FACULDADE DE MEDICINA DA UNIVERSIDADE DE COIMBRA

MESTRADO INTEGRADO EM MEDICINA

TRABALHO FINAL

NUNO ANTÓNIO VIEIRA DA SILVA

POSTURAL AND ANTHROPOMETRIC CHANGES IN CANOE SPRINT ATHLETES: THE IMPACT OF TWO DIFFERENT ACTIVE RECOVERY METHODS

- ARTIGO CIENTÍFICO ORIGINAL -

ÁREA CIENTÍFICA DE MEDICINA FÍSICA E REABILITAÇÃO

ORIENTADOR:

Professor Doutor João José Carreiro Páscoa Pinheiro

COORIENTADOR:

Professora Doutora Beatriz Branquinho Gomes

JANEIRO/2018

Postural and anthropometric changes in canoe sprint athletes:

The impact of two different active recovery methods

Nuno António Vieira da Silva

Faculty of Medicine, University of Coimbra, Portugal

nuno_90_vs@hotmail.com

Table of Contents

Abbreviations

cm – Centimeters

h – Hours

IRT – Infrared thermography

LA – Lactic acid

m – Meters

min – Minutes

mmol/L – Millimoles per litre

ROI – Regions of interest

s – Second

SD – Standard Deviation

Tsk – Skin temperature

W – Watt

Abstract

Introduction: Canoe paddling technique requires an asymmetric and cyclic muscular work, as athletes paddle on the right or left side of a canoe, that predispose athletes to muscle imbalance and injuries.

Objectives: The first aim of the study was to analyse the postural and anthropometric profile of 10 elite sprint canoeists using the biophotogrammetry technique and performing a measurement of the anthropometric characteristics. The second aim of the study was to evaluate two different active recovery methods (usual and paradoxical paddling) using a physical test protocol in order to highlight the potential of the paradoxical method suggested to minimize the problem identified. The third aim of the study was to show the usefulness of infrared thermography in sports medicine, particularly in posture diagnosis.

Methods: Ten males (22.30±3.68 years old) were evaluated using a postural assessment software and a set of anthropometric measurements that quantified the postural and anthropometric imbalances. The athletes performed two times a randomized physical protocol that differed only in the active recovery method: paddling on the usual side or paddling on the paradoxical side (focusing on the opposite muscle groups than those more requested in the usual paddling). Athletes completed a training session on a canoe ergometer followed by the respective recovery method and a simulated competition trial of 500m to evaluate the effectiveness of the recovery. Skin temperature, thermal image and blood lactate concentration assessment were the main parameters collected during the protocol.

Results: There was a postural imbalance expressed by the measured body distances between relative heights of contralateral anatomical points, being the hemibody corresponding to the side of the stroke (dominant side) always the highest. It was also observed significant differences in the segmental lean masses and the girths compared between the contralateral lower and upper limbs, being the dominant hemibody bigger in both lean mass and girth.

There were no significant differences in the 500m performance, after performing the training session and the active recovery, in terms of time, mean power and blood lactate concentration, regardless the type of active recovery performed.

Conclusion: Canoe practice leads to postural and anthropometric changes and, since there were no significant differences in the performance using the two different active recovery methods, it would be useful to implement the paradoxical active recovery as a practice of the canoeists daily training, making a symbiosis between recovery and postural compensation at sportive and medical level.

Keywords: posture; anthropometry; thermography; canoe sprint; recovery; performance.

Resumo

Introdução: A técnica de pagaiada em canoa requer um trabalho muscular assimétrico e cíclico, uma vez que os atletas pagaiam apenas do lado direito ou esquerdo de barco, predispondo, por isso, a desequilíbrios musculares e lesões.

Objetivos: O primeiro objetivo do estudo foi analisar o perfil postural e antropométrico de 10 canoístas de alto rendimento utilizando a técnica de biofotogrametria e realizando uma avaliação das alterações antropométricas. O segundo objetivo do estudo foi avaliar dois métodos de recuperação ativa distintos (pagaiar do lado habitual e paradoxal) aplicando um protocolo de teste físico de forma a realçar o potencial do método paradoxal sugerido para minimizar o problema identificado. Esta investigação pretendeu também demonstrar as utilidades da termografia infravermelha na medicina desportiva, particularmente no diagnóstico postural.

Métodos: Dez indivíduos do sexo masculino (idade 22.30±3.68 anos) foram analisados utilizando um programa de avaliação postural e uma série de medições antropométricas que permitiram quantificar os desequilíbrios posturais e antropométricos. Os atletas realizaram duas vezes um protocolo de teste físico que diferiu aleatoriamente apenas no método de recuperação ativa aplicado: pagaiar do lado habitual ou pagaiar do lado paradoxal (utilizando os grupos musculares opostos aos mais solicitados habitualmente). Os atletas completaram uma sessão de treino em ergómetro de canoa seguido pela aplicação do método de recuperação ativa respetivo e por um teste de simulação de competição de 500m para avaliar a eficácia da recuperação. Temperatura cutânea, imagem termográfica e concentração de lactato sanguíneo foram os parâmetros principais determinados durante o protocolo.

Resultados: Observaram-se desequilíbrios posturais expressos pelas distâncias corporais medidas entre alturas relativas de pontos anatómicos contralaterais, sendo o hemicorpo correspondente ao lado da pagaiada (lado dominante) sempre o mais alto. Existiram também diferenças estatisticamente significativas nas massas magras segmentares e nas circunferências corporais comparadas entre membros superiores e inferiores a nível contralateral, sendo o hemicorpo dominante maior em massa magra e circunferência. Não existiram diferenças significativas no desempenho de 500m, após a realização da sessão de treino e a recuperação ativa, em termos de tempo, potência média e concentração de lactato sanguíneo, independentemente do tipo de recuperação ativa realizada.

Conclusão: A prática de canoa conduz a desequilíbrios posturais e antropométricos e, uma vez que não existiram diferenças significativas no desempenho, independentemente do método de recuperação ativa aplicado, será adequado implementar a recuperação ativa paradoxal na prática diária de treino dos atletas, realizando uma simbiose entre recuperação e compensação, a nível médico e desportivo.

Palavras-chave: postura; antropometria; termografia; canoagem; recuperação; desempenho.

Introduction

Sports practice has undergone an overwhelming increase in recent years and has become, today, a therapeutic, social and economic methodology, obliging professionals in the field of health and sports sciences to better understand the practice and its consequences, in particular regarding the specificity of sports injuries.[1]

Canoeing is a popular worldwide sports discipline, including in Portugal that has one of the best national teams in the world. It allows a unique way of interacting with nature and is also popular due to health benefits. This sport has two main types of boat: canoe and kayak. The present work concerns to the athletes that perform in canoe boat. Canoe paddling technique requires an asymmetric and cyclic muscular work, as athletes paddle on the right or left side of a canoe, and involves forceful repetitive motions that predispose athletes to overuse injuries. Besides, repetitive one-sided paddling movement can lead to muscle imbalance and abnormal body gait in canoe sprint paddlers that can even lead to an asymmetric structure of the skeleton and degenerative changes.[2,3] Several authors have referred to static anomalies as having a preponderant role in the incidence of sports injuries.[4]

This is particularly dangerous for young athletes, especially during the phase of intense development of skeletal structures and muscle tissue growth.[2] These risk factors may have been further compounded by a lesser degree of strength by the females who in canoeing show a higher injury rate than males.[5] Due to a different organization of the hemispheres, women are characterized by a higher dynamic asymmetry during contralateral exercise.[3] Allied to this, there is an increasing media coverage of some sports like canoeing and an incessant pursuit of excellent results with an increased volume and intensity of training in the early stage of the sports career.[6]

The first aim of this study was to characterize the postural and anthropometric profile of canoe sprint athletes using the biophotogrammetry method and performing a quantitative measurement of the anthropometric characteristics.

Biophotogrammetry is a method of evaluation using computerized photographic analysis programs where the postural changes are quantified objectively [distances and angles between regions of interest (ROI)], allowing an effective comparison between individuals and between the various evolution stages of the same individual.[7]

Due to the above-mentioned, malfunctions may lead to injuries and to a numerous of harmful changes in athletes' health which can limit their normal functioning in everyday life after finishing their professional careers. Is, therefore, very important to implement preventive programs. Failure in using preventive and corrective exercises can increase the number of people experiencing injuries, specially strain injuries.[3]

The second aim of this study was to evaluate two different active recovery methods: paddling on the usual side or paddling on the paradoxical side (focusing on the opposite muscle groups than those more used in the usual paddling). Using a physical test protocol, it was tried to highlight the potential of the paradoxical recovery method suggested to minimize the problem identified.

A wide range of recovery methods are now used as integral parts of the training programs of elite athletes to help attain an optimal balance. Therefore, it is crucial to determine their efficacy and substantiate their use.[8] It's already reported that active recovery is more efficient than passive recovery.[9] Additionally, it has been reported that post-exercise active recovery should involve muscle groups which remained less affected by fatigue.[8] This is particularly important when a faster rate of lactic acid (LA) elimination is one of the main criteria for coaches as in canoeing the time between races is short and there is also a huge amount of volume/intensity training.

The original aspect of this study is the assessment of active recovery efficacy using other muscles from those which were active during the exercise in canoe sprint. Baker *et al.* also used a type of recovery focusing on different muscle groups than those more used in the exercise, and suggested that this may optimize lowering blood LA concentrations.[10] Besides this advantage, it was intended essentially to look for a muscular balance that allows the athlete to develop a healthy life during and after his career.

Our hypothesis was that doing the recovery using the opposite muscles from those which were active during fatiguing exercise wouldn't have significant differences in athlete's performance and, in this way, it could be one option to make symbioses between recovery and compensation at sportive and medical level, making time and effort profitable. Active recovery proves to be a simple recovery method, easy to execute and without associated costs or logistics.

With this research, it was aspired to achieve a practical and scientific tool for coaches to look after the health of their athletes and not only have a vision focused on the competitive goals. This process, which tries to compensate the abilities of the right and left body sides, is referred as the symmetrization of movements and has revealed to compensate the fitness of both body sides and also provide higher levels of movement coordination.[3]

To conclude, the third main objective to aim for was to show the usefulness of infrared thermography (IRT) in sports medicine, particularly in posture diagnosis.

IRT has entered the field of medicine, physical activity and sports injuries and has been used for numerous novel sporting applications, including the detection of posture, anatomical and biomechanical imbalance by recording of Skin Temperature (Tsk).[4,11] Nowadays, it is one of the most modern ways of diagnosis through digital image. This technique is simultaneously real-time, low-cost, fast and safe, harmless and easy-to-use, non-invasive, without emitting radiation, painless and highly reproducible.[12]

Recent research results have demonstrated new applications for this technique; among them, the monitoring and prevention of sports injuries appear to be one of the most interesting applications. It should be analysed the evolution of the same area over time and examine the asymmetries between contralateral ROI (i.e., left vs. right side) because it is suggested that for differences at rest of 0.5 to 1.0ºC preventive measures should be performed even if the athlete does not manifest symptoms of discomfort or injury.[3] It is accurate and reliable as a complementary tool considering the theory that musculoskeletal structures should be in thermal equilibrium when in a healthy state and strong asymmetry may indicate a pathological process or alterations in vascularity.[13] Therefore, the main contribution of IRT is to help identify an injury before it occurs, providing an opportunity for preventative action and for reducing the incidence of injury during professional sports practice.[14]

Objectives

1. Characterize the postural and anthropometric profile of canoe sprint athletes.
2. Evaluate two different active recovery methods: usual and paradoxical paddling.
3. Show the usefulness of infrared thermography (IRT) in sports medicine.

Methods

<u>Design</u>

The study was carried out in two different phases. The first one was the postural balance analysis with biophogrammetry and anthropometric quantitative measurement.

All the anthropometric measurements were taken by the same trained researcher, according to the recommendations of the International Society for the Advancement of Kinanthropometry.[15] Athletes were evaluated using a body composition analyser and an ergonomic circumferential measuring tape that allowed quantification of the segmental lean masses (Annex V) and girth evaluation of the members respectively.

The postural assessment was performed using the biophotogrammetry technique (Figure 1), with the athletes in the standing position in the anterior and posterior view. The technique is composed of a first photography following a strict protocol and then computational analysis done to produce a final objective report. It is important to make a careful identification through palpatory anatomy and bilateral marking of the selected body points: tragus, acromion, anterosuperior iliac spine, middle knee joint and lower angle of the scapula on right and left sides. The athlete should be evaluated in its natural state, being relaxed and in the posture that habitually adopts.

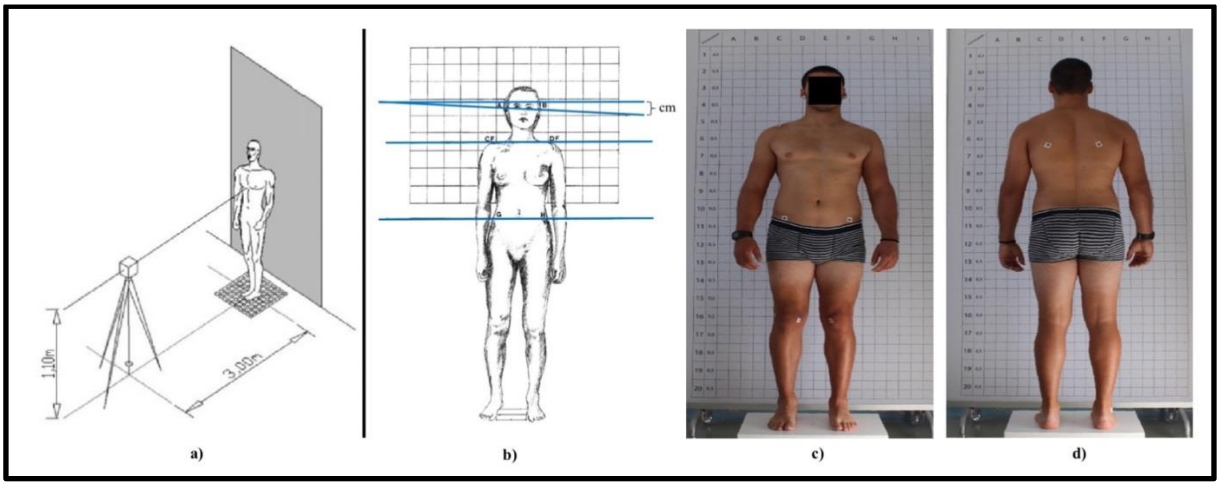

Figure 1 – Illustration of the biophotogrammetry method®.

The second phase of the study was the application of a physical test protocol. Tsk, thermal image, blood LA concentration, perception of effort, frequency of paddling and time, distance and mean power per block of paddling and in the performance test were recorded and registered in different phases of the protocol (Annex IV).

To examine the efficacy of the two methods of post-exercise recovery, athletes performed, under controlled temperature and humidity conditions, in two different days the same training session followed by a respective active recovery method. The same level of muscle fatigue was induced on the training session so it could be then compared the efficacy of each recovery method by assessing the rate of LA clearance and the performance of athletes in terms of time and mean power in a maximal distance test followed by each recuperation method respectively.

In order to minimize possible interferences of circadian variations in the performance of the individual and in the thermographic response was respected the same time schedule of the test protocols for each evaluated and an interval of more than 48h and less than 1 week was respected to guarantee a sufficient replacement of the glycogen and a similar physical form status, respectively. In addition, subjects had to maintain the same level of physical activity and type of diet in the 48h prior to the two phases of physical evaluation. On the day of the test drinking alcohol, tea or coffee was prohibited and any type of dermatological product was also asked to be avoided as it may affect the emissivity of the skin.[16]

Participants were instructed to take approximately 500ml of water two hours before the physical test protocol, in order to guarantee an adequate hydration status, as recommended by the Brazilian Society of Sports Medicine.[17] Hydration with water ad libitum was also ensured on the first phase of the ergometer protocol during intervals with sufficient amount to maintain resting body mass since a state of dehydration can affect thermoregulation responses. The same quantity of water had to be drunk on the second test day to replicate test conditions.

The subjects acclimated to the climate-controlled thermal imaging room during a 15-min period. Considering that the environmental conditions can interfere in the process of heat exchange and in the temperature values, it should be emphasized that the room temperature and relative humidity were kept stable in the two different phases of the test and both measures were recorded with a digital weather station in the beginning and in the end of the physical protocol test.

After the acclimatization, the participants did the warming up (paddling during 5min) and after this they completed a usual training on a canoe ergometer consisting of 5 blocks of 3min paddling separated by an interval of 3min. The intensity (power) of the exercise blocks was individually fixed and reproduced exactly in the two sessions.

After the training session, athletes performed the respective active recovery (paddling during 15min at 50% of the training mean power) and after it they simulated competition trial of 500m to evaluate the effectiveness of the recovery.

During the intermittent training protocol (Figure 2) performed on canoe ergometer, the main parameters assessed were: skin temperature (thermal sensors), thermography image and blood lactate concentration. IRT images were collected in four moments: after acclimatization (M1), after training session (M7), after active recovery (M8) and after performance test (M9). Blood lactate concentrations were calculated in three moments: M7, M8 and M9. Thermal Sensors were assessed in nine moments: M1, after warming up (M2), after block 1 (M3), block 2 (M4), block 3 (M5), block 4 (M6) and block 5 (M7) of training session, M8 and M9.

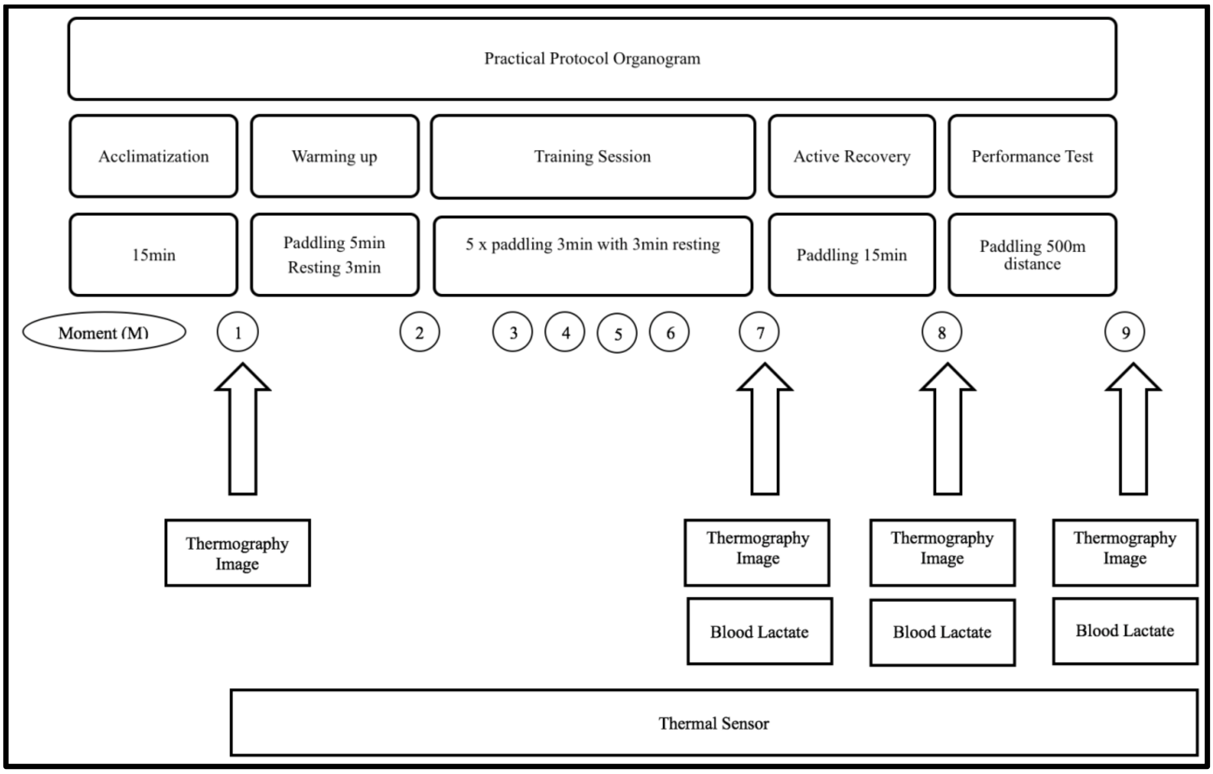

Figure 2 – Physical test protocol.

The order of accomplishment of the protocol with the respective active recovery method was performed in a randomized way, with 5 athletes performing the active recovery test first paddling on the common side and the other 5 athletes performed the first test on the paradoxical side.

To determine the enzymatic concentration of LA in plasma 10μL of capillary blood was collected into a capillary tube and immediately pipetted into a lactate starter reagent and inserted into the spectrophotometer.

The second stage of the evaluation followed the same procedure for the entire protocol and image collection, differing only in the application of one or another active recovery method.

There are different methods to evaluate skin temperature and, in this research, it was decided to use two different methods of skin temperature measurement: IRT and thermal sensors. The thermography was more useful for visualization in the resting period between distinct phases of the protocol whereas the thermal sensors had an essentially monitoring function throughout the training session showing real-time temperatures every 5 seconds that allowed us to collect results in nine different moments.

For the IRT scan, the canoeist remained in the standing position in front of the camera at 3 meters distance for the thermography measurement (Figure 3). For each participant and in each moment of the protocol, four series of thermograms were performed on selected body surfaces: the front and rear surfaces of the upper body and the front and rear surfaces of the thighs. The main ROI studied were the pectoralis major, the latissimus dorsi, the trapezius, the rectus abdominis, the quadriceps femoris, the hamstrings, the shoulder and the knee. The treatment of thermal images consisted in the analysis of these ROI that were manually delimited by a circle (circle), rectangle (area) or a simple point (spot) and the measurements obtained for each ROI were the average, maximum and minimum Tsk.

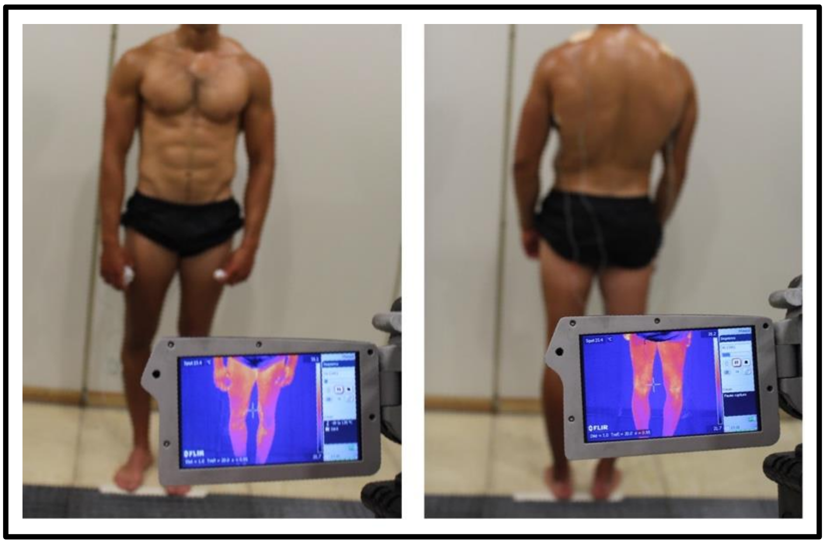

Figure 3 – Illustration of the infrared thermography scan.

Thermography for scientific research requires standardized procedures to obtain reliable images. The procedures were performed according to the Glamorgan Protocol powered by the international thermographic association such as the room size, lighting, ambient temperature, relative humidity, the exclusions factors, the positioning of subjects during experiments and techniques of image analysis.[18]

Studies have shown that during canoeing exercise the major protagonist muscles are the latissimus dorsi and trapezius and so these were the selected muscles for the application of four thermal sensors using a HOBO 4-Channel Thermocouple Data Logger (Figure 4) that allowed us to study the skin temperature surface progression.[19]

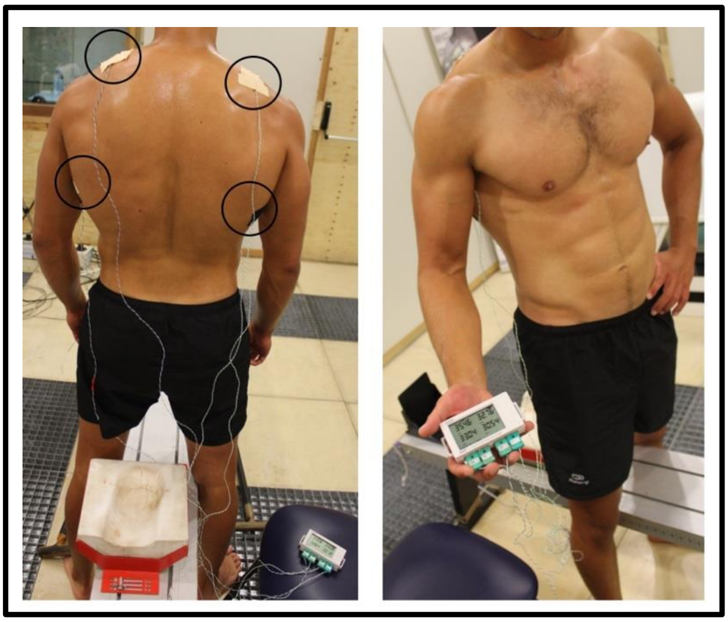

Figure 4 – Thermal sensors application.

<u>Sample</u>

Ten males (22.30±3.68 years old, 177.30±3.62 cm stature, 77.36±5.06 kg body mass, 9.40±3.04 % fat mass) were evaluated using a postural assessment software and a set of anthropometric measurements that quantified the static postural and anthropometric imbalances and performed an intermittent training protocol on canoe ergometer. The athletes performed two moments of evaluation under controlled temperature and humidity conditions (temperature 21.71±1.14 ºC; relative humidity 57.39±6.53 %; and no direct ventilation) where they differed only in the active recovery method.

In the evaluation of the athletes, a validated questionnaire (Annex III) was applied to obtain some personal data, such as age, laterality, years of practice, weeks of practice per year and number of training hours per week. With this data it was possible to calculate the accumulated training load of each athlete to relate this value to the registered posture imbalances. It was mandatory to have a minimum of 4 years of practice and an average of 15 training hours per week. It was also defined as cut-off a percentage of fat mass inferior to 15% inferred through the measurement of skinfolds to optimize the thermographic images obtained.

The study carried out has an experimental character in which each participant is the control of itself. The volunteers were informed about the procedures for all stages of the investigation and before that informed consent forms to the enrolment in the study were signed (Annex I). This study was approved by the Ethics Committee of the Medicine Faculty of Coimbra University (087/2017) (Annex II), of which followed the principles outlined by the World Medical Assembly Declaration of Helsinki.

The procedures of the anthropometric evaluation and analysis of the postural balance were performed at the Military Hospital of Coimbra. The procedures of the laboratory study were carried out at the ADAI (Association for the Development of Aerodynamics Industry), linked to the Department of Mechanical Engineering of the Faculty of Sciences and Technology of the University of Coimbra.

Measurements and equipment

Body mass (kg) and segmental lean mass (g) were determined using a body composition analyser, InBody 270 (USA), stature (cm) with a bodymeter SECA 206 (Germany) and girth (cm) using an ergonomic circumference measuring tape SECA 201 (Germany). Skinfold thickness (mm) was measured in seven body points (triceps, subscapular, supraspinal, abdominal, front thigh, chest and midaxillary) with a harpenden skinfold calliper (UK). The relative fat mass (%) was calculated according to the Jackson and Pollock protocol.[20] Biophotogrammetry was performed using a camera Canon 1200D (Taiwan) and SAPO software (Brazil). The practical physical protocol using a canoe ergometer Dansprint (Denmark), the collection and treatment of thermal images with a thermal camera FLIR SC660 (USA) and software FLIR Tools 4.40.2.10 (Sweden). Capillaries and micropipettes Dr Lange for collection of LA and mini spectrophotometer Plus Dr Lange LP20 (Germany) for analysis of LA blood concentration (mmol/L). Tsk (ºC) was collected using a HOBO 4-Channel Thermocouple Data Logger (USA).

Statistical analysis

Descriptive statistics of variables, including means and standard deviations, were calculated. The direction and strength of association between pairs of continuous variables were determined by calculating the Pearson's coefficients of linear correlation. Comparative analysis was calculated using the Wilcoxon test. The level of significance was set at $p \leq 0.05$.

Data were analysed using the Statistical Package for Social Sciences (SPSS, version 24, USA).

Results

Analysing the biophotogrammetry data, it was possible to find postural imbalances in the measured corporal distances between relative height (cm) of five contralateral anatomical points (Table 1).

Table 1 – Biophotogrammetry analysis data (difference in cm between contralateral sides in anatomical points) and training load.

Athlete	**Biophotogrammetry** (difference in cm)					**Training load** (h)
	Tragus (cm)	**Acromion** (cm)	**Antero superior iliac spine** (cm)	**Middle knee joint** (cm)	**Lower angle of scapula** (cm)	
1	1.5	2.7	0.6	1.6	1.8	8280
2	4.6	3.0	2.7	6.5	4.6	10164
3	3.7	1.7	1.5	3.2	9.3	6860
4	5.1	3.4	2.1	8.6	9.7	12420
5	3.7	0.6	1.6	5.0	2.6	6768
6	2.3	3.4	1.9	8.9	1.7	7350
7	2.3	1.7	2.2	8.3	3.6	3528
8	5.6	5.7	4.6	9.3	0.9	10560
9	1.2	1.5	2.7	5.3	1.5	6615
10	2.6	0.6	0.0	0.0	2.9	2178
Mean	3.26	2.43	1.99	5.67	3.86	7472.30
SD	1.52	1.55	1.25	3.25	3.16	3111.26

cm – centimeters; h – hours; SD – standard deviation.

Regarding the anthropometric measurements, in the contralateral upper limbs, there was a positive difference of 122.86±65.50 g in the lean mass and 0.90±0.56 cm in the girth. In the contralateral lower limbs, there was a difference of 184.29±101.47 g in the lean mass and 1.70±1.06 cm in the girth. These differences between the segmental lean masses in the upper (*p=0.030*) and lower limbs (*p=0.030*) and the girths between the contralateral upper (*p=0.025*) and lower limbs (*p=0.001*) were statistically significant, being the dominant hemibody (stroke side) bigger in both lean mass and girth.

Regarding the physical protocol test, there were no significant differences between the temperature and relative humidity in the controlled test room in the beginning and the final of the same day test and between the two different moments of the test.

Analyzing the Tsk obtained by thermal sensors (Figure 5) it was possible to see high significant differences between contralateral trapezius and latissimus dorsi muscles and these variations in all the physical protocol moments (M1 to M9), taking into account that the dominant muscle (stroke side) was always the hottest. It was also possible to verify a general increase in the Tsk until approximately the middle of the training session (M5) during the comfort zone of the athlete and after this there was a decrease on the Tsk with probable correlation with the fatigue and blood LA concentration increase.

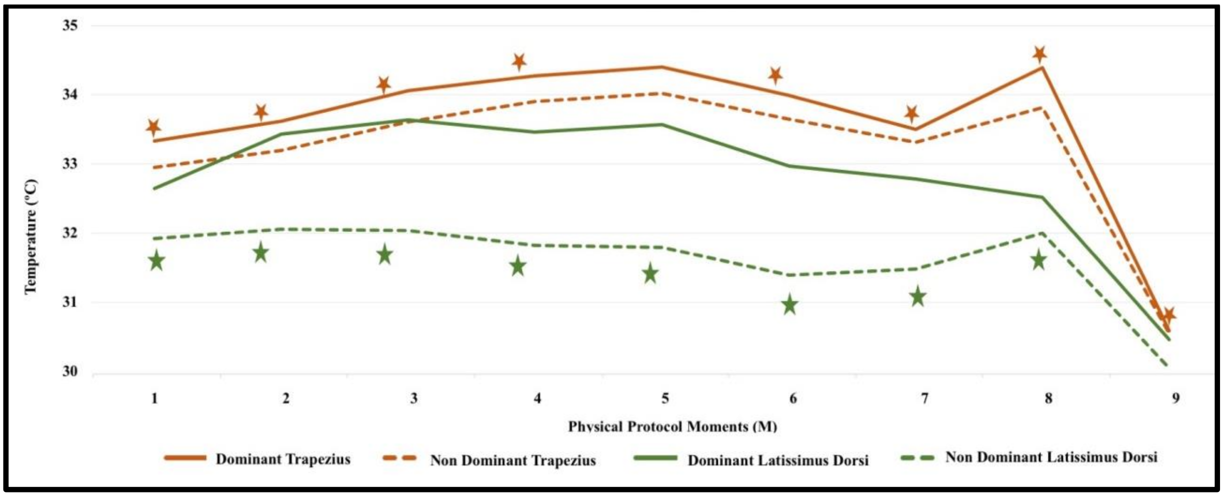

Figure 5 – Thermal sensor variations during the different moments of the physical protocol. Significant differences in skin temperature between contralateral muscles are shown by * ($p \leq 0.05$).

There was a statistical trend in the thermal variations of the same muscles when compared between dominant and non-dominant side. The statistically significant differences are marked with a star in the Graphic 1.

Analysing the results in the physical protocol test (Table 2) data, it was possible to find similar performances according to the mean and standard deviation of the assessed parameters when compared the two different active recovery methods: usual recovery (1) and paradoxical recovery (2).

Table 2 – Performance test results (M9) according to the respective active recovery method.

Athlete	Active recovery	Performance test (500m)		
		Mean power (W)	**Time** (s)	**Lactate** (mmol/L)
1	1	207	127	13.1
	2	208	128	8.1
2	1	180	134	12.2
	2	180	134	12.6
3	1	225	124	10.3
	2	227	123	9.8
4	1	226	122	13.8
	2	229	121	14.1
5	1	167	136	14.2
	2	181	132	12.2
6	1	213	126	11.8
	2	208	128	11.3
7	1	185	131	9.3
	2	153	144	12.0
8	1	194	129	14.9
	2	192	130	12.9
9	1	160	145	15.6
	2	171	139	10.9
10	1	156	142	9.0
	2	185	134	15.1
Mean	**1**	191.30	131.60	11.93
	2	193.40	131.30	12.39
	Total	192.35	131.45	12.16
SD	**1**	25.92	7.62	2.39
	2	24.41	6.95	1.93
	Total	24.53	7.10	2.13

1 – usual; 2 – paradoxical; mmol/L – millimoles per litre; s – second; SD – standard deviation; W – watt.

There was no statistically significant difference in the performance in terms of time, mean power and lactate concentration in the maximal 500m test regardless of the type of active recovery performed after the training.

There was no significant difference in the lactate blood concentration at the end of both training sessions but lactate blood concentration after active recovery was higher when practising the paradoxical side compared to the usual side.

There was a significant correlation between the training load and the postural imbalances found in two of the five measured anatomical points by biophogrammetry: tragus ($p=0.047$) and acromion ($p=0.017$). There was also a correlation statistically significant between the training load and the differences observed between the girths in the contralateral lower limbs ($p=0.050$).

The correlation between fat mass percentage obtained by skinfold measurement and bioimpedance was highly significant ($p\leq0.01$).

Analysing the thermography images, it was possible to demonstrate the applicability of the proposed paradoxical recovery method in reducing the contralateral imbalance (Figure 6) and organize some sequential thermograms to show the asymmetry induced by the paddling technique (Figure 7). A quantitative assessment of the Tsk in different ROI (Figure 8) was also possible. It is important to note that the lighter areas correspond to the hottest and therefore most requested muscles/ joints in the paddling.

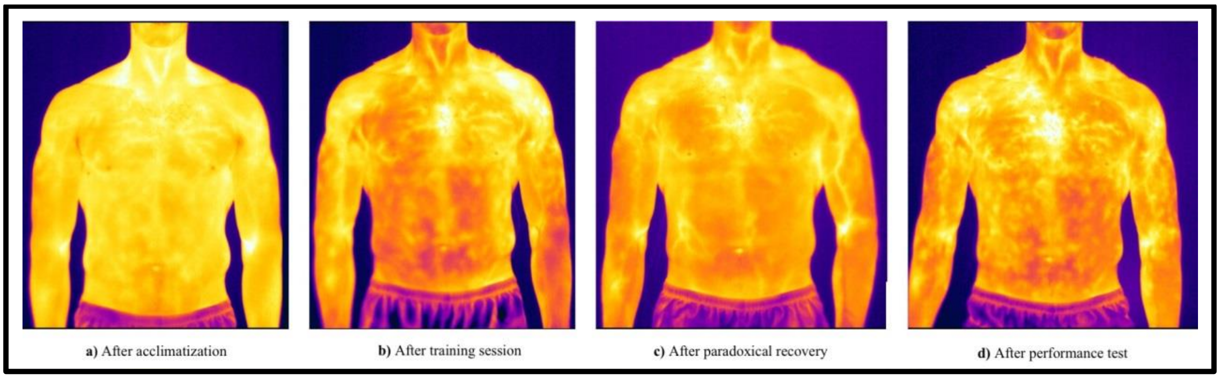

Figure 6 – Thermographic sequence of the physical protocol.

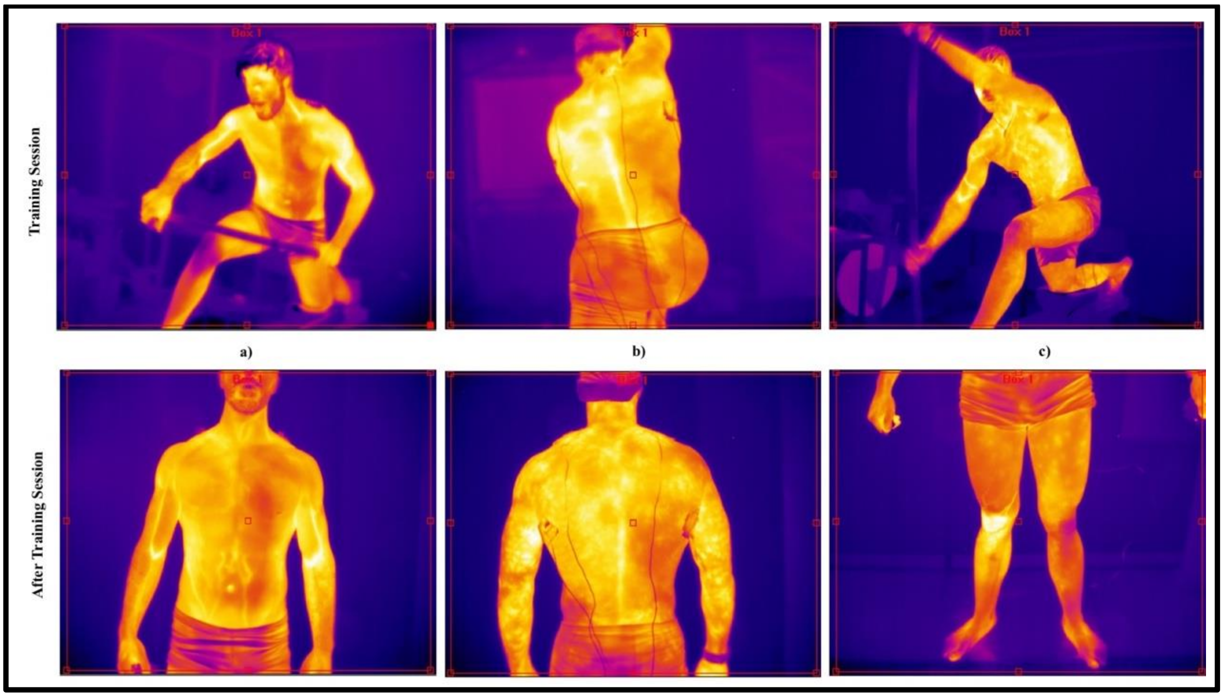

Figure 7 – Training session and respective after-exercise thermography image.

Figure 8 – Thermography analysis example.

Discussion

Postural assessment by standardized biophotogrammetry and computational analysis showed significant variations of postural alignment with a lateralization of the body to the non-dominant side in the posterior and anterior view, being the hemibody corresponding to the side of the stroke (dominant side) always the highest. The biggest discrepancy was found in the middle line of the knee joint and it can happen because the canoeist paddles kneeling on just one leg and this joint sustains a lot of loads and force movements, imposing a high stress on the joint that can lead to a deformed growth and an asymmetrical muscular development.

Using the biophotogrammetry technique, the observation of the alignment errors can contribute to the earlier establishment of broker programs. It is therefore fundamental to raise the awareness of all the involved in the sporting phenomenon, particularly athletes and coaches to the importance of the sports medical examination, mainly to enable the implementation of measures aimed at correcting compensation or control of risk factors for injury. Postural assessment is a valuable tool that has been undervalued by sports agents.[4]

Correlating the number of accumulated training hours with the level of imbalance, it was seen that longer sports practice times are associated with greater variance on some postural changes that should alert us to the interconnection between this fact and the results pointed out by previous researches that showed also a direct relationship between exposure time and injury rate.[4,5]

The high significant correlation between relative fat mass percentage obtained by skinfold measurement and bioimpedance (InBody) reveals the efficacy of this second method for assessing body composition and reinforces the accuracy of the lean mass calculated.

It was possible to compare absolute Tsk changes between muscle groups used in a decidedly asymmetric manner and higher contralateral differences were observed in the latissimus dorsi probably due to its larger size compared to the trapezium and due to its bigger specificity (it is a muscle where the dominance is very notable in the technique movement). It was also noticeable that the hottest muscle was always the most requested which agrees with other studies that have also determined that the higher Tsk are present on the dominant side and on the most susceptible muscle regions to injury.[12,21] It is important to reinforce that the initial differences in Tsk between contralateral muscles (after acclimatization moment and at rest) were statistically significant, thus revealing the chronic nature of this process.

Analysing the thermal sensor variations, this study also contributed to a better understanding of hemodynamic and thermoregulation mechanisms during intense ergometer exercise. The Tsk is a significant parameter, which is conditioned by the evolution of physiological parameters such as, for example, the production of lactate or the heart rate which have a direct influence on the process of body thermoregulation.[11] The results show that an increase in anaerobic effort is accompanied by a drop of the Tsk of engaged muscles and the degree of the drop can be proportional to the blood lactate concentration. Higher lactate level shows an increase in exercise intensity and, in its turn, leads to peripheral vasoconstriction and consequently to a general decrease in body surface Tsk.[17,22] Our results are in concordance with other studies that also reported Tsk changes during the exercise considering this variable as an indicator of muscular damage.[23]

The fact that athletes produced similar power during the entire training session and that there were no significant differences in the lactate blood concentration at the end of both training sessions shows that athletes were in similar physical conditions on both days and complied the protocol as desired (same training to evaluate the respective recovery method in the same fatigue conditions).

In relation to the higher lactate blood concentration identified after paradoxical recovery, we suggest that the paddling intensity in the non-dominant hemibody was higher in relation to the fitness level of those more inactive and not so prepared muscles in terms of strength and aerobic capacity. This may explain why there was a smaller blood lactate reduction with this recovery method (paradoxical). We also hypothesized that in the dominant muscles may have been an effective lactate clearance with the paradoxical method but, on the other hand, less conditioned muscles (non-dominant hemibody) may have produced lactate, and therefore the final balance on clearance was higher than desired, at least until the muscles come to reach a satisfactory level of symmetry. Our hypothesis is also supported by the fact that there were no significant differences of performance in the maximal 500m test regardless of the type of active recovery performed.

Baker *et al.* performed a type of recovery focusing on a different muscle group than that used in the exercise, which, as they hypothesized, optimized the lowering of the blood lactate concentration in comparison with a recovery method similar to that used to produce lactate in the first instance.[10] However, it's important to point out that in this study both groups of muscles were in the same physical condition.

This is, to our best knowledge, the first study to show a time course of body surface temperature during a training session in highly trained canoe sprinters. The thermographic monitoring in these areas made it possible to observe the thermal adjustments due to the time factor and the way of exercise execution in all the ROI. The results of this study demonstrated that exercise is a disturbing agent of thermal homeostasis and differentiated thermal responses in each body region as a function of the body segments engaged during the exercises.[24] This response can be attributed to lower local metabolic activity and reduced blood supply in inactive muscle groups.[17] However, thermoregulatory adaptation to exercise is complex and still not fully explained.[13]

Due to some limitations in the thermography software, it is not possible to carry out fast and automatic analyses yet, making it difficult to evaluate many athletes effectively. However, there is a great advantage in the analysis of ROI and comparison of temperatures at the contralateral level that may be useful for the diagnosis of asymmetry or injury. In addition, it is an excellent tool for monitoring the progression of the alterations found and its response to the compensation programme. In this research are shown some examples of thermal images (Figure 6-8) in order to verify the medical-sports applications of the technique.

In the thermography analysis example (Figure 8) it can be seen, at rest and after acclimatization, some contralateral significant differences (bigger than 0.5ºC) in the Tsk of the left pectoralis (circle 2 - 34.6ºC average) and the right pectoralis (circle 1 - 34.0ºC average) and the left upper arm (spot 2 - 34.3ºC) and the right upper arm (spot 1 - 33.4ºC). In these example situations, with a difference at rest of 0.5 to 1.0ºC, preventive measures should be performed even if the athlete does not manifest symptoms yet considering that strong asymmetry may indicate a pathological process with alterations in vascularity. In the other hand, the rectus abdominis showed a thermal equilibrium in the Tsk between the left (area 1 - 34.0ºC average) and the right (area 2 – 34.0ºC average) half of the muscle that suggests a healthy state of this structure probably due to its homogeneous and wide use in other physical activities.

In Figure 7 there are noticeable Tsk asymmetries in the anterior (a) and posterior (b) hemibody and also in the knee joint (c) observed during (up) and after (down) the training session. In Figure 6 there are Tsk asymmetries induced by the training session (Figure 6b) (quite evident in the chest and shoulder) and the advantages of applying the paradoxical active recovery (Figure 6c) that in this case allowed a stronger stimulus to the non-dominant hemibody and made the thermographic image more homogeneous at the end of the performance test (Figure 6d).

In past studies was proved that the functional asymmetry of the lower limbs tends to reduce when there is an increase of systematic training on the non-preferred limb and then we conclude that it is mandatory to apply this or other systematic and specific training for the non-dominant hemibody and promote the reduction of functional and structural asymmetry.[25]

It is important to reinforce that this study was carried out taking into account the option of active recovery paradoxical because it would be, in our perspective, the ideal way not to prejudice the competitive preparation of the athlete and make a valid option for the coaches. However, in medical terms, the ideal would be for athletes to alternate between training on both sides of the boat.

It is suggested that further longitudinal studies with a higher number of young athletes should be developed to better verify the effectiveness of this method in the prevention of postural changes caused by canoe training because as might be expected it doesn’t have immediate practical effects.

The study presents limitations inherent to the fact that it was done in a laboratory environment that simulated maximum real sports conditions.

Conclusion

High performance training pushes the locomotor system to the edge of its anatomical and physiological limits and the asymmetric canoe practice leads to postural and anthropometric changes that can predispose athletes to injuries.[11]

Posture is an important health indicator and its right assessment is essential. The biophotogrammetry technique was accurate for measuring corporal distances and should be considered as a reliable tool for postural assessment. When conducted without instruments and quantitative evaluation, abnormalities are only visually inspected and postural assessments are often subjective, not being possible to see that gradual adaptation of the body to the kind of exercise.

Since there were no significant differences in the athletes' performance using the two different active recovery methods, it should be useful to implement the paradoxical active recovery as a practice of the canoeists daily training, making a symbiosis between recovery and postural compensation at sportive and medical level.

Taking into account that preventive care is always better than cure, the intervention programs by coaches should always aim to health promoting. Striving for symmetry of muscle mass distribution should correspond to an objective for all canoeists.

Our results may also contribute to the development of thermography application in scientific studies and professional practice. IRT seems to have potential in sports medicine and its daily use allows rapid assessment of quantitative and qualitative manner. In addition, it can monitor the thermal response of the athlete which may provide us relevant information not only for increasing the athletes' performance but also for their health. When the medical community becomes familiar with IRT technology, it will most likely be considered a more reliable method for diagnosing some diseases and injuries.

Acknowledgments

It is with sincere gratitude that I leave special thanks:

To Professor Doctor João Páscoa Pinheiro and Professor Doctor Beatriz Gomes for all the support, wise guidance and demand that always demonstrated.

To Portuguese Canoe Federation, to ADAI, in the person of Doctor Manuel Gameiro, and to Coimbra Military Health Center, in the person of Doctor Frederico Silva, for the loan of infrastructures and equipment for carrying out the research.

To Professor Doctor Amândio Santos for the guidance and to all who helped me during the laboratory tests.

To the athletes who voluntarily contributed to make this study possible.

To my parents and my girlfriend, my pillars of life, for all the love and for having always been on my side.

To Coimbra, and all that it contains.

References

1 Pessoa P, Jones H. Traumatologia desportiva. LIDEL: Lisboa; 2014.

2 Rynkiewicz M, Rynkiewicz T, Starosta W. Asymmetry of Spinal Segments Mobility in Canoeists and its Relationship with Racing Speed. Journal of Human Kinetics. 2013; 36: 37–43.

3 Rynkiewicz M, Starosta W. Asymmetry of Paddling Technique, Its Selected Conditions and Changeability in Highly Advanced Kayakers. AWF Poznań and IASC Warszawa. 2011; 35.

4 Sillero-Quintana M, Fernández-Jaén T, Fernández-Cuevas I, Gómez-Carmona PM, Arnaiz-Lastras J, Pérez M et al. Infrared Thermography as a Support Tool for Screening and Early Diagnosis in Emergencies. Journal of Medical Imaging and Health Informatics. 2015; 5: 1223–1228.

5 Mukherjee S, Leong HF, Chen S, Foo YXW, Pek HK. Injuries in competitive dragon boating. Orthopaedic Journal of Sports Medicine. 2014; 2: 1–9.

6 Horta L. Prevenção de lesões no desporto. 2 ed. Livros Horizonte: Lisboa; 2000.

7 Ferreira E, Duarte M, Maldonado E, Bersanetti A, Marques A. Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior, and lateral views. Journal of Manipulative and Physiological Therapeutics. 2011; 34: 371–380.

8 Mika A, Oleksy Ł, Kielnar R, Wodka-Natkaniec E, Twardowska M, Kamiński K *et al*. Comparison of two different modes of active recovery on muscles performance after fatiguing exercise in mountain canoeist and football players. PLoS ONE. 2016; 11: 1–14.

9 Ahmaidi S, Granier P, Taoutaou Z, Mercier J, Dubouchaud H, Prefaut C. Effects of active recovery on plasma lactate and anaerobic power following repeated intensive

exercise. Medicine and Science in Sports and Exercise. 1996; 28: 450–456.

10 Baker SJ, King N. Lactic acid recovery profiles following exhaustive arm exercise on a canoeing ergometer. British Journal of Sports Medicine. 1991; 25: 165–167.

11 Arfaoui A, Polidori G, Taiar R, Popa C. Infrared Thermography in Sports Activity. Infrared Thermography. 2012; : 141–168.

12 Bandeira F, Borba Neves E, Muniz MA, Percy N. A termografia no apoio ao diagnóstico de lesão muscular no esporte. Revista Brasileira de Medicina do Esporte. 2014; 20: 59–64.

13 Korman P, Straburzyńska A, Kusy K, Kantanista A, Zieliński J. Changes in body surface temperature during speed endurance work-out in highly-trained male sprinters. Infrared Physics and Technology. 2016; 78: 209–213.

14 Sillero-Quintana M, Gomez-Carmona PM, Fernández-Cuevas I. Infrared Thermography as a Means of Monitoring and Preventing Sports Injuries. Innovative research in thermal imaging for biology and medicine. 2017; 165–198.

15 Stewart A, Marfell-Jones M, Olds TS, Carter L. International standards for anthropometric assessment. International Society for the Advancement of Kinanthropometry. 2011.

16 Gabriel J, Aguiar-Branco C, Pinhão-Ferreira A, Ramalhão C, Vardasca R, Pais-Clemente M. Termografia - Imagem médica e síndromes dolorosas. LIDEL: Lisboa; 2016.

17 González JA, Crandall CG, Johnson JM. The cardiovascular challenge of exercising in the heat. Journal of Physiology. 2008; 586: 45–53.

18 Korman P, Zielinski J, Kusy K, Straburzynska-Lupa A. Possible uses of infrared thermography in sport. Trends in Sport Sciences. 2016; 2: 57–62.

19 Baker SJ, Hardy L. Effects of high intensity canoeing training on fibre area and fibre

type in the latissimus dorsi muscle. British Journal of Sports Medicine. 1989; 23: 23–26.

20 Costa R. Equações preditivas de gordura corporal: Saber escolher é fundamental. Revista Brasileira de Medicina do Esporte. 2010; 16: 393.

21 Fernandes AA, Pimenta EM, Moreira DG, Sillero-Quintana M, Marins JCB, Morandi RF et al. Effect of a professional soccer match in skin temperature of the lower limbs: a case study. Journal of Exercise Rehabilitation. 2017; 13: 330–334.

22 Adamczyk JG, Boguszewski D, Siewierski M. Thermographic evaluation of lactate level in capillary blood during post-exercise recovery. Kinesiology. 2014; 46: 186–193.

23 Hadžić V, Širok B, Malneršič A, Čoh M. Can infrared thermography be used to monitor fatigue during exercise? A case study. Journal of Sport and Health Science. 2015.

24 Cárceles FA, Muyor JM, Alvero-Cruz JR, Isorna M, López-Miñarro PA. Anthropometric indexes in young elite male sprint canoeists. International Journal of Morphology. 2012; 30(2): 583–287.

25 Guilherme J, Garganta J, Graça A, Seabra A. Influence of non-preferred foot technical training in reducing lower limbs functional asymmetry among young football players. Journal of Sports Sciences. 2015; 33: 1790–1798.

Annexes

Annex I – Informed Consent

FACULDADE DE MEDICINA DA UNIVERSIDADE DE COIMBRA
MESTRADO INTEGRADO EM MEDICINA

<u>CONSENTIMENTO INFORMADO, ESCLARECIDO E LIVRE PARA PARTICIPAÇÃO EM ESTUDOS DE INVESTIGAÇÃO</u> (de acordo com a Declaração de Helsínquia da Associação Médica Mundial e suas atualizações e a Convenção de Oviedo)

Título do projecto de investigação: Alterações posturais e antropométricas em atletas de canoagem: o impacto de dois diferentes métodos de recuperação ativa.

Enquadramento: Esta investigação enquadra-se na área da Medicina Física e Reabilitação e no âmbito do trabalho final do Mestrado Integrado em Medicina da Universidade de Coimbra do aluno Nuno Silva. Tem como co-investigadores responsáveis os Professores Doutores João Páscoa Pinheiro e Beatriz Branquinho Gomes.

Explicação do estudo: O objetivo do estudo é traçar um perfil postural e antropométrico de um grupo de atletas de elite de canoagem a fim de verificar um desenvolvimento postural inadequado consequente ao movimento cíclico assimétrico realizado no gesto técnico e demonstrar a necessidade de implementar métodos de recuperação ativa que simultaneamente permitam ao atleta recuperar das altas cargas de treino exigidas e também combater o desequilíbrio postural, permitindo um desenvolvimento saudável a longo prazo. Os métodos de recuperação ativa sujeitos a avaliação serão: pagaiar a baixa intensidade do lado habitualmente solicitado pelo atleta e pagaiar a baixa intensidade do lado oposto ao habitual. Através do segundo movimento, paradoxal para o atleta, poderá realizar-se um trabalho de simbiose entre recuperação e compensação, numa única sessão, rentabilizando tempo e esforço.

Metodologia: Os atletas realizarão uma avaliação postural e antropométrica com recurso a uma técnica de biofotogrametria, medição de circunferências corporais e bioimpedância. Realizarão também um protocolo em ergómetro composto por aquecimento, sessão de treino (5 séries de 3 minutos), recuperação ativa e um teste de performance (1 série de 500m). Durante a realização do protocolo serão capturadas sequências de imagens corporais com câmara termográfica, monitorização da temperatura cutânea através de sensores térmicos colocados à superfície da pele e serão também recolhidos 10 μL de sangue capilar em três momentos para determinação da concentração de ácido lático. O protocolo em ergómetro será replicado em dois momentos distintos sob condições controladas, variando apenas no tipo de recuperação ativa realizada.

Condições de participação: este projeto possui um carácter de participação voluntária, não existindo qualquer prejuízo caso não aceite participar ou se interromper a sua participação no decorrer do estudo.

Condições de financiamento: O estudo não possui nenhum financiamento exterior à instituição que o acolhe.

Confidencialidade e anonimato: Todos os dados recolhidos para o presente estudo são confidenciais e anónimos, garantindo o investigador que cada participante terá acesso a um pequeno relatório final individual que a si apenas diz respeito. Os resultados deste projeto poderão ser publicados, mas jamais permitirão a identificação de qualquer elemento.

1

FACULDADE DE MEDICINA DA UNIVERSIDADE DE COIMBRA
MESTRADO INTEGRADO EM MEDICINA

Obrigada pela sua participação e apoio no estudo!

Por favor, leia com atenção a seguinte informação. Se achar que algo está incorreto ou que não está claro, não hesite em solicitar mais informações. Se concorda com a proposta que lhe foi feita, queira assinar este documento.

Quem pede consentimento:
Nome: Nuno António Vieira da Silva
Assinatura: ____ **Data:** ___/___/______
Contacto: nuno_90_vs@hotmail.com

Declaro ter lido e compreendido este documento, bem como as informações verbais que me foram fornecidas pela/s pessoa/s que acima assina/m. Foi-me garantida a possibilidade de, em qualquer altura, recusar participar neste estudo sem qualquer tipo de consequências. Desta forma, aceito participar neste estudo e permito a utilização dos dados que de forma voluntária forneço, confiando em que apenas serão utilizados para esta investigação e nas garantias de confidencialidade e anonimato que me são dadas pelo/a investigador/a.

Nome: ____
Assinatura: ____ **Data:** ___/___/_______

ESTE DOCUMENTO É COMPOSTO DE 2 PÁGINAS E FEITO EM DUPLICADO: UMA VIA PARA O /A INVESTIGADOR /A, OUTRA PARA A PESSOA QUE CONSENTE.

2

Annex II – Approval by the Ethics Committee of FMUC

· U C ·

FMUC FACULDADE DE MEDICINA
UNIVERSIDADE DE COIMBRA

COMISSÃO DE ÉTICA DA FMUC

Of. Refª **098-CE-2017**

Data 21/9/**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-087/2017).

Investigador(a) Principal: Nuno António Vieira da Silva

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

Título do Projeto: ***"Avaliação de diferentes métodos de recuperação ativa em canoagem".***

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

SERVIÇOS TÉCNICOS DE APOIO À GESTÃO - STAG • COMISSÃO DE ÉTICA
Pólo das Ciências da Saúde • Unidade Central
Azinhaga de Santa Comba, Celas, 3000-354 COIMBRA • PORTUGAL
Tel.: +351 239 857 708 (Ext. 542708) | Fax: +351 239 823 236
E-mail: comissaoetica@fmed.uc.pt | www.fmed.uc.pt

Annex III – Postural and Anthropometric Assessment

FACULDADE DE MEDICINA DA UNIVERSIDADE DE COIMBRA
MESTRADO INTEGRADO EM MEDICINA

Nome: ____

Data: ____/____/_______ **Hora:** ___: ____

Data de Nascimento: ____/____/_______

Peso: ____ **Estatura:** ____ **IMC:** ____

Ano de iniciação da prática desportiva federada em canoagem: _______

Número de horas de treino semanais: ______

Número de semanas de treino por época desportiva: ______

Carga de treino acumulada: _______

Alguma lesão/ dor musculoesquelética sentida nos 7 dias anteriores ao teste: ______

Se sim, caracterize: ____

De acordo com a Escala de Borg, quantifique:

Grau de adaptação ao ergómetro (1-10): ______

Nível de conforto ao pagaiar do lado paradoxal (0-10): ______

Nível de fadiga sentido no 1º momento de teste (0-10): ______

Nível de fadiga sentido no 2º momento de teste (0-10): ______

Dificuldade no cumprimento do protocolo em ergómetro (0-10): ______

Prega	Subescapular	Tricipital	Peitoral	Supra-Ilíaca	Abdominal	Crural	Axilar Média

Massa Gorda Corporal (%): ______

Massa Muscular Esquelética (kg): _____

	Membro Superior		Membro Inferior	
	Dominante	Não-dominante	Dominante	Não-dominante
Perímetros				
Massa Magra Segmentar				

Annex IV – Physical Protocol Assessment

· U C · FMUC

FACULDADE DE MEDICINA DA UNIVERSIDADE DE COIMBRA
MESTRADO INTEGRADO EM MEDICINA

Nome: ____

Data: ____/____/_______ **Hora:** ___: ____ **Teste nº:** _____

Inicio: Temperatura: ____ **Humidade:** ____

Final: Temperatura: ____ **Humidade:** ____

Lado Pagaiada: _____ **Lado Recuperação:** _____

Peso: _____ **Nível Ergómetro:** _____

Potência Treino: _____

Potência Aquecimento/ Recuperação: ______

Água ingerida: _______

Sensor Térmico		Início	Final Aquecim	Final 1ª Série	Final 2ª Série	Final 3ª Série	Final 4ª Série	Final 5ª Série	Final Recup	Final Teste Perfomance
1	Trapézio Esquerdo									
2	Trapézio Direito									
3	Latissimus Esquerdo									
4	Latissimus Direito									

Treino	Aquecimento	1ª Série	2ª Série	3ª Série	4ª Série	5ª Série	Recuperação	Teste Performance
Potência Média								
Frequência Pagaiada								
Distância / Tempo								
Perceção Esforço								

Lactato	Final Sessão Treino	Final Recuperação	Final Teste Performance

Annex V – Body composition analysis

InBody

ID	Altura	Idade	Género	Testar Data / Hora
58746846548	171cm	23	Masculino	01.08.2017. 12:50

Análise da Composição Corporal

Quantidade total de água no corpo	Água Corporal Total	(L)	47,5	(36,2~44,2)
Para o desenvolvimento dos músculos	Proteínas	(kg)	12,9	(9,7~11,9)
Para o fortalecimento dos ossos	Minerais	(kg)	4,18	(3,35~4,09)
Para o armazenamento da energia em excesso	Massa Gorda	(kg)	6,8	(7,7~15,5)
A soma dos itens acima	Peso	(kg)	71,4	(54,7~73,9)

Análise Músculo-Gordura

Abaixo | Normal | Acima

	%	
Peso (kg)	55 70 85 100 115 130 145 160 175 190 205	71,4
Massa Muscular Esquelética (kg)	70 80 90 100 110 120 130 140 150 160 170	37,1
Massa Gorda (kg)	40 60 80 100 160 220 280 340 400 460 520	6,8

Análise da Obesidade

Abaixo | Normal | Acima

IMC Índice de Massa Corporal (kg/m²)	10,0 15,0 18,5 22,0 25,0 30,0 35,0 40,0 45,0 50,0 55,0	24,4
PGC Percentagem de Gordura Corporal (%)	0,0 5,0 10,0 15,0 20,0 25,0 30,0 35,0 40,0 45,0 50,0	9,5

Análise da Massa Magra Segmentar

Massa magra / % / Avaliação

	Esquerdo	Tronco	Direito
Braço	4,27kg / 135,5% / Acima		4,14kg / 131,3% / Acima
Tronco		30,9kg / 122,9% / Acima	
Perna	9,06kg / 103,5% / Normal		9,25kg / 105,6% / Normal

Análise da Gordura Segmentar

Massa gordurosa / % / Avaliação

	Esquerdo	Tronco	Direito
Braço	0,1kg / 20,0% / Abaixo		0,1kg / 20,0% / Abaixo
Tronco		3,1kg / 75,9% / Abaixo	
Perna	1,1kg / 65,5% / Abaixo		1,1kg / 67,5% / Abaixo

* A Gordura segmentar é estimada.

Histórico da Composição Corporal

	01.08.17. 12:50
Peso (kg)	71,4
Massa Muscular Esquelética (kg)	37,1
PGC Percentagem de Gordura Corporal (%)	9,5

☑ Recente ☐ Total

Pontuação InBody

90/100 Pontos

* Pontuação total que reflecte a avaliação da composição corporal. Uma pessoa musculada pode pontuar 100 pontos.

Controlo do Peso

Peso Ideal	71,4 kg
Controlo de Peso	0,0 kg
Controlo de Gordura	0,0 kg
Controlo Muscular	0,0 kg

Avaliação da Obesidade

IMC ☑ Normal ☐ Abaixo ☐ Ligeiramente Acima ☐ Acima

PGC ☑ Normal ☐ Ligeiramente Acima ☐ Acima

Relação Cintura-Anca

0,84 (0,80 0,90)

Nível de Gordura Visceral

Nível 2 (Abaixo 10 Acima)

Parâmetros de Pesquisa

Massa Livre de Gordura	64,6 kg
Taxa Metabólica Basal	1765 kcal
Grau de Obesidade	111 % (90~110)
Ingestão calórica recomendada	2728 kcal

Gasto calorico do exercicio

Golf	126	Gateball	136
Caminhar	143	Ioga	143
Badminton	161	Ténis de mesa	161
Tenis	214	Ciclismo	214
Boxe	214	Basquetebol	214
Escalada	233	Saltar à corda	250
Aeróbica	250	Jogging	250
Futebol	250	Natação	250
Esgrima Japonesa	357	Raquetebol	357
Squash	357	Taekwondo	357

*Com base no seu peso actual
*Com base numa duração de 30 minutos

Impedância

Z(Ω)	BD	BE	TR	PD	PE
20 kHz	252,8	244,0	19,1	251,9	261,6
100 kHz	216,9	209,1	15,5	217,3	226,0

Ver.LookinBody120.3.0.0.6