between them. Due to that and to prevent heat stress, which can impair aerobic performance when hyperthermia occurs[3], one of the major questions that appears is to find a way to cool down and, consequently, recover better in a brief time using simple tools that does not require many facilities.

It is common to use active recovery (AR) after maximal intensity efforts, several bouts of exercises, competitions or training sessions. There is an agreement over the fact that active recovery is more efficient than passive recovery in improving blood lactate concentration (BLC) removal because AR increases blood flow to the working muscles, as indicated by the increased heart rate[4,5]. BLC values are positively correlated with muscular fatigue which facilitates injuries occurrences[6,7]. This reduces in BLC leads to a reduction of muscular fatigue[4] and, consequently, a reduction of injuries rate.

Cryotherapy methods are applied to speed up the regeneration of tissues and prepare the athlete for a faster return to training or participation in another activity[8] and to prevent swelling of acute musculoskeletal injuries if used regularly[9,10]. Although the scientific evidence is not consensual, there are many advantages described and it's commonly used as a recovery method after elite sport events, especially for those who have a training and competition schedule that requires several bouts of exercises within 1 day or under environments of extreme heat and humidity[9]. Cold stimulation shows positive effects on the muscular enzymes creatine kinase and lactate dehydrogenase, and it should be considered a procedure that facilitates athletes' recovery[3]. The initial response to cold is vasoconstriction followed by vasodilatation, which can last up to six hours, leading to increase in blood flow through the tissues[8,11]. The resulting hyperemia provides conditions for improving metabolism, increasing oxygen supply, eliminating waste products such as lactate or histamine, and increasing concentrations of bradykinin and angiotensin[8]. Furthermore, there is an increase in β-endorphin secretion by the pituitary gland and a decrease in nociceptive pulsation of mechanoreceptors, mainly in C fibers. The effect of the reactions described above is the reduced perception of pain and a placebo effect in recovery feeling[8,12].

There are several methods, such as cold-water immersion (CWI), cooling garments, cold fluids ingestion, ice massage, hole body cryotherapy, among others. Although CWI is one of the most effective cooling strategies[1], it's not practical to use during races. According to *Pèriard et al.*[12] the decrease in core temperature is smaller with a cooling vest than with CWI or mixed-cooling methods. However, cooling garments present the advantages of lowering skin temperature thus reducing cardiovascular strain and eventually heat storage and are practical in reducing skin temperature without reducing muscle temperature, so athletes can wear them during recovery breaks.

Upper and lower abdominals, *pectoralis*, *latissimus dorsi*, anterior *serratus* and other trunk muscles are some of the primary and supporting muscles of paddling technique[13], so a cooling vest with ice packs inside in direct contact with the muscle groups in use, probably provide a recovery feeling, may reduce skin and core temperature and are suitable to use during paddling.

Skin temperature is directly correlated with micro vascular flow, which is influenced by the autonomic nervous system and for conduction and convection phenomena of our body's structures[12]. Due to that, our body emits radiation which can be detected with infrared thermographic imaging (IRT). IRT is a non-radiating and contact-free technology used to monitor skin temperature[14] that allows transforming body's radiation in temperature values[15]. IRT images can be captured statically or dynamically as a sequence before, during and after a stimulus, such as the application of cold. Although it has a lot of advantages, IRT requires, as mentioned by *Korman et al.*[16] a room with controlled temperature (18-25ºC) and humidity (40-70%), reduced air flow and the subject needs to follow some recommendations[15,16], such as avoidance of cream applications, hot drinks and heavy meals and contact with objects and surfaces, in order not to compromise the measurement. If there is more than a moment of study, the images should be done at the same time of the day due to the circadian rhythm of thermoregulation. It is needed at least 10 to 15 min of sited acclimatization with the body part in study unclothed and pictures should be taken always in the same position.

Accordingly to *Costello et al.*[17] the greatest advantage of IRT is that temperature variation over large areas of skin can be quantified quickly and accurately, with high resolution rendering each image the equivalent of hundreds or thousands of individual thermistor readings. According to all of this IRT seems to be a valid and useful tool to monitor athletes' training routine.

In sports IRT has already been used in many studies and it seems to be an efficient, reliable and safe method for monitoring skin temperature during and following cold treatment[8,17]. Physical activity, specially performed mainly above the anaerobic threshold, is associated with a significant increase in lactate concentration. It is one of the causes of the deteriorating exercise capacity and sense of fatigue that occur during/after a workout[8]. There are, also, several studies which indicate that the changes detected by IRT in skin temperature are correlated with muscle fatigue. In one of the studies[18] the authors have investigated thermoregulation of a local muscle area involved in a localized steady-load exercise (2 min of standing heels raise), using IRT in seven trained females and seven untrained female controls. The results have shown that the skin temperature following the dynamic exercise protocol has increased 1.0° ± 0.2°C and 0.4° ± 0.1°C in trained and untrained females, respectively. Other study performed in a 23-year-old trained middle distance runner[14] showed a significant negative correlation between skin temperature and power in the quadriceps muscle.

Most scientists and practitioners in the health sciences agree that it is important to understand subjective symptoms and how they relate to objective findings. In sports we can apply the same principle because perceived exertion is related closely to the heart rate among other strain variables, such as blood lactate levels[19] and can be an important complement to physiological measurements[20]. In addition, subjective estimates reflect the individual perception of the amount of physical and motivational resources that the subjects invest to meet the demand imposed by the physical task[21]. The Borg's rate of perceived exertion (RPE) scale (6 to 20) is the best and the most simple to applied on studies of perceived exertion, for exercise testing and predictions[19].

In recent years some elite teams had started to use cooling vests combine with active rest after competition in order to accelerate recovery in hot environments. However, there are few studies which evaluate its efficiency. It is important to find an effective strategy to avoid the potential maladaptive physiological and psychological effects of overtraining[22]. Due to that, the main goal of this study is to evaluate the cooling vest's impact in kayak sprint athletes' recovery and performance, analyzing differences in IRT, perceived exertion and BLC.

MATERIALS AND METHODS

Participants

Ten kayak sprint athletes (mean ± standard deviation (SD)); age, 21.63 ± 2.85; height, 177.9 cm ± 7.33; body mass, 75.18 ± 7.33 kg; arm span, 180.92 ± 9.5 cm; fat mass %, 10.19 ± 4.65) participated in the present study. The inclusion criteria were: (1) participation in at least one international event in the last 2 years; (2) follow a planning that aims to participate in international events. The exclusion criterion was: to have a fat mass percentage higher than 20%. All participants were volunteers and signed a written informed consent (*attachment 1*). Each subject was his own control.

Experimental protocol

The study had three different moments and all of them were performed in a kayak ergometer (Dansprint PRO kayak). In the first moment the athletes performed a maximal 4 min test to determine the maximal average power (MAP). This test defined the training session's and active recovery's power output. The second and third moments had the same protocol. All protocol was performed in a 25m^2 room with controlled temperature and humidity. Room's temperature throughout the two moments of the test had a mean value between 20.93°C and 21.22°C. The optimal temperature for the use of the infrared camera in the study of the human body is 21°C[16] because the greatest infrared emission in humans occurs in this temperature. The relative humidity had a mean between 66.04% and 68.90%. The usually values are 40% to 70% but there are not established norms yet[16].

The protocol consisted in 15 min of acclimatization, warm-up (5 min at 40% MAP), an aerobic training session (5 times 3 min with 3' of passive rest) at 75% of MAP, similar to what they are used to do in their daily training routine. After it they had 5 min of passive rest and paddled for 15 min (40% MAP) as active rest with or without the cooling vest (Inuteq

Siku PAC® & H2O®), depending on the moment of study. This cooling vest has pockets to put 4 cold accumulators inside, 2 in the anterior side of the trunk and 2 in the posterior side. After it they rested passively for 15 min and after it performed 500 m race simulation to evaluate the performance (*Figure 1*). The use of the cooling vest was determined randomly with Excel 2013.

Prior to the test, body characteristics such as height, body mass, arm span and fat mass percentage were determined by *Jackson and Pollock's protocol*. It is a generalized formula for the calculation of body density (BD) of men aged between 18 and 61 years old, using the sum of seven skinfolds (subscapular, triceps, abdominal, suprailiac, thigh, chest and medium axillar). BD result makes possible the calculation of the fat mass percentage with Siri's formula[23].

During all tests it was assessed the skin temperature with sensors above latissimus dorsi muscle and were taken five infrared pictures of the posterior part of the upper body. It was measured the lactate concentration four times and the core temperature, using urine's temperature, twice during all protocol. In each phase of the study were asked the RPE using Borg's RPE Scale. Prior to the 500 m race simulation were asked to all kayakers to classify their recovery state, from 0 to 10 (with 10 representing completely recovered).

The study was approved by the Faculty of Medicine's Ethics Committee, University of Coimbra, with the official reference 131-CE-2017 (*attachment 2*).

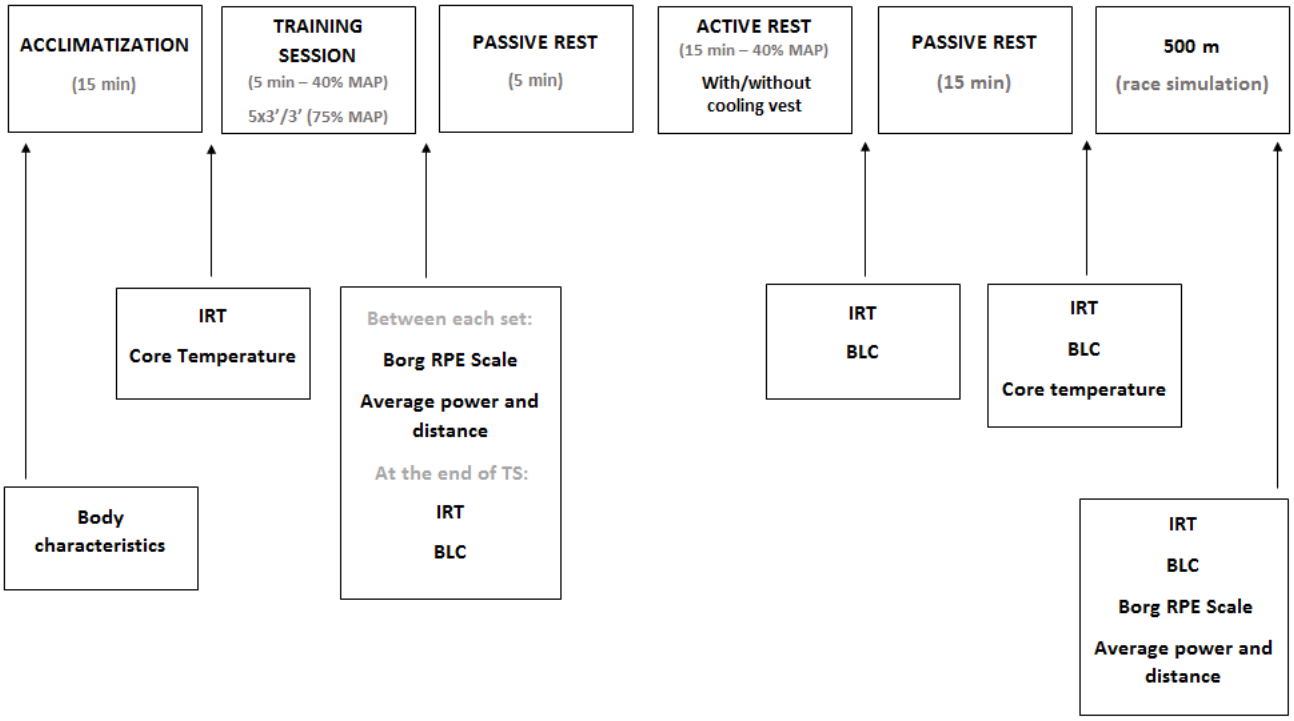

Figure 1 – study protocol which was replicated twice. It expresses the procedures and the assessments made in each phase.

IRT – infrared thermographic imaging; BLC – blood lactate concentration; TS – training session

Skin temperature and core temperature

Skin temperature above part of latissimus dorsi muscle was assessed during all protocol with IRT (*Figure 2).* Importance was given to 5 different moments, at resting conditions after acclimatization, training session (TS), active rest (AR) and before and after 500 m race simulation. During the performance of physical exercise, there is an increased metabolic rate and therefore increased internal heat. Later, with the continuity of the exercise, occurs the redirection of blood flow to the skin, in order to exchange heat with the environment[24]. To assess this it was used an infrared camera (FLIR® SC660; FLIR Systems). All participants were aware of the recommendations before IRT screening. It was also used skin sensors to measure skin temperature but due to lack of experience and detection of errors, their results were not considered in the analysis.

A non-invasive measurement of core temperature based on skin surface measurements may be influenced by multiple factors such as measurement site, evaporation and clothing[25], so, in order to reduce the error in the measurement of core temperature, it was used urine temperature (Checktemp® digital thermometer 1HI98509, Hanna Instruments). The measurement of urine temperature is less invasive than other techniques, such as rectal and esophageal temperature. According to *Lefrant et al.*[26], urinary bladder technique is more accurate than others to measure core temperature. Urine temperature was assessed in two moments, prior to the training session and before the 500 m simulation race (*Figure 1*).

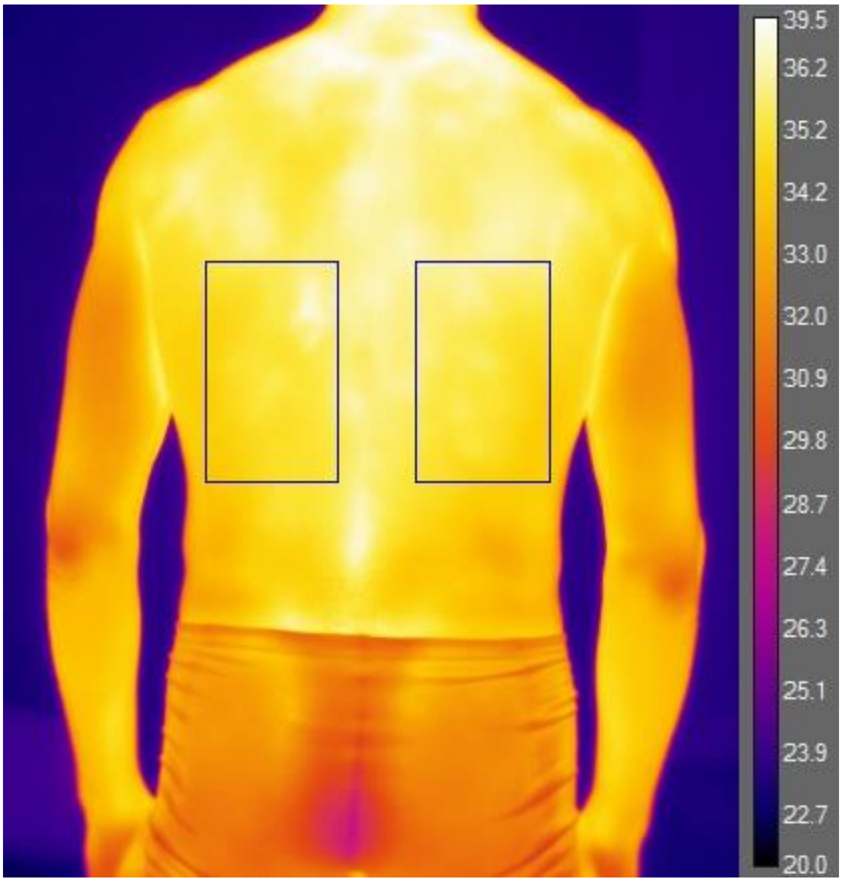

Figure 2 – The back thermogram with region of interest (ROI) marked with rectangles. The area comprises part of the skin above the latissimus dorsal muscle.

Blood lactate concentration (BLC)

BLC was measured after TS, after AR, before and after it 500 m race simulation. It was measured in a capillary finger sample and determined by spectrophotometric method with micro spectrophotometer LP20–DR Lange which has a concentration range between 0.5 – 18 mmol/L. This method has high degree of specificity for the determination of lactic acid concentration in biological liquids[27].

Statistical analysis

Body mass percentage was calculated using Excel 2013 for Windows 7. Statistical analysis was done using IBM SPSS Statistics version 24 for Windows 7. Descriptive statistics were applied to all variables. The *n* of this study was 10 kayakers so the comparison between the two moments of the study was done with Wilcoxon's test and the correlation was tested with Spearman's test. Values of $p \leq 0.05$ were considered statistically significant.

RESULTS

Changes in temperature values

In both moments, the skin temperature above *latissimus dorsi* muscle dropped after the AR. Comparing the image (*Figure 3*) after TS and the thermogram after AR, the temperature drop (*Table 1)* was higher when the cooling vest was used than without it. Skin temperature after active rest with the vest was significantly lower (p<0.01) (*Figure 4 – red asterisk*). There were no significant differences in the temperature after the 500 m race simulation. The difference can be evaluated in *Figure 4.*

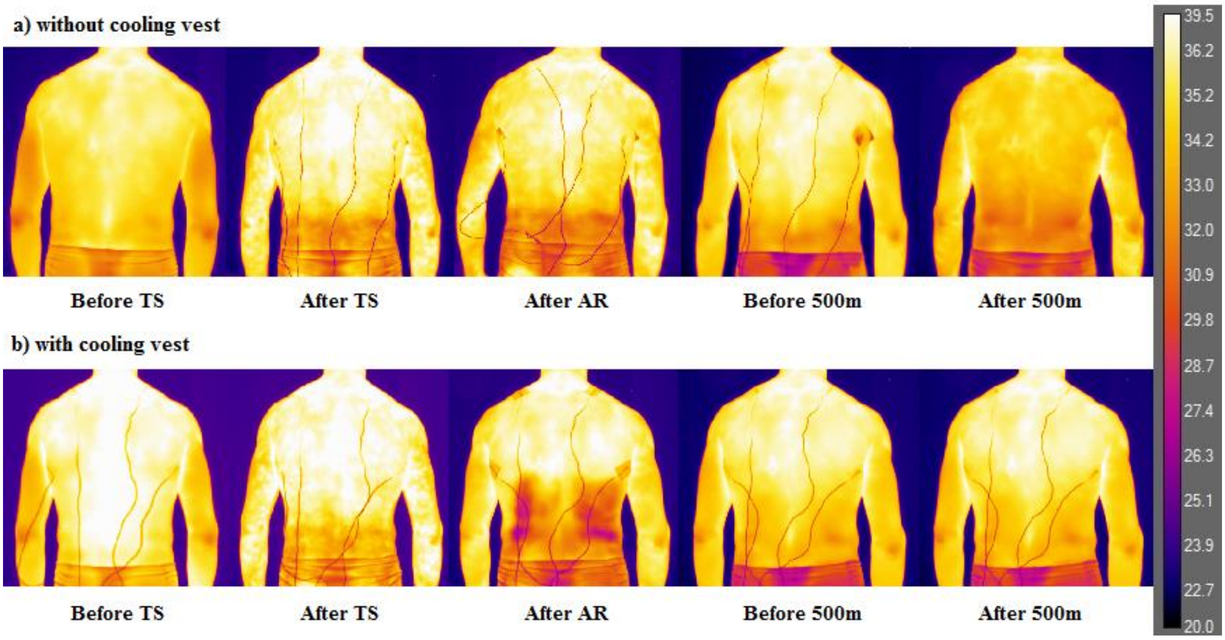

Figure 3 – Example of two sequences of thermographic images collected in different moments of protocol, with and without the cooling vest. Scale from 20.0ºC to 39.5ºC.
TS – training session; AR – active recovery.

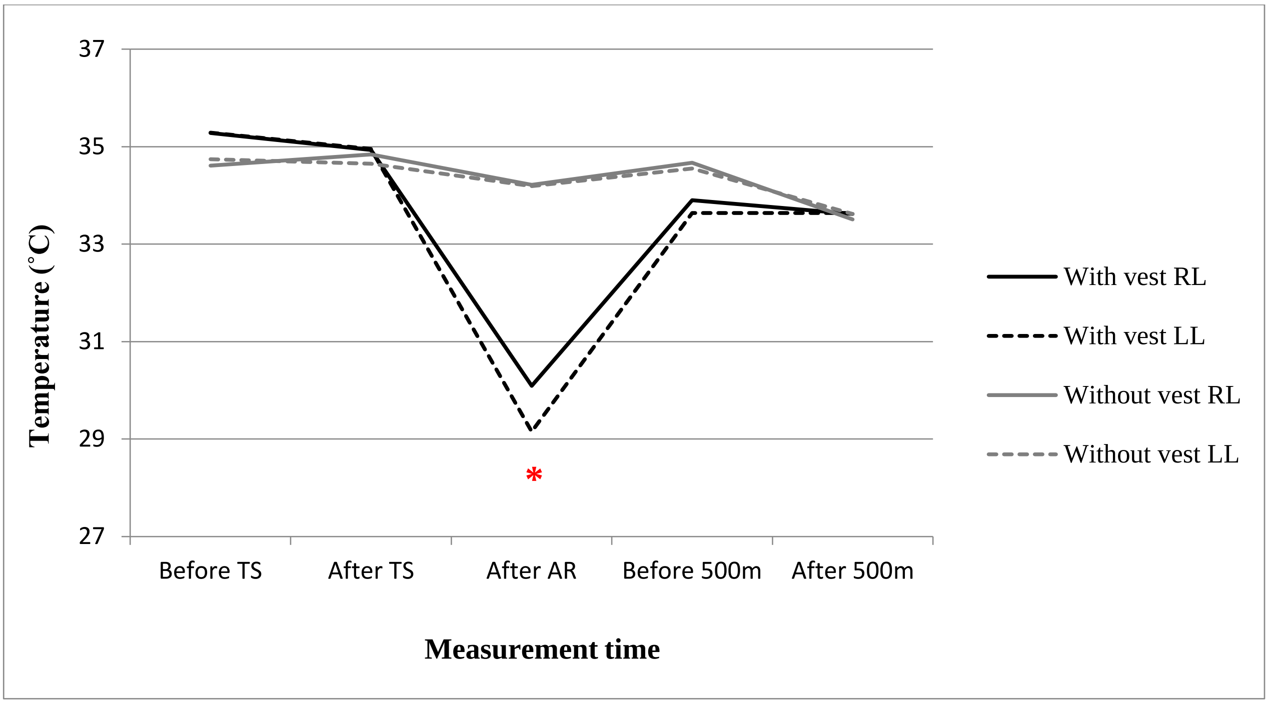

Figure 4 – Skin temperature variation during all protocol in both moments of study. Grey lines represent the moment that the kayakers did not use the cooling vest in the AR and black lines represent the moment with cooling vest. The asterisk indicate that there was a significant difference (p<0.01) between each moment of the study. RL – right latissimus; LL – left latissimus.

When analyzing core temperature values in both moments, there was no significant difference between the measurements before TS. On the other hand, 15 min after the active recovery, core temperature was significantly lower after using the cooling vest ($p<0.05$) comparing with the moment that athletes didn’t use the cooling vest. All temperature values are registered in *Table 1*.

Table 1 – Temperature values during all protocol

	With cooling vest (temperature ˚C)			Without cooling vest (temperature ˚C)		
	RL	LL	Core	RL	LL	Core
Before TS	35.28 ± *0.79*	35.29 ± *0.93*	36.3 ± *0.22*	34.61 ± *0.89*	34.74 ± *0.77*	36.7 ± *0.26*
After TS	34.93 ± *0.89*	34.95 ± *0.90*	-	34.84 ± *1.26*	34.65 ± *1.39*	-
After AR	30.09 ± *2.12*	29.15 ± *2.39*	-	34.22 ± *0.94*	34.19 ± *1.05*	-
Before 500 m	33.9 ± *0.97*	33.64 ± *1.01*	37.1 ± *0.46*	34.67 ± *0.86*	34.55 ± *0.81*	37.4 ± *0.32*
After 500 m	33.62 ± *0.88*	33.64 ± *1.02*	-	33.51 ± *0.82*	33.62 ± *0.88*	-

Legend: Skin temperature above right (RL) and left (LL) latissimus dorsi muscle and core temperature registered during all protocol (before and after the training session, after the active recovery and before and after 500m test) in the two moments of study. The values which are statistically different, when comparing the use of the cooling vest with the moment without it, are marked in dark grey for skin temperature (p<0.01) and in light grey for core temperature (p<0.05). Mean ± SD.

<u>Changes in lactate values</u>

There were no significantly differences in the values of BLC after TS when comparing the moments with cooling vest and without it.

After AR with cooling vest the BLC was significantly lower ($p<0.05$) when comparing with the values obtained in the same moment without cooling vest (*Table 2).*

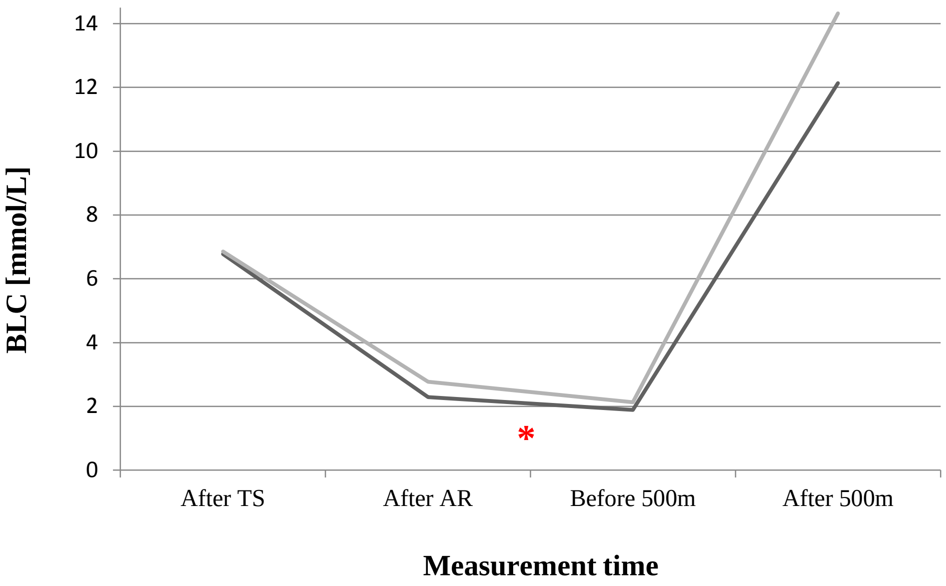

Figure 4 – BLC changes during all protocol in both moment of the study. The red asterisk indicate that there was a significant difference (p<0.05) between each moment of the study.

BLC – blood lactate concentration; TS – training session; AR – active recovery.

Table 2 – BLC values during all protocol

	With cooling vest (mmol/L)	Without cooling vest (mmol/L)
	BLC	BLC
After TS	6.78 ± *2.61*	6.86 ± *2.86*
After AR	2.29 ± *1.10*	2.77 ± *1.11*
Before 500 m	1.89 ± *1.01*	2.13 ± *1.13*
After 500 m	12.13 ± *2.70*	14.31 ± *3.87*

BLC values during all protocol with and without cooling vest. The values which are statistically different (p<0.05) are marked with light grey. TS – training session; AR – active recovery. Mean ± SD.

Despite there were no statistical differences (p=0.139) between the BLC before the 500 m race simulation, the average BLC was lower in the moment that was used the cooling vest during the active recovery than in the moment without it. The same happened with BLC after the 500 m test (p=0.66) and the mean value was also lower when using the cooling vest during the active recovery comparing with no cooling vest *(Table 3)*. The variation of BLC values before and after 500 m for each athlete are discriminated in *Figure 5*.

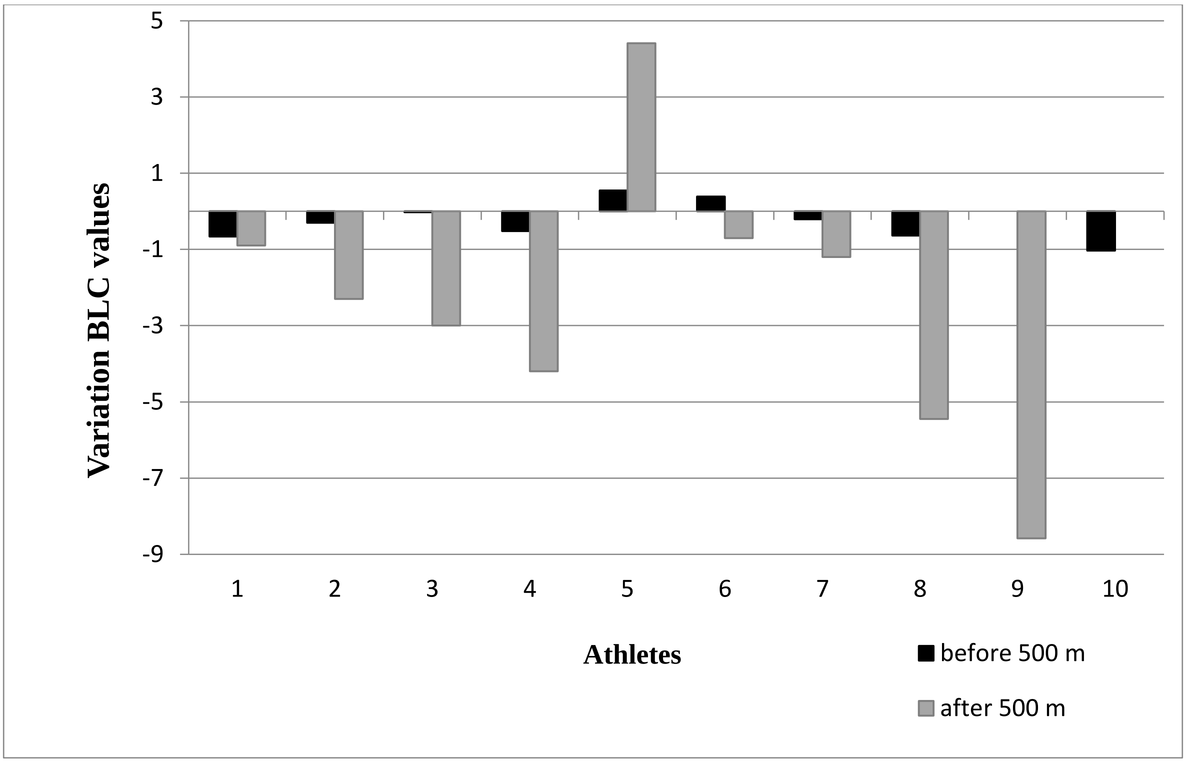

Figure 5 – Variation of BLC values before (black columns) and after (grey columns) 500 m race simulation for each athlete (1 to 10). Variation = (BLC with vest) – (BLC without vest).

<u>Perceived exertion data, performance and recovery feeling</u>

There is no significant difference between perceived exertion (Borg's RPE Scale) and the power registered in the ergometer in any period of the study when comparing the two moments, with or without the cooling vest during the active recovery period.

The athletes' recovery subjective perception before 500 m simulation race was significantly higher after they used the cooling vest ($p<0.01$) (*Table 4*).

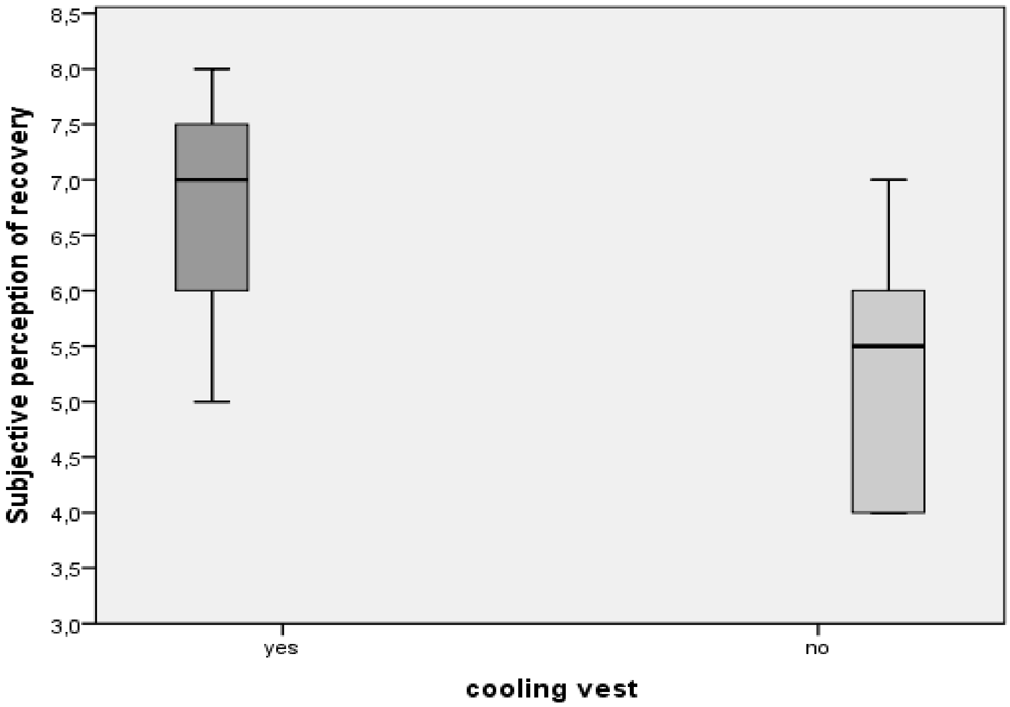

Figure 6 – Subjective perception of recovery before 500m test. Mean ± SD with vest (6.85 ± 0,94) and without vest (5,25 ± 1,09) during the AR.

There was no statistical difference between the average power of the maximal 500 m test between the protocol with cooling vest and without it. The same happened for the time performance over 500 m race simulation test, which was not statistically different when comparing protocols of active recovery with and without cooling vest.

In both moments, there was no correlation between the BLC before the 500 m test with the performance time in the race simulation test.

DISCUSSION

The main goal of this study was to evaluate the cooling vest's impact in kayak sprint athletes' recovery and performance analyzing differences in IRT, perceived exertion and BLC.

The cooling vest reveals that it is a suitable instrument to induce a lowering in skin temperature while paddling (*Figure 4*). It is light and does not limit the movement of paddling at low intensity.

IRT was used to evaluate the changes during all the protocol in skin temperature. As described in other studies[8,17] it can be used to monitor skin temperature during physical activity and cold treatments. In *Table 1* we can evaluate that the skin temperature above *latissimus dorsi* when the athletes used the cooling vest during the AR was almost 4 degrees lower when comparing with the AR without cooling vest. After the application of the cooling vest the body needs to increase the blood flow in that area to return to the homeostasis. This increase leads to a quicker elimination of waste products such as lactate, promoting a better and faster recovery[8,11]. If used regularly[10] in the hotter days, by reducing the lactate levels, the cooling vest would reduce the fatigue and consequently, the probability of developing an injury or reach overtraining level is lower.

When analyzing *Figure 5* we can verify that 8 athletes presented, before and after the 500 m race simulation, lower BLC values when they used the cooling vest during the AR comparing with AR without cooling vest. 1 athlete (number 5 – *Figure 5*) presented higher BLC values after performing AR with cooling vest and 1 athlete (number 6 – *Figure* 5), after the use of cooling vest presented higher BLC values before race simulation but lower values after it. These changes were more evident when comparing the values after 500 m race simulation, as indicated by the size of the grey columns, and it clearly suggests a difference in the kayakers' physiologic response to this recovery method. It leads us to a singularity of high performance sports, the individualization and a different response to the same recovery method which tell us that which is an advantage for one athlete cannot be for another.

The RPE and the power in the two moments of study was similar so it means that the kayakers performed the TS and the AR with similar intensity and the same amount of physical and motivational resources[21]. Due to that we can assume that the differences found in BLC values are independent of these variables. As the RPE has a correlation with lactate levels[19], it was expected that the RPE of the AR with cooling vest would be lower when comparing with the AR with vest but this fact was not verified.

As described in literature[8,12] the cold increases the athlete's subjective perception of recovery with an effect similar to placebo. This effect is linked to dopamine release from the *nucleus accumbens*, a central component of the brain reward system and it is known that the expectation of an analgesic effect can trigger endogenous opioid systems[22]. In the current study we had similar results and confirmed that when kayakers performed the AR with the cooling vest they felt more recovered than when they did not use it. The individual perception of recovery is related to subsequent performance and that psychometric measures can be more sensitive than physiological markers in determining the recovery state of athletes[22].

The fact that performance was not different in the two moments of study means that despite the difference in physiological response to the cold, the performance was not positively affected by the use of the cooling vest. This may happen due to the small number of participants and we should consider performing the same protocol with a larger number of athletes.

Limitations

Core temperature measurement was not assessed with a sensor or a thermistor inside of the body because it is an invasive method and is not practical to perform during a protocol with physical activity. In further studies this parameter need to be fixed or a correlation between urine's temperature inside and outside of the bladder should be done previously to the study.

The study was performed in a room with controlled temperature and humidity which does not replicate the real weather conditions in international events. Due to that there is the need to test these recovery method results in the real environment of racing and in different weather conditions.

There is also, the need to perform this study involving more muscles and with other cooling vests to see if there is consistency of the results.

CONCLUSION

Despite there is no agreement about the efficiency of cryotherapy treatments, in this study we may conclude that the cooling vest could be a useful tool to use between training sessions or races with short time to recover.

However in high performance sports we should evaluate it case by case and we did not register the same advantage to all kayakers, it seems that the cooling vest may lead to a quicker physiological recovery, by reducing core and skin temperature leading to a faster lowering of BLC levels. Nevertheless we did not find a correlation between these effects and a better performance. IRT appears to be a reliable method to monitor skin temperature before and after physical activity and cold treatment in a room with controlled temperature and humidity.

ACKNOWLEDGMENTS

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Thank to my parents, my family and friends which supported me all along this journey and was always there to encourage me.

I also thank the enthusiasm of the kayakers when participating in the study. Without them this was not possible.

To all people that somehow have a role in this journey my huge thank.

Finally, to Coimbra, my "borrowed" city for the past 6 years where I went through some of the best moments of my life, met incredible people and lived the most amazing experience as a student.

"Uma vez Coimbra, para sempre Saudade!"

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ATTACHMENTS

ATTACHMENT 1 – Written informed consent

FORMULÁRIO DE INFORMAÇÃO E CONSENTIMENTO INFORMADO

TÍTULO DO PROJECTO DE INVESTIGAÇÃO:
"A eficácia do uso do frio na recuperação muscular pós-exercício em kayak de velocidade"

PROMOTOR: Francisca Dias Laia

INVESTIGADOR COORDENADOR: Este estudo será orientado pelo Professor Associado, João Páscoa Pinheiro e co-orientado pelo Professor Auxiliar, Amândio Manuel Cupido Santos.

CENTRO DE ESTUDO
ADAI - Associação para o Desenvolvimento da Aerodinâmica Industrial

INVESTIGADOR PRINCIPAL: Francisca Dias Laia
MORADA: Tapada do Chafariz, lote 6, 2º ESQ, 2200-235 Abrantes
CONTACTO TELEFÓNICO: 913539936

NOME DO ATLETA:

É convidado a participar voluntariamente neste estudo por ser atleta de kayak de velocidade da categoria sénior (18-35 anos).
Este procedimento é chamado Consentimento Informado e descreve a finalidade do estudo, os procedimentos, os possíveis benefícios e riscos. A sua participação poderá contribuir para melhorar o conhecimento sobre a utilidade do uso do frio como método de recuperação após sessões de treino e prova.
Receberá uma cópia deste Consentimento Informado para rever e solicitar aconselhamento de familiares e amigos. O Investigador irá esclarecer qualquer dúvida que tenha sobre o termo de consentimento e também alguma palavra ou informação que possa não entender.
Depois de compreender o estudo e de não ter qualquer dúvida acerca do mesmo, deverá tomar a

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decisão de participar ou não. Caso queira participar, ser-lhe-á solicitado que assine e date este formulário. Após a sua assinatura e a do Investigador, ser-lhe-á entregue uma cópia. Caso não queira participar, não haverá qualquer penalização.

1. INFORMAÇÃO GERAL E OBJETIVOS DO ESTUDO

Este estudo irá decorrer na **ADAI - Associação para o Desenvolvimento da Aerodinâmica Industrial** com o objetivo de verificar se a utilização de um colete de frio no decorrer do período de recuperação ativa permitirá melhorar a recuperação muscular e, posteriormente, ser utilizado entre regatas e treinos intensos.

Trata-se de uma investigação sobre a o frio como método de recuperação, na qual, o protocolo foi construído de acordo com os planos de treino habitualmente realizados pelos atletas.

Este estudo foi aprovado pela Comissão de Ética da Faculdade Medicina da Universidade de Coimbra (FMUC) de modo a garantir a proteção dos direitos, segurança e bem-estar de todos os atletas incluídos e garantir prova pública dessa proteção.

Como participante neste estudo beneficiará da vigilância e apoio do seu médico, garantindo assim a sua segurança.

Este estudo tem por objetivo tentar encontrar um método de recuperação de utilização fácil e rápida que possa ser usado pelos atletas nas suas rotinas de treino e competições. Assim e como referido anteriormente, será utilizado um colete de frio no decorrer do período de recuperação ativa do protocolo do estudo com o objetivo de avaliar as alterações fisiológicas provocadas pelo mesmo aferindo melhora a recuperação muscular, ajudando assim na prevenção de lesões por fadiga extrema.

Serão incluídos neste estudo 10 atletas da categoria Sénior da modalidade de Canoagem, vertente de kayak, disciplina de velocidade que tenham realizado provas internacionais nos últimos 2 anos e que pratiquem a modalidade ativamente neste momento.

2. PROCEDIMENTOS E EXPLICACÃO DO ESTUDO

2.1. Procedimentos

Em primeiro lugar será realizada uma análise antropométrica, incluindo, estatura, envergadura, massa corporal e pregas cutâneas com o objetivo de facilitar a interpretação dos dados recolhidos.

Todo o restante procedimento será realizado em ergómetro de kayak.

Antes da realização do protocolo do estudo, será pedido aos atletas que realizem um teste de 4 minutos a intensidade máxima para definir as intensidades de realização do treino e da recuperação ativa no decorrer do protocolo de estudo.

O estudo, propriamente dito, será composto por 2 momentos e será aplicado um protocolo composto por aquecimento, sessão de treino (5 séries de 3 minutos), recuperação ativa com e sem colete de frio, dependendo do momento de avaliação, descanso passivo e uma série de 500m simulando uma situação de prova, semelhante ao habitualmente realizado no planeamento de treino.

Durante a realização do protocolo serão capturadas imagens corporais com câmara termográfica, será feita uma monitorização da temperatura cutânea através de sensores térmicos colocados à superfície da pele corresponde aos músculos trapézios e latissimus dorsais (dos mais recrutados durante a técnica de pagaiada), será medida a temperatura corporal central através da temperatura da urina em dois momentos do protocolo e serão também recolhidos 10 µl de sangue capilar em quatro momentos para determinação da concentração de ácido lático, recolha com a qual todos os atletas já estão familiarizados por ser prática corrente nos momentos de testes físicos realizados nas Equipas Nacionais.

2.2. Calendário das visitas

Este estudo terá a necessidade de 3 visitas ao local do estudo.

- 1ª visita – Avaliação antropométrica e realização do teste de 4 minutos a intensidade máxima;
- 2ª visita – 1º momento do protocolo de estudo;
- 3ª visita – 2º momento do protocolo de estudo;

O uso do colete ocorrerá apenas num dos momentos de estudo que será escolhido de forma aleatória. Esta será efetuada no Excell 2013.

2.3. Tratamento de dados

Os dados serão introduzidos e tratados com auxílio do Excell 2013 e do IBM SPSS versão 24.

3. RISCOS E POTENCIAIS INCONVENIENTES

Não existem riscos para além dos habituais durante a execução de um treino do dia-a-dia dos atletas. Como referido anteriormente, todos os procedimentos efetuados neste protocolo são comuns nas Equipas nacionais e, por isso, já conhecidos dos atletas.

4. POTENCIAIS BENEFÍCIOS

Este estudo tem a vantagem de estudar as respostas fisiológicas a um método de recuperação de fácil e rápida utilização na modalidade de canoagem. Existem variados estudos sobre o uso do frio em vários desportos mas na canoagem esse estudo está pouco desenvolvido.

5. SEGURANÇA

O protocolo do estudo foi pensado tendo em conta o planeamento habitual dos atletas e estando já familiarizados com o ergómetro de kayak utilizado não se espera que devido à sua participação venha a sofrer problemas de saúde ou lesões. No entanto, se sofrer alguma lesão física como resultado de quaisquer procedimentos do estudo, realizados de acordo com o protocolo, será reembolsado pelas despesas médicas necessárias para as tratar.

6. PARTICIPACÃO/ ABANDONO VOLUNTÁRIO

É inteiramente livre de aceitar ou recusar participar neste estudo. Pode retirar o seu consentimento em qualquer altura sem qualquer consequência para si, sem precisar de explicar as razões, sem qualquer penalidade ou perda de benefícios e sem comprometer a sua relação com o Investigador que lhe propõe a participação neste estudo. Ser-lhe-á pedido para informar o Investigador se decidir retirar o seu consentimento.

O Investigador do estudo pode decidir terminar a sua participação neste estudo se entender que não é do melhor interesse para si prosseguir.

7. CONFIDENCIALIDADE

Os seus registos manter-se-ão confidenciais e anonimizados de acordo com os regulamentos e leis aplicáveis. Se os resultados deste estudo forem publicados a sua identidade manter-se-á confidencial.

Ao assinar este Consentimento Informado autoriza este acesso condicionado e restrito.

Pode ainda em qualquer altura exercer o seu direito de acesso à informação. Pode ter também acesso a todos os seus dados recolhidos no estudo. Tem também o direito de se opor à transmissão de dados que sejam cobertos pela confidencialidade profissional.

A Comissão de Ética responsável pelo estudo pode solicitar o acesso aos seus registos para assegurar-se que o estudo está a ser realizado de acordo com o protocolo. Não pode ser garantida confidencialidade absoluta devido à necessidade de passar a informação a essas partes. Ao assinar este termo de consentimento informado, permite que as suas informações deste estudo sejam verificadas, processadas e relatadas conforme for necessário para finalidades científicas legítimas.

<u>Confidencialidade e tratamento de dados pessoais</u>

Os dados pessoais dos participantes no estudo, incluindo os dados recolhidos durante o estudo, serão utilizados para condução do estudo, designadamente para fins de investigação em medicina desportiva relacionados com a modalidade de canoagem.

Ao dar o seu consentimento à participação no estudo, a informação a si respeitante, designadamente a informação clínica, será utilizada da seguinte forma:

1. O promotor, os investigadores e as outras pessoas envolvidas no estudo recolherão e utilizarão os seus dados pessoais para as finalidades acima descritas.
2. Os dados do estudo, associados a um código que não o identifica diretamente serão comunicados pelo investigador e outras pessoas envolvidas no estudo ao promotor do estudo, que os utilizará para as finalidades acima descritas.
3. Os dados do estudo, associados a um código que não permita identificá-lo diretamente, poderão ser comunicados a autoridades de saúde nacionais e internacionais.
4. A sua identidade não será revelada em quaisquer relatórios ou publicações resultantes deste estudo.
5. Todas as pessoas ou entidades com acesso aos seus dados pessoais estão sujeitas a sigilo profissional.
6. Ao dar o seu consentimento para participar no estudo autoriza o promotor ou empresas de monitorização de estudos especificamente contratadas para o efeito e seus colaboradores e/ou autoridades de saúde, a aceder aos dados para conferir que a informação recolhida e registada pelos investigadores, designadamente para assegurar o rigor dos dados que lhe dizem respeito e para garantir que o estudo se encontra a ser desenvolvido corretamente e que os dados obtidos são fiáveis.
7. Nos termos da lei, tem o direito de, solicitar o acesso aos dados que lhe digam respeito, bem como de solicitar a retificação dos seus dados de identificação.
8. Tem ainda o direito de retirar este consentimento em qualquer altura através da notificação ao investigador, o que implicará que deixe de participar no estudo. No entanto, os dados recolhidos ou criados como parte do estudo até essa altura que não o identifiquem poderão continuar a ser utilizados para o propósito do estudo, nomeadamente para manter a integridade científica do estudo, e a sua informação médica não será removida do arquivo do estudo.
9. Se não der o seu consentimento, assinando este documento, não poderá participar neste estudo. Se o consentimento agora prestado não for retirado e até que o faça, este será válido e manter-se-á em vigor.

8. COMPENSAÇÃO

Este estudo será realizado no âmbito do Trabalho Final de 6º ano do Mestrado Integrado em Medicina e, por isso, solicita-se a sua participação sem uma compensação financeira para a sua execução, tal como também acontece com os investigadores e o Centro de Estudo. No entanto, se além das visitas previstas lhe forem solicitadas visitas suplementares no âmbito deste estudo, as despesas decorrentes dessas deslocações e ser-lhe-ão reembolsadas. O Centro de Estudo suportará todos os custos inerentes aos procedimentos das visitas. Não haverá portanto qualquer custo para o participante pela sua participação neste estudo.

9. CONTACTOS

Se tiver perguntas relativas aos seus direitos como participante deste estudo, deve contactar:
Presidente da Comissão de Ética da FMUC,
Azinhaga de Santa Comba, Celas – 3000-548 Coimbra
Telefone: 239 857 707
e-mail: comissaoetica@fmed.uc.pt

Se tiver questões sobre este estudo deve contactar:
Francisca Dias Laia
Tapada do Chafariz, lote 6, 2º ESQ
2200-235, Abrantes

NÃO ASSINE ESTE FORMULÁRIO DE CONSENTIMENTO INFORMADO A MENOS QUE TENHA TIDO A OPORTUNIDADE DE PERGUNTAR E TER RECEBIDO RESPOSTAS SATISFATÓRIAS A TODAS AS SUAS PERGUNTAS.

CONSENTIMENTO INFORMADO

De acordo com a Declaração de Helsínquia da Associação Médica Mundial e suas atualizações:

1. Declaro ter lido este formulário e aceito de forma voluntária participar neste estudo.
2. Fui devidamente informado da natureza, objetivos, riscos, duração provável do estudo, bem como do que é esperado da minha parte.
3. Tive a oportunidade de fazer perguntas sobre o estudo e percebi as respostas e as informações que me foram dadas.

A qualquer momento posso fazer mais perguntas ao responsável do estudo. Durante o estudo e sempre que quiser, posso receber informação sobre o seu desenvolvimento. O investigador responsável dará toda a informação importante que surja durante o estudo que possa alterar a minha vontade de continuar a participar.

4. Aceito que utilizem os meus dados no estrito respeito do segredo médico e anonimato. Os meus dados serão mantidos estritamente confidenciais. Autorizo a consulta dos meus dados apenas por pessoas designadas pelo promotor e por representantes das autoridades reguladoras.

5. Aceito seguir todas as instruções que me forem dadas durante o estudo. Aceito em colaborar com o investigador e informá-lo imediatamente das alterações do meu estado de saúde e bem-estar e de todos os sintomas inesperados e não usuais que ocorram.

6. Autorizo o uso dos resultados do estudo para fins exclusivamente científicos e, em particular, aceito que esses resultados sejam divulgados às autoridades sanitárias competentes.

7. Aceito que os dados gerados durante o estudo sejam informatizados pelo promotor ou outrem por si designado.

   Eu posso exercer o meu direito de retificação e/ ou oposição.

8. Tenho conhecimento que sou livre de desistir do estudo a qualquer momento, sem ter de justificar a minha decisão e sem comprometer. Eu tenho conhecimento que o investigador tem o direito de decidir sobre a minha saída prematura do estudo e que me informará da causa da mesma.

9. Fui informado que o estudo pode ser interrompido por decisão do investigador, do promotor ou das autoridades reguladoras.

Nome do Participante____

Assinatura : ________________________________ ***Data:***_______/_____/____

Confirmo que expliquei ao participante acima mencionado a natureza, os objectivos e os potenciais riscos do Estudo acima mencionado.

Nome do Investigador:____

Assinatura: ________________________________ ***Data:***______/_____/____

ATTACHMENT 2 – Ethics Committee Approbation.

FACULDADE DE MEDICINA
UNIVERSIDADE DE COIMBRA

COMISSÃO DE ÉTICA DA FMUC

Of. Refª **131-CE-2017**

Data 18/12/**2017**

C/C aos Exmos. Senhores
Investigadores e co-investigadores

Exmo. Senhor
Prof. Doutor Duarte Nuno Vieira
Director da Faculdade de Medicina de
Universidade de Coimbra

Assunto: Pedido de parecer à Comissão de Ética - Projeto de Investigação autónomo (refª CE-120/2017).

Investigador(a) Principal: Francisca Dias Laia

Co-Investigador(es): João José Carreiro Páscoa Pinheiro, Amândio Cupido dos Santos e Beatriz Branquinho Gomes

Título do Projeto: *"A eficácia do uso do frio na recuperação pós-exercício em kayak de velocidade"*.

A Comissão de Ética da Faculdade de Medicina, após análise do projeto de investigação supra identificado, decidiu emitir o parecer que a seguir se transcreve:

"Parecer favorável não se excluindo, no entanto, a necessidade de submissão à Comissão de Ética, caso exista, da(s) Instituição(ões) onde será realizado o Projeto".

Queira aceitar os meus melhores cumprimentos.

O Presidente,

Prof. Doutor João Manuel Pedroso de Lima

HC

ATTACHMENT 3 – Borg's RPE Scale.

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion