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Training Loads, Spontaneous Physical Activity And Sleep In Youth Elite Canoe Sprint Athletes: Are They Performing Well In Their Daily Lives?

PhD Thesis of the Doctorate Program in Sport Sciences, Branch of Sport Training, supervised by Professors Luís Rama, Aristides Machado-Rodrigues, and Fábio Nakamura, and submitted to the Faculty of Sport Sciences and Physical Education of the University of Coimbra.

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“All of old. Nothing else ever. Ever tried. Ever failed. No matter. Try again. Fail again. Fail better.” by Samuel Beckett - Worstward Ho 1983

Abstract

The present thesis has been divided into seven chapters and the main purpose was to understand the daily 24h routine of elite young male and female canoeing athletes, and their relationship between training loads, different training and competition settings, stress-recovery responses and off-training (sleep, spontaneous physical activity and sedentary behaviour). The first chapter presents the introduction and the theoretical rationale of the thesis. The second chapter consists of a literature review of the various concepts and instruments that make up the following chapters. The third chapter characterizes the physiology, training load and training intensity distribution (TID) of elite young sprint canoeing athletes during two typical training camps of the national team with different objectives (selecting and preparing the participation in the European Junior Canoe Championship and sub23). This chapter allowed to characterize the training load through the training impulse and the session rating of perceived exertion of the training sessions, as well as to understand the typical training intensity distribution, with predominance of low intensity due to the high volume of training.

Once the typical training load of these athletes was analyzed, in the fourth chapter we analyzed the heart rate variability (HRV) and stress-recovery responses during a national training camp in young elite sprint canoeing athletes. This chapter verified the differences between sexes, the stress and recovery responses for the same training sessions, with male athletes presenting a higher training load than female athletes and with differences in autonomic responses. It also showed that HRV monitoring and psychometric responses can help to avoid excessive training loads (which can lead to overreaching or overtraining).

After understanding training loads and recovery, in the fifth chapter we evaluate the sleep patterns of young elite canoeing athletes in national training camps, training at homes, pre-competition, competition and post-competition national periods. This chapter observed differences between female and male athletes, which varied differently between sexes, according to the places and contexts where they spent the night (national training camp, home, competition). Both sexes showed total sleep time and better sleep efficiency while in the training camps. The athletes generally presented inappropriate total sleep time and sleep efficiency for their ages.

In the sixth chapter we present the off-training assessment (spontaneous physical activity and sedentary behaviour) of young elite canoeing athletes in national training camps, training at homes, pre-competition, and post-competition periods. This chapter identified differences between female and male athletes, which varied according to the places and contexts (national training camp, home, competition). Both sexes reached the recommendations of the world health organization for physical activity in the off-training encompassing all places and contexts; however, they presented very high and worrying values of sedentary behaviour too.

In the last chapter we carry out the discussion and general conclusion of the thesis, and the results of the various studies are summarized, discussed and their practical implications contextualized. Our work highlighted the need to create stable training and free-living environments and patterns, in order to encourage the correct adaptation of athletes and healthy habits.

Key words: Physical activity, health, sport, performance, lifestyle, recovery.

Resumo

A presente Tese está dividida em sete capítulos e tem como objetivo principal a compreensão das 24 horas dos atletas de elite jovens de canoagem, femininos e masculinos, e a relação entre as cargas de treino, diferentes configurações de treinos e competições, as respostas do stress e recuperação e os estilos de vida (sono, atividade física espontânea e sedentarismo) extra treino. O primeiro capítulo apresenta a introdução e o racional teórico da tese. O segundo capítulo é composto pela revisão da literatura dos vários conceitos e instrumentos que compõe os capítulos seguintes. O terceiro capítulo caracteriza a fisiologia, carga de treino e distribuição da intensidade de treino de atletas elite jovens de canoagem de velocidade durante dois estágios de treino típicos da equipa nacional com objetivos distintos (selecionar e preparar a participação no Campeonato da Europa de Canoagem Júnior e Sub-23). Este capítulo permitiu caracterizar a carga de treino através do impulso de treino e da avaliação da perceção de esforço percebida das sessões da sessão de treino, assim como perceber a distribuição da intensidade de treino típica destes atletas, com uma predominância de alto volume de baixa intensidade.

Uma vez analisada a carga de treino típica destes atletas, no quarto capítulo analisámos a variabilidade da frequência cardíaca (VFC), e respostas de stress e recuperação durante um estágio nacional de treino em jovens atletas de elite de canoagem de velocidade. Este capítulo permitiu verificar diferenças entre os sexos, as respostas de stress e recuperação para as mesmas tarefas de treino, com os atletas masculinos a apresentarem maior carga de treino que as atletas femininas, e com diferenças nas respostas autonómicas, e mostrou que as monitorizações da VFC e as respostas psicométricas podem ajudar a evitar cargas de treino excessivas.

Após a compreensão das cargas de treino e a recuperação, no quinto capítulo avaliamos os padrões de sono de jovens atletas de elite de canoagem em estágios de treino nacionais, treinos nos seus clubes, dos períodos pré-competição, competição e pós-competição nacional. Este capítulo permitiu constatar diferenças entre os atletas femininos e masculinos, que variou de acordo com os locais e contextos onde pernoitaram (estágio nacional, clube, impacto da competição) de forma diferente entre sexos. Ambos os sexos apresentaram tempo de sono total e melhor qualidade de sono durante os estágios de treino. Os atletas apresentaram na generalidade tempo total de sono e qualidade do sono inapropriado para as suas idades.

No sexto capítulo apresentamos a avaliação dos estilos de vida (atividade física espontânea e sedentarismo) extra treino (vigília) de jovens atletas de elite de Canoagem em estágios de treino nacionais, treinos nos seus clubes, dos períodos pré-competição, competição e pós-competição nacional. Este capítulo permitiu constatar diferenças entre os atletas femininos e masculinos, que variou de acordo com os locais e contextos (estágio nacional, clube, impacto da competição). Os atletas de ambos os sexos, atingiram as recomendações da organização mundial de saúde para a atividade física fora do treino em todos os contextos, contudo, apresentaram valores muito elevados e preocupantes de tempo sedentário.

No último capítulo realizamos a discussão e conclusão geral da tese, na qual os resultados dos vários estudos são resumidos, discutidos e as suas implicações práticas contextualizadas. O nosso trabalho permitiu a análise das 24 horas dos atletas de elite jovens de canoagem e da relação entre as cargas de treino, os locais da realização dos treinos, e respostas dos estilos de vida (sono, atividade física espontânea e sedentarismo) dos atletas extra treino. Evidenciou a necessidade de criar ambientes e padrões estáveis, que fomentem a correta adaptação dos atletas, nos vários contextos e momentos extra treino.

Palavras-chave:Atividade física, saúde, desporto, desempenho, estilos de vida, recuperação.

Contents

List of Tables

List of Figures

List of Abbreviations

AC	activity counts
AM	anthropometric measurements
ANS	autonomic nervous system
AT	anaerobic threshold
AU	Arbitrary Units
Aul	Arbitrary units of load
Avg	Average
BM	Body mass
CA	chronological age
CAR	High-Performance Centre
CL	Confidence limits
Cpm	counts per minute
CR 100 scale	Borg CR100 scale
CR100	Borg centiMAx
CV	Coefficient variation
ECC	European Canoeing Championships Junior & U23
ECG	electrocardiogram
ENMO	Euclidean Norm Minus One
ES	Effect sized
FFT	functional fitness training
G1	Group 1
G2	Group 2
GPS	Global Positioning System
GXT	Graded exercise test
HIIT	High-intensity training
HIT	high-intensity training
HPC	High-performance center
HR	heart rate
Hr	Hours
HR_{peak}	peak heart rate
HRV	heart rate variability
HVLIT	high-volume low-intensity training
ICC	intraclass-correlations

IPMA	Portuguese Institute for Sea and Atmosphere
IT TRIMP	training session impulse of the interval-training performed
La	Blood lactate
Light PA	Light Physical Activity
Ln	natural logarithm
LnRMSSD	natural logarithm of the square root of the mean sum of the squared differences between R-R intervals
$lnRMSSD_{CV}$	natural logarithm of the square root of the mean sum of the squared differences between R-R intervals - coefficient of variation
$LnRMSSD_{M}$	natural logarithm of the square root of the mean sum of the squared differences between R-R intervals mean
LOW	low intensity
LT	lactate threshold
LT_1	aerobic thresholds
LT_2	anaerobic thresholds
m	Meters
M1	Moment 1
M2	Moment 2
M3	Moment 3
MAD	mean amplitude deviation
METs	metabolic equivalents
Min	minutes
Min	minutes
MLSS	maximum lactate steady state
Moderate PA	Moderate Physical Activity
MPVA	Moderate and Vigorous Physical Activity
NC	National Competition
P1	Period 1
P2	Period 2
PA	Physical activity
PB	Physical behaviours
PghSD	Pittsburgh Sleep Diary
Post-C	Post-Competition
Pre-C	Pre-Competition
PSG	polysomnography

PSQI	Pittsburgh Sleep Quality Index
PSQI-PT	Questionnaire Pittsburgh Sleep Quality Index – Portuguese version
RCP	respiratory compensation point
RESTQ-52	Recovery-Stress Questionnaire-52
RESTQ-Sport	Recovery-Stress Questionnaire for Athletes
RR	R-R intervals
SB	sedentary behaviour
SD	Standard deviation
SE	sleep efficiency
SOL	Sleep Onset Latency
SPA	spontaneous physical activity
SpD	Sleep diaries
SR	stroke rate
sRPE	Session Rating of Perceived Exertion
STL	subjective training load
TC	Training camp
TC1	Training camp 1
TC2	Training camp 2
TCs	Training camps
TE	training experience
TH	Training at home
TIB	Time in bed
TID	training intensity distribution
TL	Training load
TRIMPs	Training Impulse
TST	Total sleep time
VFC	variabilidade da frequência cardíaca
Vigorous PA	Vigorous Physical Activity
VO_2max	maximal oxygen consumption
VT	ventilatory threshold
VT_1	ventilatory thresholds 1
VT_2	ventilatory thresholds 2
W	watts
WASO	Wake after sleep onset
WHO-5	World Health Organization Well-Being Index

WURSS21	Wisconsin Upper Respiratory Symptom Survey – 21
yrs	years
Z1	Zone 1
Z2	Zone 2
Z3	Zone 3

Chapter I

General introduction

1 General introduction

1.1 General Introduction

Sport is multifactorial, as it has been recognised as a way of overcoming individual challenges, a promoter of social life, or merely an entertainment. Nowadays, the large amounts of information and distractions could affect athletes' performance. Elite athletes are the best athletes in the world in their sport, who dedicate part of their lives to achieving that sports performance. Throughout an athlete's career, lifestyle crucially affects performance and later, after retirement, it facilitates the athlete's re-integration into society. Therefore, monitoring the training load, as well as the fitness and fatigue status is essential to the athletes' careers.

The study of athletes' lifestyle variables such as sleep is important for recovery and training adaptation. Moreover, the balance between sedentary behaviour and activity levels (planned physical activity and spontaneous physical activity) is important to control body composition and promote healthy lifestyles. Therefore, it is necessary to understand how lifestyle patterns change according to the contexts athletes are submitted to, predominantly training sessions with different training loads, training camps and competitions. This holistic approach is essential to understanding the impact of external stimuli affecting athletes' lifestyles.

There is a lack of scientific evidence about the impact of athletes' behaviour during off-training, in particular concerning elite young canoeing sprint athletes. In fact, the training loads in different training settings (training camps, training at home, and previous and after the competition) have not taken into consideration off-training behaviours of these athletes, such as spontaneous physical activity, sedentary behaviour and sleep.

This doctoral thesis aims to analyse the physical behaviours and sleep patterns of young canoe and kayak sprint elite athletes of both sexes. The first objective aims to quantify the training load and training intensity distribution in two typical national training camps, using a sample of youth elite canoeing sprint athletes. The training camps were chosen and prepared by the national team for participation in the international competition European Canoeing Championship Junior & U23. To assess the training load, the session rating of perceived exertion (sRPE) and the training impulse (TRIMP) were measured through the athletes' heart rates. To evaluate training intensity distribution (TID), the heart rate of the kayak athletes was analysed to understand how long they spent in the three defined training zones.

The second objective intends to assess the heart rate variability and stress-recovery responses during a national training camp for elite young canoeing sprint athletes. The training camp was used to prepare the national team for participation in the international competition European Canoeing Championship Junior & U23. To assess athletes' stress and recovery responses, the status of the autonomic nervous system was monitored via heart rate variability measurements collected each morning. In addition, psychometric stress-recovery responses were collected using the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport), applied before, during and after the training camps.

The third objective aims to study the daily sleep patterns in different training settings (training camps, training at home, and previous, during and after the competition). Especifically, we intend to characterize the sleep patterns of young canoeing sprint elite athletes of both sexes, as well as to understand the impact of the training load and of a national competition. To understand athletes' sleep patterns in their real context, athletes wore an accelerometer during periods of sleep.

The fourth objective aims to assess the daily physical behaviour patterns (spontaneous physical activity and sedentary behaviour) in different training settings (training camps, training homes, and previous and after the competition). To characterize the patterns of physical behaviours in young canoeing sprint elite athletes of both sexes, and understand how they are affected by the training load and the impacts of a national competition. To understand the patterns of spontaneous physical activity and physical inactivity of athletes in critical moments of preparation and competition, athletes wore an accelerometer during periods of wakefulness.

Most of the previous studies carried out in Canoeing use samples comprising male and adult athletes. Therefore, more studies are necessary concerning young canoe and kayak sprint elite athletes of both sexes, in order to improve current practices.

This research intends to understand and promote well-being and better recovery for young elite athletes, studying sleep, spontaneous physical activity, sedentary behaviour, training load and recovery responses.

The present thesis aims to fullfill the following purposes: (1) describe physical behaviours, and sleep patterns of canoeing competitive athletes using an observational design; (2) explore the associations between physiological and psychological markers of health, performance, and recovery of canoeing competitive athletes.

This doctoral thesis aims to contribute to a new approach that takes into account the influence of off-training behaviours and sleep patterns, as a way to optimize performance and recovery.

This thesis is organized as follows:

Review of the current literature to develop a theoretical basis for this doctoral thesis.

Analyse the two weeks of training camp by characterization and physiological comparison of training load in elite young canoeing sprint athletes, before an international competition.

Analyse the heart rate variability and stress-recovery responses during a training camp for elite young canoeing sprint athletes.

Analyse the different training settings on the sleep patterns of young canoe and kayak athletes.

Analyse the different training settings on spontaneous physical activity and sedentary behaviour.

General discussion.

Conclusions.

Chapter II

State of the art

2 State of the art

In this chapter, we review the current scientific literature and develop a theoretical basis for the thesis objectives.

The topics covered will be monitoring training load, the monitoring methods based on heart rate, the training impulse, the heart rate variability in athletes, the session rating of perceived exertion (sRPE), well-being and health-related parameters in athletes, the training intensity distribution in endurance sports, the sleep patterns in athletes, the spontaneous physical activity and sedentary behaviour in athletes.

2.1 Monitoring training load

Athletes and coaches work to improve performance through manipulation of the training load. Changes in frequency, duration, and intensity are common options for this purpose. Training loads are adjusted frequently during each training cycle to either increase or decrease fatigue and recovery, depending on the phase of training (i.e., baseline or competition phase).

Monitoring and quantifying daily training load, training effects and performance in endurance sports to understand the relationship between training and performance is one of the main goals of coaches, athletes and researchers (Borresen & Lambert, 2008; Buchheit, 2014; Halson, 2014; Henrique et al., 2020; Manzi et al., 2009; Roos et al., 2013; Taha & Thomas, 2003; Vermeire et al., 2021)

The main objectives of monitoring during training are to maximize positive training effects (for example, fitness, readiness, and performance) and to reduce the adverse effects (for example, excessive fatigue, injury, and illness) (Borges et al., 2012; Halson, 2014; Hedelin et al., 2000). For adequate decision making, it is necessary to know the limitations and determinants of the sport (Mujika, 2013). It cannot be possible to identify the training effects without an accurate quantification of the training load (Mujika, 2013).

It is imperative to distinguish the internal and external load. Traditionally, the external load has been the foundation of most monitoring systems (Halson, 2014). The external load could be defined as the amount of work performed by the athlete, measured independently of her or his internal response (Wallace et al., 2009). For example, in canoeing, coaches often prescribe training concerning external measures (i.e., distance [m] and/or velocity [m.s-1]—e.g., 10 X 250 m rest 4 min). The external load is essential for the understanding of the "work" completed by the athlete. The quantification of external training load for sprint kayak athletes can be challenging due to the influence of the water and other external factors on boat velocity. To monitor and prescribe training intensities during on-water kayak training, external measures of stroke rate (SR) and those obtained from Global Positioning System (GPS) are commonly used (Bullock et al., 2012; Gomes et al., 2015; Hogan, Binnie, Doyle, Lester, et al., 2020a, 2020b; Hogan, Binnie, Doyle, Peeling, et al., 2020; Paquette et al., 2019). The power output (PO) measures could better account for the influence of water compared to traditional GPS measures, and therefore, may be more suitable for quantifying athletes' external training load (Hogan et al., 2021). However, only the exclusive use of external load measurements (SR, GPS, PO) seems insufficient to assess the impact of the load that the athletes were exposed to in the kayak training sessions.

Additionally, the Internal load is relative to the physiological and psychological stress imposed and critical in determining the training load (Halson, 2014). It is common that sprint kayak athletes monitor and prescribe training intensities by use of raw heart rate measures (Hogan, Binnie, Doyle, Lester, et al., 2020a, 2020b; Winchcombe et al., 2019). However, it is not so common the use of the training impulse (TRIMP) and rating of perceived exertion in the prescription and control of canoeing training, although a lot of research was produced with these markers (Hogan, Binnie, Doyle, Lester, et al., 2020a, 2020b; Oliveira Borges et al., 2014; Winchcombe et al., 2019).

Both external and internal loads are critical for understanding the athlete's response to the training load. A combination of both may be relevant for a suitable training monitoring system (Halson, 2014; Souza et al., 2019).

2.2 Monitoring based on Heart Rate methods

The heart rate (HR) measurement method is widely implemented in the sports world as a way of assessing internal load in athletes. The heart rate monitoring during exercise is based on the linear relationship between HR and oxygen consumption rate during steady-state exercise (Arts & Kuipers, 1994; Hopkins, 1991; Robinson et al., 1991).

The percentage of maximum HR is frequently used to both prescribe and monitor intensity (Borresen & Lambert, 2008). Nonetheless, controlling for factors such as hydration, environment, and medication is essential. The HR has been used to monitor, evaluate, prescribe training and define the intensity of canoeing effort for many years (Gray et al., 1995; Hogan et al., 2020; Nakamura et al., 2004; Zamparo et al., 1999).

Furthermore, with the association of HR with the intensity of effort, other forms of evaluation have emerged, such as evaluations in kayak ergometer, comparing the performance with that obtained in the ecological context (Van Someren & Oliver, 2002). Kayak ergometers are frequently used in control training adaptation. An example of the former statement is the determination of intensity domains through assessing the ventilatory thresholds (David Bishop et al., 2001, 2003; Borges et al., 2015; Coelho et al., 2021).

Quantifying exercise intensity and effort by heart rate represents an objective measure of training tasks, being easy to measure, popular and inexpensive.

2.3 Training Impulse

An athlete's heart-rate response to exercise, combined with exercise duration, might represent an objective measure of physical effort that would allow the quantification of a training session into a unit "dose" of physical effort (Borresen & Lambert, 2008).

Quantifying physical effort during individual sports of a continuous nature can be done in various ways (Hopkins, 1991). The diagram of Morton et al. (Morton et al., 1990) shows how training input (dose) affects fitness and fatigue, combining these responses, positively the fitness and negatively the fatigue, into a single performance output. The training impulse (TRIMP) proposed by Banister (Banister E.W., 1991) has been proven accurate in profiling the individual responses to training load (TL) in endurance (e.g., professional road cycling) and team sports (e.g., field hockey) elite athletes (Foster et al., 2005; García-Ramosa et al., 2014; Ozaeta et al., 2021; Padilla et al., 2000; Rodríguez-Marroyo et al., 2009; Sanders et al., 2018; Stagno et al., 2007).

The duration of a training session is multiplied by the average HR achieved during that session. It is weighted for exercise intensity to avoid giving disproportionate importance to low-intensity, long-duration training sessions compared to high-intensity, short-duration training sessions (Banister E.W., 1991). The TRIMP is often considered a valuable way of assessing TL (Pyne & Martin, 2011). A TRIMP is a unit of physical effort that is calculated using training duration and maximal, resting, and average HR during the exercise session (Morton et al., 1990).

Since the TRIMP is computed from both intensity (the mean exercise heart rate) and duration, it can be used to measure training load in training sessions, even in sports that demand intermittent efforts (Hopkins, 1991; Morton et al., 1990; Padilla et al., 2000).

Since its the introduction (Banister E.W., 1991), further attempts have been made to improve the sensitivity of TRIMP in quantifying individual responses to a given external TL.

Edwards adopted a progressive weighting factor for each HR zone. The factors proposed by a corresponding coefficient (Zone 1 – 50 to 60% HRmax, factor 1/; Zone 2 – 60 to 70% HRmax, factor 2/; Zone 3 – 70 to 80% HRmax, factor 3/; Zone 4 – 80 to 90% HRmax, factor 4/; Zone 5 – 90 to 100% HRmax, factor 5) were used in this study (Edwards, 1993).

Lucía and co-workers adapted the exercise intensity dividing into three phases according to the reference HR values: phase I (<ventilatory threshold (VT)), phase II

(between VT and the respiratory compensation point (RCP)) and phase III (>RCP) (Lucía et al., 2003). Total volume and intensity were integrated as a single variable. The score for volume × intensity in each phase was computed by multiplying the accumulated duration in the phase by a multiplier for this phase (Lucía et al., 2003).

Stagno et al. (2007) introduced a modified version of the original Banister's proposed method (Banister E.W., 1991), providing TRIMP values for selected HR zones (i.e., zones vs average values). This method has been shown to track individual TL profiles and correlate with athletes' variation in training outcomes. The modified TRIMP by Stagno (2007) found relationships between the mean weekly time spent engaged in the high-intensity activity and changes in VO_2max and speed at 4 $mmol^{-1}$. The modified TRIMP supports the quantitative measure of training load during non-steady-state exercise, including high-intensity, sport-specific training and competition of a high-intensity and intermittent nature (Stagno et al., 2007). Coaches can use the modified TRIMP to tailor training sessions on an individual athlete basis to ensure that all athletes receive a sufficient training stimulus to maintain aerobic fitness (Stagno et al., 2007).

The authors concluded that TL calculated from different methods (Banister TRIMP, Lucia TRIMP, Edwards TRIMP) could not be interchangeably used because they develop differently (Vermeire et al., 2021).

Some authors recognize the technical and scientific expertise and resources required for this type of individualized internal load monitoring (Halson, 2014). Previous observations with trained endurance runners suggest that the relationship between TRIMP methods and training outcomes may be improved if the TRIMP calculation is modified to account for individual physiological thresholds (Wallace et al., 2014).

Concerning the competitive runners, to determine the relationship between training load and competitive performance, Esteve-Lanao and co-workers applied the Lucia TRIMPS method to quantify the total physiological load (time spent in each HR zone, TRIMP) in each training session, over a long period of the season (Esteve-Lanao et al., 2005). A relationship between the training session impulse of the interval-training performed (IT TRIMP) and VO_2max improvements was observed in endurance runners (Parmar et al., 2021).

In the case of junior cyclists, relationships between different TRIMP training load and sRPE were found demonstrating the importance of training load monitoring and nutritional-hydration support for young cyclists' fatigue management (Cesanelli et al., 2021). In canoeing athletes, Borges and co-workers showed the validity of TRIMP to monitor the training load of well-trained canoeing athletes (flatwater) in individual boats (Borges et al., 2014).

However, in young canoeing sprinters, the typical training loads are undertaken during crucial phases of the preparation (i.e., National Team training camps) leading up to team formation and its effects on TRIMP values have not been studied.

2.4 Session rating of perceived exertion

The session rating of perceived exertion (sRPE) method was developed 26 years ago, as of 2021, as a modification of the Borg concept of rating of perceived exertion (RPE), designed to estimate the intensity of an entire training session (Foster et al., 1995, 2021).

The sRPE represents an alternative for the intensity of an entire training session (warm-up, conditioning bout, and cool-down) within the TRIMP concept developed by Banister et al. (Banister E.W., 1991; Fitz-Clarke et al., 1991; Morton et al., 1990).

The Rating of Perceived Exertion (RPE) has well-established correlations with both %HRR and blood/muscle lactate (Eston, 2012). Modifying the use of the RPE of a momentary rating to a post-exercise rating representing the entire training bout (the Session RPE or sRPE) retained the relationship with %HRR and blood lactate while allowing multi-mode, non-steady-state and even competitive game type exercise to be included (Foster et al., 1995, 2001).

If the sRPE is multiplied by the duration of the activity, then one has a surrogate TRIMP score for training load that is much simpler than the original concept of Banister et al. (Banister et al., 1999; Fitz-Clarke et al., 1991), which is not dependent on accurately measuring HR and can be used with different types of exercise, including resistance exercise (Meghan et al., 2004).

The time point of sRPE assessment should be kept constant to compare the sRPE values for one athlete over various training sessions. Women reported lower sRPE values than men at the same relative exercise intensity (Roos et al., 2018).

The RPE is assessed by asking athletes to report their perceived intensity of the exercise. It is a valuable method for tracking the intensity of exercise, the process of systematically asking the athlete 'how do you feel?' holds the potential for monitoring the response to training (Foster et al., 2017). The development of the Session RPE and similar low-tech methods has demonstrated a way to evaluate training load, along with derived variables, in a simple, responsive way (Foster et al., 2017).

A comparison between three rating scales developed by Borg (Borg RPE (Rating of Perceived Exertion) scale; Borg CR10 (Category Ratio) scale; Borg centiMax (CR100) scale) for perceived exertion are compared on bicycle ergometer work (Borg & Kaijser, 2006). The tendency of using the numbers primarily at the exact locations of the verbal anchors was a little less with the Borg CR100 scale (cM) (CR100 scale), which can thus be said to meet with the demand of being a more acceptable- graded scale than the CR10 scale. The CR100 scale has a more comprehensive numerical range and it is a little finer graded, having the advantage of giving associations to a percentage scale (Borg & Kaijser, 2006).

In functional fitness training (FFT) sessions, when performing four 4-minute intervals, the sRPE was more accurate than TRIMP methods to represent the overall training load of the FFT sessions (Henrique et al., 2020).

The assessment of sRPE is influenced by several factors, such as survey method, sex, training type, and the cross-level interaction "time point x TRIMP x training type" (Athletes, recreational or competitive runners or triathletes Roos et al., 2018).

In other sports, sRPE has been too sensitive to changes in external training load, demonstrating the training load fluctuations (Coutts, Reaburn, et al., 2007; Coutts, Slattery, et al., 2007; Freitas et al., 2014).

Further, sRPE is sensitive enough to differentiate between different endurance training types, e.g. interval sessions versus regenerative, slow, and speedy runs (Roos et al., 2018). Variables derived from the sRPE, specifically, the monotony and strain of training, also appear to be able to account for adverse training outcomes, particularly banal infections (Foster, 1998; Fusco et al., 2020). While more technically demanding methods (HR monitoring and blood lactate) can provide rapid and user-friendly data, they tend to result in data overload. The sRPE seems to be a practical and straightforward solution to evaluating the internal TL (Impellizzeri et al., 2019).

The sRPE appears to work well with a variety of types of exercise, from aerobic to resistance to competition, with a large variety of sporting activities (Coutts, Reaburn, et al., 2007; Coutts, Slattery, et al., 2007; Freitas et al., 2014; Henrique et al., 2020; Borges et al., 2014; Roos et al., 2018).

Although it is not ideal for the precise recording of the details of the external training load, it has considerable advantages evaluating the internal training load and as a method of monitoring training of extreme simplicity (Foster et al., 2021).

Comparing the CR10 scale with the ratings of subjective training load (RTL), validated in canoeists, was correlated, showing that these subjective scales are sensitive and valid for canoeists and swimmers (Berglund & Säfström, 1994; Talsnes et al., 2020; Teixeira, A., & Rama, 2004).

The sRPE is a valid method to quantify internal training load in canoeing sprinters due to its high correlation with heart rate-based training impulse (Borges et al., 2014). The session-RPE (session-RPE: 6–20, category ratio [CR]-10 and CR-100 scales) is a valid method for monitoring TL for Junior Sprint Kayak athletes, showed a large-to-very large correlation with various HR and GPS- derived TL methods, indifferent of the RPE scale used (Borges et al., 2014).

Recent studies have used sRPE to quantify the training load of sessions and maximum efforts in canoeing, especially in adult athletes, proving to be a valid and reproducible tool (Coelho et al., 2019; Garatachea et al., 2011; Halley et al., 2020; Jones & Peeling, 2014; Nakamura et al., 2009; Ribeiro Neto et al., 2021; Staiano et al., 2019; Sun et al., 2008; Talsnes et al., 2020; Van Someren & Oliver, 2002; Winchcombe et al., 2019). However, in young canoeing sprinters, the typical training loads by sRPE are undertaken during crucial phases of the preparation (i.e., National Team training camps) leading up to team formation, and its effects have not been explored.

2.5 Monitoring of training load, and training responses

Training loads are adjusted at various times during the training cycle to either increase or decrease fatigue and recovery, depending on the stage of training, aiming to improve performance.

We can consider variables that can be used to monitor training load, for example, frequency, time, intensity, type, maximal effort, repeat efforts, training volume, perception of effort, perception of fatigue, and recovery, etc. (Halson, 2014). The nature of the monitoring is likely to be very different depending on the sport, and more than one monitoring tool is often utilized (Halson, 2014). This is likely the consequence of individual physiological adaptation and responses to exercise and the specificity required to be relevant to differing sports (Halson, 2014).

Buchheit emphasized that the measures of HR cannot inform on all aspects of wellness, fatigue, and performance (Buchheit, 2014). This author suggests the need to use in combination with daily training logs, psychometric questionnaires, and noninvasive, cost-effective performance tests, which may offer a better solution to monitor training status in endurance athletes. (Mujika, 2017).

Halson (2014) summarized the key features of a sustainable athlete-monitoring system to ensure that data are effectively captured and reported, which include ease of use and intuitive design, efficient result reporting, ability to be used effectively remotely, the possibility of data translation into simple outcomes such as effect sizes, flexibility and adaptability for different sports and athletes, simple and efficient identification of a meaningful change, assessment of cognitive function, and provision of both individual and group responses (Mujika, 2017).

Concomitant evaluations of the various quantification methods permit researchers and coaches to evaluate stress/ recovery balance, adjust individual training programs, and determine the relationships between external load, internal load, and athletes' performance. Further research is needed to verify responses to the training load of canoeing athletes.

2.6 Training intensity distribution in endurance sports

To improve the targeted physiological capacities required for athletes' performance, the coaches and sports scientists use the training zones for the prescription and monitoring of intensity during training. The nature of VO2 response to exercise is a function of exercise intensity, which can be divided into three domains (moderate, heavy and severe intensity) (Fan Xu & Rhodes, 1999; Gaesser & Poole, 1996; Whipp, 1987). Moderate exercise is characterized by the work rate doesn't induce a significant increase in blood lactate and the upper limit of this domain is associated with the individual lactate threshold (LT) or anaerobic threshold (AT) (Fan Xu & Rhodes, 1999; Gaesser & Poole, 1996; Whipp, 1987). Heavy exercise exercise is characterized by the exercise intensity is higher than LT, the rate of lactate production exceeds the clearance rate. The blood lactate levels increase progressively, but lactate levels can be stabilised once again at an elevated new level if the work rate is below the maximum lactate steady state (MLSS) (Fan Xu & Rhodes, 1999; Gaesser & Poole, 1996; Whipp, 1987). In severe intensity, the work rate above MLSS results in a systemic increase in blood lactate during the exercise (Fan Xu & Rhodes, 1999; Gaesser & Poole, 1996; Whipp, 1987).

One of the most common methods to characterize the distribution of training intensity is to define the percentage of time spent in each intensity zone, based on heart rate values, the heart rate time-in-zone approach (T. Stöggl & Sperlich, 2015). This approach consists on a three-zone model: low-intensity Zone 1, medium intensity Zone 2, and high-intensity Zone 3. When training in Zone 1, an athlete can exercise for hours, nevertheless, in Zone 3, the athlete would probably get tired after 15–30 min (T. Stöggl & Sperlich, 2015).

Several training intensity distributions (TID) are commonly used by athletes and have been published in sports science papers, using the three-zone intensity model. If the major proportion of the training is low intensity (Zone 1) and typically of longer duration (volume), it is called a high-volume low-intensity training (HVLIT), executed with low (LOW) intensity [approximately 65–75% of peak oxygen uptake (VO_{2peak}) <80% of peak heart rate (HR_{peak}) or <2 $mmol \cdot L^{-1}$ blood lactate (Laursen & Jenkins, 2002; Seiler & Kjerland, 2006)]. Aditionally, High-intensity training (HIT), or "zone-3" training, (e.g., >4 mmol lactate/L blood, >90% maximal heart rate) involves mainly interval training, intermittent intervals, or burst-training (short, high-intensity sprints) (T. Stöggl & Sperlich, 2015). Big focus on Zone 3 and only a minor focus on Zones 1 and 2 has revealed great improvements in athletic performance and related key variables of endurance (e.g., time to exhaustion, time trial performance, VO_{2peak}, maximal and submaximal running speed, running economy) in both trained and untrained individuals (Laursen & Jenkins, 2002). Based on the three-zone intensity model, TID can therefore present two distributions: pyramidal and inverse pyramidal. Pyramidal TID focus the largest proportion of training in Zone 1, followed by a decreasing proportion in Zones 2 and 3. In the pyramidal distribution, most training is at low intensity, with decreasing proportions of threshold and high-intensity training (Billat et al., 2001; T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2014, 2015). Inverse pyramidal training is just the opposite, with the largest proportion of the training in Zone 3, followed by Zone 2 and Zone 1 (Billat et al., 2001; T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2014, 2015).

Training performed mainly at an exercise intensity corresponding to the lactate threshold (e.g., 4mM blood lactate) or second ventilatory threshold, involves primarily continuous or intervals of moderate-intensity exercise and is often defined as “zone-2” training (Faude et al., 2009; T. Stöggl & Sperlich, 2015). This type of “zone-2” training has been shown to improve endurance performance, particularly in untrained participants (Denis et al., 1984; Londeree, 1997).

Alternatively, the polarised-training model was proposed by a limited number of published observations of international elite athletes (Seiler & Kjerland, 2006; Steinacker, 1993; Yu et al., 2012) or well well-trained athletes (Esteve-Lanao et al., 2007; Neal et al., 2013; Rosenblat et al., 2019; Stöggl & Sperlich, 2014). Polarized training has the main focus on Zones 1 and 3, with almost no training in Zone 2. As the main training is performed in the two extremes (or poles) of the intensity scale, the polarized training consists of significant proportions of both high- and low-intensity training and only a small proportion of threshold training. The distribution between low and high intensity training is often quantified as 80:20%, or 75–80% with low intensity, 5% threshold intensity, and 15–20% as high intensity training (Billat et al., 2001; Fiskerstrand & Seiler, 2004; Hagan et al., 1981; Seiler & Kjerland, 2006; T. Stöggl & Sperlich, 2014, 2015);

The polarised-training model suggested that high-performance athletes generally trained below the lactate threshold intensity , possibly 75% of the sessions or training distance, or higher than the anaerobic threshold intensity (15–20% of the time) (Laursen, 2010). Inverse polarized TID has a greater amount of Zone 3 training compared with Zone 1 (T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2015). If all three zones are trained in equal proportion it is called uniform, even, or equal TID (T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2015).

In summary, the training intensity distribution is polarised away from the moderately hard intensity range represented by the lactate anaerobic threshold (Laursen, 2010). Several groups have used the ventilatory threshold approach to defining three intensity zones (Boulay et al., 1997; Erez-landaluce & Rodr, n.d.; Lucia et al., 1999; Seiler & Kjerland, 2006; S. Seiler, 2010). It seems that relatively low-intensity training (zone 1) is an essential part of any competitive endurance training program (Esteve-Lanao et al., 2007).

The competitive runners spent most of their training at low intensities, suggesting that total training time spent at low intensities might be associated with improved performance during highly intense endurance events, at least if the event duration is around 35 minutes (Esteve-Lanao et al., 2005). The regional/national class endurance runners spent the majority (71%) of their training time at low intensities (zone 1 (i.e., below ~60% VO_2max or ~70% HRmax)). The proportion of moderate (60–85% VO_2max) and high-intensity training (>85% VO_2max) was significantly lower (i.e., 21 and 8%, respectively) (Esteve-Lanao et al., 2005). In addition, a review of the effect sizes for increasing aerobic endurance performance for the polarised training model was consistently superior to that of the threshold training model (Jay & Bruce, 2015).

Changing the type of periodization from pyramidal to polarized in the second half of the periodization (16 weeks) in well-trained endurance runners induced bigger improvements compared to the simple pyramidal and polarized ones, or compared to switching from polarized into pyramidal periodization (Filipas et al., 2021).

Currently, the training intensity distribution is not well defined and characterized in young elite canoeing athletes, which reinforces the need for conducting research.

2.7 Heart rate variability in athletes

The heart rate (HR) and the contractile properties of the myocardium, are modulated by the main components of autonomic nervous system (ANS), the parasympathetic and sympathetic nervous systems (Ferreira & Zanesco, 2016). The activity of these two ANS components with opposite effects on HR causes continuous fluctuations in HR, named HRV (Ferreira & Zanesco, 2016). The control of Heart Rate Variability (HRV) at rest has gained increasing importance in monitoring training in athletes and regular exercise users (Plews, Laursen, Stanley, et al., 2013).

High values of HR variability are associated with the concept of good health or good physical condition. Contrary to HR, low HRV values are associated with coronary heart disease and mortality from different causes (Dekker et al., 2000), differs between sexes, as studies have shown a trend for females to have significantly lower HRV values, while all power spectral indices of HRV were negatively correlated with age (Jensen-Urstad et al., 1997).

It is well accepted that substantial changes in HRV values associated with negative changes in perceptual variables constitute a sign of excessive overload with possible consequences on performance (Buchheit, 2014; Faude et al., 2011; Plews, Laursen, Stanley, et al., 2013).

HRV variables can provide information about positive and negative adaptions over short and long periods throughout the competitive season (J. Costa & Nakamura, 2022). It is accepted that subtle changes in HRV could be a sign of excessive overload, impairing performance and training adaptation (Faude et al., 2011; Flatt & Esco, 2015). Furthermore, monitoring health (also intends to reduce the risk of injury, illness, and non-functional overreaching) parameters in athletes is likewise crucial to understand responses to training and readiness, enabling appropriate planning (J. Costa & Nakamura, 2022). The basic principle of HRV monitoring is to make inferences on possible changes in cardiac ANS status due to exercise while using repeated HRV measures over time (J. Costa & Nakamura, 2022).

Whereas ANS activity is highly sensitive to environmental conditions (e.g., noise, light, temperature) (Achten & Jeukendrup, 2003), it is important to take some precautions so as to standardize recording conditions, in order to isolate the training-induced effects on ANS (J. Costa & Nakamura, 2022). Factors that can affect HRV measurements include nicotine, caffeine, time of day, physical activity, alcohol consumption, diet, digestion, hydration, age, sex.

Precise detection of electrocardiogram (ECG) R-waves is necessary for the analysis of beat-to-beat R-R interval oscillation (Ferreira & Zanesco, 2016). Actually, for practical reasons, heart period is normally measured from R-R intervals (Task Force, 1996). The assessment of autonomic cardiac activity assessment of the HRV can be executed from records with durations of 2, 5, and 15 minutes (short-time), and over 24-hours (long-time) (J. A. Costa et al., 2022; Ferreira & Zanesco, 2016).

Collections of very short duration in the control of HRV - the control of the lnRMSSD determined in a short period of 1 minute (Ultra-short-term heart rate variability) is sensitive to the changes induced by training in futsal players - is helpful to monitor the cardiac autonomic adaptation (Nakamura et al., 2015). In elite athletes, we must pay attention to individuality in the responses of HRV (Nakamura et al., 2016).

The current trend with elite athletes points to de use of HRV natural logarithm (Ln) of the square root of the mean sum of the squared differences between R-R intervals (LnRMSSD). This marker is considered the most appropriate HRV value to monitor the adaptation and possible disturbances over performance (Boullosa et al., 2013; Buchheit, 2014; Plews et al., 2014; Plews, Laursen, Stanley, et al., 2013).

The mean value and CV of LnRMSSD can be calculated weekly to analyse the variation of parasympathetic influence, providing relevant information on the disturbance of homeostasis (Plews et al., 2014). It has been demonstrated that HRV values averaged over 1 week provide a better representation of training-induced changes than HRV values taken on a single day (Plews, Laursen, Kilding, et al., 2013). In trained athletes, at least 3 weekly measurements are required to access a credible variation of the weekly vagal variation (5 to 7 measurements preferable) (Plews et al., 2014).

Athletes with low CV values lnRMSSD tend to demonstrate better aerobic condition, better aptitude to deal with high training loads and lower perceived exertion values (Boullosa et al., 2013). Athletes with lower lnRMSSDCV are more aerobically fit and seem to cope better with a given level of training load by reporting reduced perceived fatigue (Boullosa et al., 2013), yet, the detected changes limits its usefulness since the differences found may fall within the daily variability of these markers (Bosquet et al., 2008). Consequently, the correct interpretation of HRV fluctuations during the training process requires comparison with other signs and symptoms (Bosquet et al., 2008). A variation of at least ≈ 3% must be considered (Bosquet et al., 2008). To interpret the fatigue or readiness to compete in elite athletes are recommended the LnRMSSD (weekly average) and the LnRMSSD ratio with the R-R interval (LnRMSSD: R-R interval) (Plews et al., 2016). Substantial reductions (> 0.5 Cv) in LnRMSSD concomitant with an increase in the R-R interval seems to be indicative of fatigue (Plews et al., 2016). Moreover, reductions in the two indicators predict an excellent state of readiness (Plews et al., 2016). On the other hand, the coefficient of variation of lnRMSSD (lnRMSSDCV) can also be calculated weekly to reflect the day-to-day variations in cardiac parasympathetic activity, providing valuable information concerning the training-induced perturbation of homeostasis (Buchheit, 2014).

In a study carried out with swimmers, it was verified that high sports results were obtained when parasympathetic activity was high. On the other hand, they worsened when parasympathetic activity decreased (Atlaoui et al., 2007). Other study showed that HRV is sensitive to physiological and psychological responses, in two moments (pre-training and pre-competition), indicated by the cortisol levels as well as the somatic anxiety results (Souza et al., 2019).

Power spectral analysis (frequency domain) did not support an altered autonomic balance in international-class adults canoeists after the decrease in performance, illustrated by reductions in time to exhaustion (Hedelin et al., 2000). However, high levels of HF and total heart rate variability seemed to constitute a favourable condition associated to the increase VO_2max in seven regional and national canoeists (Hedelin et al., 2001). Nevertheless, canoe and kayak paddlers, as well as cyclists' triathlons, showed higher age-corrected HRV parameters (time and frequency domain) than runners (Kiss et al., 2016). It remains to be investigated whether lnRMSSD and lnRMSSDCV are valuable markers to monitor young canoeing sprinters of both sexes during training camps.

2.8 Monitoring Well-being and health related parameters at athletes

The importance of optimal well-being and mental health in elite athletes has received increasing attention and debate (Giles et al., 2020).

The 5-item World Health Organization Well-Being Index (WHO-5) is among the most widely used questionnaires assessing subjective psychological well-being (Topp et al., 2015). Since its first publication (1998), WHO-5 has been translated into more than 30 languages and has been used in research studies worldwide. The WHO-5 was derived from the WHO-10 (Bech et al., 1996), which in turn was derived from a 28-item rating scale (Wan et al., 1985).

The WHO-5 is a short questionnaire consisting of 5 non-invasive and straightforward questions, which tap into the respondents' subjective well-being. The scale has adequate validity to the screening tool as an outcome measure in clinical trials and has been applied successfully across a wide range of study fields (Topp et al., 2015).

The optimization of athletes' health and well-being should also be considered for sports performance (Giles et al., 2020). The variations in the perceived motivational climate may provide further insight can be health promotive or potentially damaging to athletes' welfare (Reinboth & Duda, 2004).

In male adolescents, the coach's perceived motivational climate may also correspond in ways to indices of athletes' mental and physical welfare (Reinboth & Duda, 2004). The implications of the coach-created motivational climate have implications for the quality and potential maintenance of sport involvement among young athletes (Alvarez et al., 2012).

A study revealed clear evidence of the social benefits for school-age children and adolescents associated with participation in canoeing in the following categories: mental health and well-being, education, active citizenship, social behaviour, and environmental awareness (Rocher et al., 2020). Elite canoeing athletes are dedicated to studying the challenge of pursuing an academic education and making difficult choices in a dual career (González et al., 2019).

In young elite canoeing athletes, the well-being indicators are not identified and characterized.

2.9 Sleep in athletes

One of the most critical aspects of the continuum recovery in athletes is the total sleep time and sleep eficiency. Parallel to the effects of sleep loss on the body's response to exercise, several studies have shown an adverse effect on physiological mechanisms involved in post-exercise recovery (Halson, 2008, 2013). In fact, sleep has been rated as the most important off-training factor, regardless of gender, type of sport or level of participation in the recovery process (Venter, 2014). Whilst athletes experience several environmental factors that could interfere with their sleep, little is known about the quality and quantity of sleep achieved by elite athletes (Fullagar et al., 2015; Leeder, Glaister, Pizzoferro, Dawson, & Pedlar, 2012).

2.9.1 Sleep and recommendations

A U-shaped association was observed between sleep duration and health outcomes (optimal health and cognitive function) and the dose–response curves showed that a sleep duration of minimum of 7 hours of night-time sleep was most favorably associated with the health outcomes among adults aged 18 to 60-64 years (Ferrara & De Gennaro, 2001; Ross et al., 2020; Watson et al., 2015).

Indeed, it is recommended that adults sleep at least 7 hours per night and achieve a sleep efficiency (i.e., time asleep as a percentage of time in bed) of at least ≥ 75% regularly to promote health (Ohayon et al., 2017; Watson et al., 2015). At the ages most relevant to aspiring and established athletes, it is recommended a sleep time of between 8–10 hours for an adolescent (aged 15 years) (Mah et al., 2011), which contains approximately 57% light sleep, 22% deep sleep and 21% REM sleep; and a sleep time of around 7–9 hours for a young adult (aged 30 years), which contains approximately 61% light sleep, 16% deep sleep and 23% REM sleep (Ohayon et al., 2004).

Interestingly, athletes sleep is characterised by habitual sleep durations of less than 7 hours (Gupta et al., 2017; Roberts et al., 2018), sleep dissatisfaction, unrefreshing sleep (Tuomilehto et al., 2017), long Sleep Onset Latency (SOL) (Schaal et al., 2011; Tuomilehto et al., 2017), day-time sleepiness (Swinbourne et al., 2016) and day-time fatigue (Sargent, Lastella, et al., 2014). Studies reporting global sleep quality show that 50%–78% of elite athletes experience sleep disturbance in which22%–26% suffer highly disturbed sleep (Gupta et al., 2017; Swinbourne et al., 2016). Elite athletes are particularly susceptible to sleep inadequacies, characterised by habitual short sleep (<7 hours/night) and poor sleep quality (eg, sleep fragmentation) (Walsh et al., 2021).

In one cohort study with 479 elite athletes (371 female and 108 male) across 20 Olympic teams and individual sports, 52% were categorised as ‘poor sleepers’, with longer sleep onset latencies and greater daytime dysfunction observed in female athletes compared with male athletes (Halson et al., 2021).

Interestingly, habitual sleep duration was shorter in athletes from individual sports than in athletes from team sports, despite their similar sleep demand (Halson et al., 2021; Lastella et al., 2015; Sargent et al., 2021). Although, team sport athletes reported shorter sleep onset latency, longer sleep durations, later wake times and spent significantly more time in bed than those of individual sports, they showlower sleep efficiency (Halson et al., 2021).

It is important to mention that although some studies have reported sleep efficiency (SE) ≤85% as insufficient sleep quality (Roberts et al., 2018), according to the National Sleep Foundation report (M. Ohayon et al., 2017), SE ranging from 75–84% is considered uncertain for young adults/adults, whereas SE ≤74% indicates inappropriate sleep quality for the respective age category. Therefore, sleep quantity (TST) and sleep efficiency (SE) are analyze according to the Sleep National Foundation report (i.e., TST <7h; 420 min as an indicator of inappropriate sleep quantity, and SE ≤74% as inappropriate sleep quality) (M. Ohayon et al., 2017).

Thus, athlete support staff should avoid the “vicious cycle” in which poor sleep may compromise emotional regulation withincreasing og negative emotions, which may in turn disrupt sleep (Vitale et al., 2021).

2.9.2 Sleep and athletic career

Professional athletes show higher risk of sleeping disturbances, especially during the competitive season, than younger elite amateur athletes (Penttilä et al., 2021). The total sleep time that athletes require can vary depending on the training load, in addition tothe sport and the age of the athlete (Walsh et al., 2021). Therefore, it has been recommended an individualised approach that considers the athlete’s perceived sleep needs (Walsh et al., 2021).

When the quantity of sleep in elite athletes from various sports was analysed compared to non-athletic peers, the significant difference in assessed 'time asleep', suggested insufficient sleep characteristics in the athlete's group (Leeder et al., 2012).

The athletes reported need 8.3 hours of sleep to feel rested (self-assessed), but their average sleep duration was 6.7 hours (Sargent et al., 2021). Of the fourteen national German kayakers and canoeists (17 years old, six men and eight women), one mesocycle reported 450 minutes of sleep duration (Zinner et al., 2020). In the German national elite U23 rowers, the average sleep was 8.18 ± 1.24 h per day during the week and 8.07 ± 1.34 h per day on the weekend (Sperlich et al., 2017). Experts speculate that athletes need more to recover from the physical and psychological demands of the sport (Bird, 2013). It has been suggested that naps of 30 minutes prior to training or competition can reduce sleep inertia leading to better performance outcomes (Lastella et al., 2021). Accordingly, sleep log data and subjective ratings of the recovery and stress state revealed a negative influence of a reduced night, whereas an extended night resulted in positive effects (Kölling et al., 2016). Minimal effects of partial sleep deprivation on the physical performance show that single bouts of aerobic exercise and maximal strength measures are affected (Fullagar et al., 2015).

In comparison, sports-specific skill execution, submaximal sustained exercise bouts, and anaerobic power appear to be more prone to impairment (Fullagar et al., 2015; Halson, 2013; Reilly & Edwards, 2007). Sleep latency and efficiency were altered on the night and in the week before injury (Nédélec, Leduc, Dawson, Guilhem, & Dupont, 2017).

Insomnia symptomatology is high among elite athletes, with sleep quality appearing most vulnerable prior to major competitive events, during periods of high-intensity training and travel to competitions (Gupta et al., 2017). Athlete sleep disturbances can affect training and competition directly, through fatigue, or indirectly, through sleep-related performance anxieties (Gupta et al., 2017).

The designing schedules could have implications for the timing of training sessions for sleep and fatigue (Sargent, Lastella, et al., 2014). It has been demonstrated that schedules that require athletes to train early in the morning reduce sleep duration and increase pre-training fatigue levels (Kölling et al., 2016; Sargent, Lastella, et al., 2014).

Swimmers presented an average total sleep of 7.1 hours, higher daily training load induced an earlier bedtime and reduced total sleep time and perceived sleep quality, with higher sleep fragmentation (Aloulou et al., 2021). Elite athletes' results indicate that early-morning training sessions severely restrict the amount of sleep obtained, revealed that on nights before training days, bedtimes and get-up times were significantly earlier, time spent in bed was significantly shorter (Sargent, Halson, et al., 2014). The amount of sleep obtained was significantly less than on nights before rest days (Sargent, Halson, et al., 2014).

2.9.3 Sleep and different sports

In team sports, sleep efficiency was higher during the competition period compared to the remaining days. However, the competition period and the night before the match showed lower sleep duration when compared to other nights (Lalor, Halson, Tran, Kemp, & Cormack, 2017). The match time may cause disruptions in the players sleep characteristics. The clearest interruption to sleep occurs in the nights immediately following a match (Lalor et al., 2017).

In professional male Australian Rules Football players showed the time of the day of the game had a marked influence on sleep/wake behaviour later that night, sleep onset was later, time in bed was shorter and total sleepwas less than after the game day (Sargent & Roach, 2016).

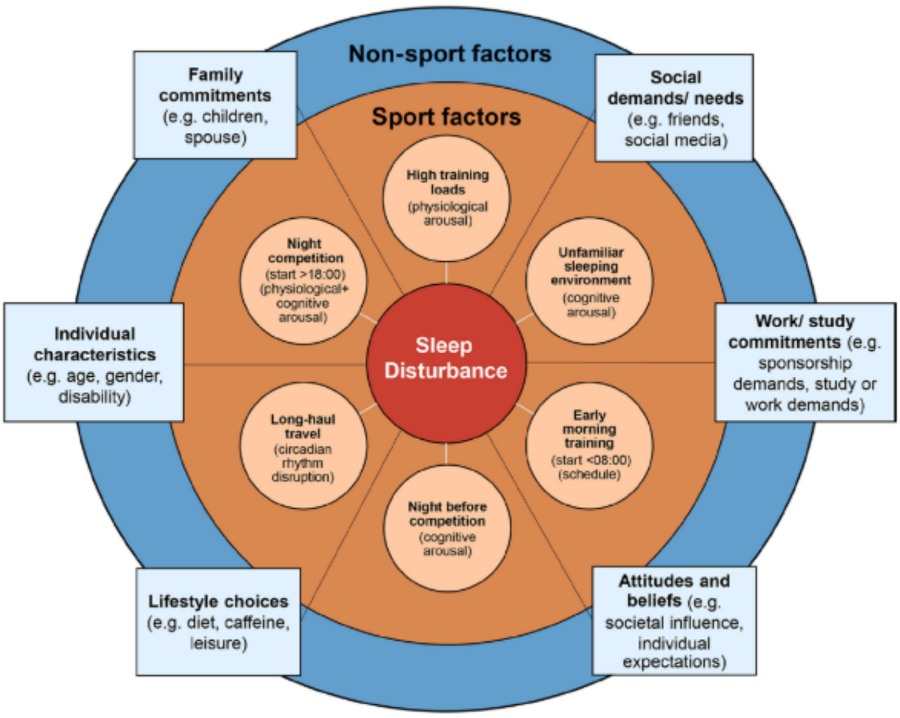

Figure 1: Contributory factors for sleep disturbance in athletes; including sport- specific factors (orange shading) and non- sport factors (blue shading) (Walsh et al., 2021).

Football players reported shorter sleep onset latency, fewer awakenings, higher scores of sleep quality and lower variability of sleep from weekdays than to weekends (Brand et al., 2009). Most studies have simulated extreme cases of sleep loss, in which participants do not sleep for extended periods (Fullagar et al., 2015).

Sport-specific risk factors for sleep inadequacy in athletes have broadly been identified as those related to training, travel and competition (Gupta et al., 2017; Nedelec et al., 2018). More specifically, the risk factors include: high training loads (Hausswirth et al., 2014; Kölling et al., 2016); short-haul and long-haul travel (P. Fowler et al., 2015; P. M. Fowler et al., 2017); the night before competition (J. A. Costa, Brito, Nakamura, Oliveira, et al., 2019; Erlacher et al., 2011; Juliff et al., 2015); evening competition (start times after 18:00) (J. A. Costa, Brito, Nakamura, Figueiredo, et al., 2019; Fullagar et al., 2016; Nédélec et al., 2019) and early morning training (start times before 8:00) (Sargent, Lastella, et al., 2014).

The athlete sleep appears to be influenced by sport-specific factors (relating to training, travel and competition), also by societal factors (eg, pervasive use of smart phones and social media in an 'always connected' society) and non-sport factors (eg, sex, stress and anxiety) (Gupta et al., 2017; Halson, 2016).

Extended sleep duration can lead to better psychomotor accomplishment and technical accuracy (Mah et al., 2011), with likely positive effects on competitive and training performance (Kölling et al., 2016). Moreover, moderate physical activity can promote nocturnal sleep, resulting in a reciprocally beneficial relationship between sleep and sport (Brand, Beck, Gerber, Hatzinger, & Holsboer-Trachsler, 2009).

2.9.4 Sleep and performance

A study of trained cyclists and triathletes, showed better endurance performance after three consecutive nights of sleep extension (~8.4 hours sleep each night) compared with habitual sleep (~6.8 hours sleep each night) (Roberts et al., 2019). Studies have shown that sleep extension improves sport specific skill execution (Schwartz & Jr, 2015), as well as sprint performance (Mah et al., 2011). In addition, due to their habitual mental and physical exertion demands (e.g., double daily training sessions) athletes require more accumulated sleep time. In fact, extended sleep time can lead to better psychomotor performance and technical accuracy (Mah et al., 2011), with likely effects on competitive performance (Kölling et al., 2016).

Evidence suggests that sleep extension has meaningful, beneficial effects on subsequent performance (Bonnar, Bartel, Kakoschke, & Lang, 2018). Providing the opportunity of extended sleep (and a day-off) seems the most simple and effective strategy to enhance recovery and stress-related ratings (Kölling et al., 2016). In periods in which training was more intense, and the training load was considerably increased, compared to usual home training, the athletes indicated that sleep might have been less restful (Kölling et al., 2016).

Therefore, it is essential and it has been advised to ensure sufficient sleep times in anticipation of important events, such as competitions. A period of sleep extension might be a beneficial measure (Kölling et al., 2016).

2.9.5 Sleep and associated measures

The gold standard for sleep monitoring is polysomnography (PSG), which uses surface electrodes to monitor physiological parameters such as brains, muscle, heart, and respiratory activity,allowing the precise determination of thesleep stages (Kushida et al., 2005; Pandi-Perumal et al., 2014; Robertson et al., 2014; Roomkham et al., 2018). PSG is beneficial for investigating sleep pathologies, including sleep-disordered breathing (George et al., 2003). However, PSG is expensive, requiring special hardware and medical assistance making it impractical for monitoring athletes in the field (Sargent et al., 2016). Hence, it can only be administered for very small periods of time, and when sleep is assessed out of a normal context (Ibáñez et al., 2018). When patients are hooked up to various machines with up to 20 electrodes placed on their body and head, in a lab with cameras rather than their own bed, they understandably might not sleep normally (Ibáñez et al., 2018), which is not very recommended for elite athletes who are training for an international competition.

On the other hand, the actigraphy based in the accelerometry has been increasingly employed in a wide variety of research settings in children and adults (Crouter et al., 2006; Quante et al., 2015). It was considered a valid methodology instrument to estimate total sleep time, wake after sleep onset and sleep efficiency (Quante et al., 2018; Roomkham et al., 2018). Moreover, the sadeh algorithm used to provide data generated comparable results to in-home polysomnography (Quante et al., 2018; Sadeh et al., 1994; Staudenmayer et al., 2015). Individual nights of sleep can be analysed for the following range of variables: time in bed, sleep latency, time asleep, time awake, percentage of time sleeping whilst in bed (sleep efficiency), actual sleep percentage, moving minutes, percentage moving time and sleep restlessness (Sargent et al., 2016). The ActiGraph accelerometer allows to study athletes in the the same environment wherethe training and competition constexts are (J. A. Costa, Brito, Nakamura, Oliveira, et al., 2019; Fullagar et al., 2015; Halson et al., 2021; Lastella et al., 2021; M. Ohayon et al., 2017; Walsh et al., 2021).

Another way to assess sleep are questionnaires and sleep diaries. They are mostly subjective and provide discrete approximations of real sleep quality (Ibáñez et al., 2018). However, they are cheap, can be administered at home for long periods of time, and contain useful complementary information (eg, daily activities) (Ibáñez et al., 2018). Questionnaires are often the first diagnostic assessment used in primary care, and they provide a general (quantitative) measure of the subjective quality of sleep (Ibáñez et al., 2018).

Among others, the Pittsburgh Sleep Quality Index (PSQI) is used to measure the quality and patterns of sleep in adults (Buysse et al., 1989). It differentiates ‘poor’ from ‘good’ sleep quality by measuring seven areas: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month (Buysse et al., 1989). Libman and collaborators illustrate the need to tailor the measurement modality, retrospective or daily to the setting and the purpose of the evaluation (Libman et al., 2000). Sleep diaries are typically used in addition to or in place of objective measures (ie, PSG or actigraphy) (Carney et al., 2012). The PSQI should be administered at regular intervals due to variability within individuals, it may be useful for practitioners in guiding decision-making regarding sleep interventions in athletes (Halson et al., 2021).

Sleep diaries (SpD) are typically prospective (ie, completed over multiple time-points) self-report measures in which patients and participants record their sleep patterns and answer other questions related to their sleep on a daily basis (eg, sleep quality, daytime sleepiness, stimulant use) (Dietch et al., 2019). The SD capture night-to-night variability in sleep, which a growing literature suggests is associated with poor health outcomes (younger age, non-White race/ethnicity, living alone, physical health conditions, higher BMI, weight gain, stress, and evening chronotype) (Bei et al., 2016). The daily SD demonstrated good psychometric properties, furthermore, when prospective sleep diaries are not feasible, the SD are acceptable substitutes to retrospectively estimate sleep parameters (Dietch et al., 2019). Moreover, retrospective estimation of sleep parameters separately for weekdays/ weekends may offer advantages compared to whole week estimation (Dietch et al., 2019).

The Pittsburgh Sleep Diary (PghSD) was shown to have sensitivity in detecting differences due to weekends, age, gender, personality and circadian type, and validity in agreeing with actigraph estimates of sleep timing and quality (Carney et al., 2012).

Incorporation of data from additional diary entries may further refine the ability to distinguish and quantify duration in sleep and physical activity (Quante et al., 2015). Several studies have recommended that accelerometery monitoring should be accompanied by sleep diaries to record information about daily routines, specific activities, bedtimes, and nonwear time of accelerometers. In this way, it is possible to trck unusual activities, naps, sleeping times, or times in which subjects removed the accelerometer (eg, for water-based activities, contact sports), therefore improving data management (Meester et al., 2011).

In sleep assessment studies, athletes used the sleep diaries and wrist actigraphy monitors (Juliff et al., 2017). Epoch concordance rates of 81 - 90% with polysomnography have been found for sleep/wake activity using actigraphy monitors (Sargent et al., 2016). Actigraphy uses accelerometers embedded in wearable devices to record movements that can be analysed using algorithms that estimate sleep duration and quality and with the ability to record continuously for extended periods (Ancoli-israel et al., 2003). Actigraphy is inexpensive and can be administered with minimal impact on habitual sleep or training and/or competitions/training routines. Consequently, actigraphy is the preferred method for objectively monitoring during the night the sleep of athletes (Sargent et al., 2016).

Conventional sleep screening and intervention approaches may not be adequate for athletes, given their lifestyle and the demands of training (Bonnar et al., 2018). Sleep interventions among different athlete populations, comparison of results, and further establishment of guidelines and intervention tools for athletes addressing their specific sleep demands is needed (Bonnar et al., 2018).

Probably it will be beneficial for future research to explore the competition load interaction with sleep characteristics (Juliff, Peiffer, & Halson, 2017). Consequently, there is an emerging awareness among athletes and coaches about the importance of sleep (Venter, 2014). Because of training-induced stress in elite athletes, further research is required to investigate the importance of sleep and its relationship with training tolerance and adaptation (Leeder et al., 2012).

The research on the sleep patterns in young canoeing sprinters undertaken during crucial preparation phases (i.e., National Team training camps and Competition) and its effects have not been explored.

2.10 Spontaneous Physical Activity and Sedentary Behaviour in athletes

An athlete's ability to reach his or her potential and achieve a high level of success in sports is determined by several factors. Knowing how athletes behave during the off-training (~20-22 h) (e.g., including sitting, lying, working, studying, active, and passive transportation) and social engagements (for example, media, sponsor, and family activities) and sleep. All these activities modulate psycho-biological responses to training (Sperlich & Holmberg, 2017). Izzicupo and collaborators constructed a scoping review about spontaneous physica activity (SPA) and sedentary behaviour (SB) could affect training response but there is a paucity of literature and for the moment it can be only speculated (Izzicupo et al., 2019).

2.10.1 Concepts

Physical activity (PA) is any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985), above resting (basal) levels, PA broadly encompasses exercise, sports, and physical activities done as part of daily living, occupation, leisure, and active transportation (Garber et al., 2011). On the other hand, exercise is PA that is planned, structured, and repetitive and that has as a final or intermediate objective the improvement or maintenance of physical fitness (Caspersen et al., 1985). The sport participation is all forms of physical activity which, through casual or organised participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all level (European Commission, 2007).

Physical activity is composed of spontaneous physical activity (i.e., activity associated with daily life, excluding any volitional exercise), obligatory physical activity (i.e. activity we are forced to do to survive), and voluntary physical activity (e.g. formal exercise) (Garland et al., 2011; Thorburn & Proietto, 2000).

Humans engage in much physical activity that does not qualify as voluntary exercise, and this is often termed spontaneous physical activity; it would comprise energy expenditure produced by all physical activity outside of formal exercise programs (i.e. such as walking and standing), may be considered all activity unstructured and everyday life activity, namely every daily PA excluding any volitional exercise (Garland et al., 2011; Kotz et al., 2008; Ravussin et al., 1986; Schutz et al., 1982).

During free-living daily life, the amount of energy expended during SPA can also be greatly impacted by cultural and/or societal factors and environmental conditions (Dishman, 2008), including the so-called 'built environment' (Sallis & Glanz, 2006) and habitual physical activity is subject to substantial biological control (Rowland, 1998).

Historically, sedentary behaviour was conceptualised as the lower end of the PA spectrum of light intensity, and extends to movement of moderate and vigorous intensity. Now increasingly being viewed as a behaviour distinct from PA, defined as any waking behaviour characterised by an energy expenditure ≤ 1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture (M. Tremblay, 2012). Consequently, physical inactivity is considered a lack of meeting the recommended levels of PA and not synonymous with SB (M. S. Tremblay et al., 2017).

Sedentary behaviour (SB) is defined as time spent sitting or lying with low energy expenditure (about 1–1.5 METs), while awake, in the context of educational, home, and community settings and transportation (Owen et al., 2010) (World Health Organization, 2020). Examples are sitting, watching television, playing video games, and using a computer (Owen et al., 2010). The screen-time is included in SB, media exposure, time spent watching TV, movies, videos, playing video, computer, mobile games, listening to music, using social media, reading, and using digital devices for entertainment purposes (Zhu & Owen, 2015).

It is important highlight some concepts to understand the balance between training and off-training behaviour: first, athletes should be active de facto but some exception could exists (e.g., shooting and other static activities, youth sports); second, athletes could be very inactive in specific circumstances such as during travel, holidays, injuries; third, SB can be considered necessary for athletes, because they need to recover after training, but recent changes in lifestyle (e.g., smartphone, social media) increases the amount of time spent in SB.

2.10.2 Recommendations and guidelines

In addition to exercising regularly, there are health benefits in concurrently reducing total time engaged in sedentary pursuits and also by interspersing frequent, short bouts of standing and physical activity between periods of sedentary activity, even in physically active adults (Garber et al., 2011).

It seems possible that in the absence of an essential need to be active, as is the case in modern society, genetic and metabolic factors predominately determine spontaneous physical activity levels (Thorburn & Proietto, 2000). In non-athletes, the attention had been centred on SPA, defined to include all physical activities (e.g., daily living activities), excluding volitional exercise (Garland et al., 2011).

Reducing physical inactivity is a mammoth societal challenge (Bull et al., 2020; Ding et al., 2020). *Physical activity* is a complex trait determined by the interaction of biological and psycho-social factors and the physical environment (Eisenmann & Wickel, 2009). The guidelines of the World Health Organization recommend for all adults a target range of 75−150 min per week of vigorous-intensity physical activity or 150−300 min per week of moderate-intensity physical activity (Bull et al., 2020; Ding et al., 2020). PA recommendation for children and adolescents (5-17 years), can be undertaken as part of recreation and leisure (play, games, sports or planned exercise), physical education, transportation (wheeling, walking and cycling) or household chores, in the context of educational, home, and community settings (Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020).

It is recommended that children and adolescents should do at least an average of 60 minutes per day of moderate- to vigorous-intensity, mostly aerobic, PA, across the week. Vigorous-intensity aerobic activities, as well as those that strengthen muscle and bone, should be incorporated at least 3 days a week (Bull et al., 2020; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). The guidelines recommend the regular muscle-strengthening activity for all age groups, reducing and interrupting as much as possible sedentary time, distinguishing the health risks due to physical inactivity from the ones related to prolonged sitting time (Bull et al., 2020; Ding et al., 2020).

On the other hand, SB recommendation for children and adolescents, higher amounts of sedentary behaviour are associated with the following poor health outcomes: increased adiposity; poorer cardiometabolic health, fitness, behavioural conduct/pro-social behaviour; and reduced sleep duration (Okely et al., 2022; World Health Organization, 2020). It is recommended that children and adolescents should limit the amount of time spent being sedentary, particularly the amount of recreational screen time (Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020).

The evidence indicate that different types of sedentary behaviour time may have different impacts on different indicators of health (Bull et al., 2020; Carson et al., 2016; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020). Reducing sedentary behaviours is recommended across all age groups and abilities, although evidence was insufficient to quantify a sedentary behaviour threshold (Bull et al., 2020; Chaput et al., 2020; Okely et al., 2022; Ross et al., 2020; Wu et al., 2017).

2.10.3 Measurements

There are many approach in PA measurement as direct calorimetry, labelled water, indirect calorimetry, multi-sensor devices, heart rate, accelerometers and questionnaires (Bull et al., 2020; Chaput et al., 2020; Freedson, 2018; Izzicupo et al., 2019; Júdice et al., 2022; Koorts et al., 2019; Okely et al., 2022; World Health Organization, 2020).

Questionnaires have historically been the most widespread tool used in epidemiological studies to measure PA. Questionnaires are limited in their ability to estimate physical activity energy expenditure at individual level and have varying validity for categorising individuals into groups and ranking activity levels (Ainsworth, Haskell, et al., 2000; Bull et al., 2009; Craig et al., 2003). Questionnaires vary greatly in their scope and level of detail and dimensions are not recorded to the same extent by each (Ainsworth, Haskell, et al., 2000; Bull et al., 2009; Craig et al., 2003). The face and content validity of the specific questionnaire should therefore be considered alongside the research question (Ainsworth, Haskell, et al., 2000; Bull et al., 2009; Craig et al., 2003). Diaries and logs typically allow detailed descriptions of duration, intensity, type and context of physical activity, and use free-form data capture resulting in rich descriptive information from the participant (Ainsworth, Bassett, et al., 2000).

Some questionnaires strengths: Number of participants; Relative cost (Cambridge Biomedical Research Centre). Some questionnaires limitations; Participant burden; Researcher burden of data collection; Risk of reactivity bias; Risk of recall bias; Risk of social desirability bias; Risk of observer bias; Participant literacy required; Cognitively demanding (Cambridge Biomedical Research Centre).

The accelerometery is a tool, it must consider the following technical specifications of sampling rate, dynamic measurement range (g), body site, wear time, metrics, activity counts (AC), Euclidean Norm Minus One (ENMO), mean amplitude deviation (MAD), epoch length and cut-points (Cain et al., 2017; de Almeida Mendes et al., 2017; Sievänen & Kujala, 2017). Accelerometers can measure acceleration in one, two or three directions (Chen et al., 2012). Tri-axial accelerometers are therefore more sensitive to certain types of activity where movements are more variable in three-dimensional space, such as climbing, jumping or spontaneous play (Pavey et al., 2017).

Some accelerometery strengths: objective data collection eliminates recall bias; no social desirability bias (except possibly as reactivity bias or differential non-wear time); no requirement for literacy and numeracy; data quality should not differ by educational attainment, ethnicity or socio-economic status, in particular for wear-and-forget protocols; continuously captures movement in much finer detail than even the most detailed PA diary; greater sensitivity to changes in behaviour over time, so useful for evaluating interventions (Cambridge Biomedical Research Centre). Some accelerometery limitations; missing data / non-wear time / non-compliance; objective methods currently provide no information on domain or behaviour type (e.g. driving, working, TV/computer use); negative aesthetic effects; some devices are not waterproof and need to be removed prior to swimming or bathing, resulting in non-wear time/missing data (Cambridge Biomedical Research Centre).

In adolescents, <4–9 days of monitoring are normally considered appropriate to obtain reliable estimates of physical activity which is in accordance with recommendations given (Trost et al., 2005). To observe weekend and weekday differences in physical activity behaviour, a 7-d monitoring protocol would appear to be a sensible choice for youths (Trost et al., 2005). To measure SB, the authors conclude that more than 7 days are needed to achieve reliability (Aadland & Ylvisåker, 2015).

2.10.4 Athletes and non-athletes

Athlete and non-athlete university students study suggested proximity between PA levels of athletes and non-athletes, mainly in the case of SB (Clemente et al., 2016). Athletes with higher amounts of SB presented higher total and trunk fatness levels, regardless of age, weekly training time, and residual mass. Even high moderate-to-vigorous PA levels did not mitigate the associations between sedentary behaviour and body fatness in highly trained athletes (Júdice et al., 2014, 2022).

A study with football players showed an alarming sedentary behaviour in their leisure time, comparatively more than non-athletic groups of a similar age and older (Weiler et al., 2015). In the referred study, the majority (79%) of waking hours (excluding training/matches) was spent on sedentary behaviour (500.6 min ± 59.0 per day) (Weiler et al., 2015). Whilst exceeding recommended levels of physical activity for health and fitness, athletes spend most of their leisure time in sedentary activity during the off-training time (Weiler et al., 2015). The high amount of habitual PA and prescribed endurance training was associated with good training response in physically active males (Hautala et al., 2012). These findings raise important questions about leisure time management for optimum recovery, performance (Weiler et al., 2015).

The fourteen national German kayak and canoeing young athletes (17 years) (six men and eight women), in one mesocycle, reported physical activity mean duration in minutes 623 Lying down, 360 siting, 205 light activity, 59 moderate activity, 53 vigorous activity (Zinner et al., 2020). The German national elite U23 rowers where average sedentary time was 11.63 ± 1.25 h per day during the week and 12.49 ± 1.10 h per day on the weekend, the average time per day in the light, moderate and vigorous PA during the weekdays was 1.27 ± 1.15, 0.76 ± 0.37, 0.51 ± 0.44 h per day, and 0.67 ± 0.43, 0.59 ± 0.37, 0.53 ± 0.32 h per weekend day (Sperlich et al., 2017).

The German national elite U23 rowers when compared to non-athletic population studies displayed a larger proportion of time sedentary (<1.5 MET), a lower proportion of light PA, but at the same time display a greater amount of moderate to vigorous PA (>3 MET) in addition to their often-vigorous training activity (Sperlich et al., 2017).

This study with young athletes characterised the PA and SB during non-training hours according to their usual activities schedule in a typical week revealed three distinct profiles of MVPA and SB spent daily (Exel et al., 2018). The Sedentary group showed the highest mean sedentary PA per hour of waking time. In contrast, the Balanced group presented the highest mean MVPA per hour of waking time, and the Hazardous group had the lowest sedentary PA and MVPA (Exel et al., 2018). Most weekdays waking hours are spent at school or home, promoting sedentarism (Exel et al., 2018). The young soccer players revealed alarming SB patterns, demonstrating long periods of SB during off-training periods (Mateus et al., 2021). Thus, results indicate that the displacement among these behaviours is also present in young athletes' lifestyles (Exel et al., 2018).

In study young soccer players, the MVPA attained on practice days is not achieved on days without practice, and on weekdays without practice, the MVPA recommendations are not met (Ala-Kitula et al., 2019). Previous PA of the same day before soccer practice positively correlates with PA during soccer practice at several different activity levels (Ala-Kitula et al., 2019).

2.10.5 Recovery benefits and performance

Delivering accurate and practical lifestyle advice to professional athletes can help establish favourable patterns of physical activity behaviours that could benefit recovery and performance (Staudenmayer et al., 2015; Weiler et al., 2015). Possibly, managing light-intensity physical activity throughout the day, especially during non-training hours, will have beneficial biological effects, such as interrupting venous stasis and preventing blood volume reduction and avoiding low shear stress. There is a necessity to explore sedentary behaviour profiles more widely and deeply in athletes (different sports, genders, aged and populations), because maybe variability in sedentary behaviour between sports, and other sociobiological and environmental determinants, which could include demographics such as cohabitants, ethnicity, culture and socioeconomic strata (Weiler et al., 2015). Furthermore, the sedentary time spent using prolonged electronic devices causes mental fatigue, can reduce the physical and technical performance of young footballers (Greco et al., 2017).

These findings raise important questions over leisure time management for optimum recovery and performance. Even an imbalance between physical activity and sedentariness following retirement, coupled with the possibility of a less athletic diet and increasing age, poses mounting risk factors for chronic disease (Weiler et al., 2015).

That indicates a necessity to explore objective sedentary behaviour profiles and optimal recovery more widely and deeply in athletes. In this context, sedentary off-training behaviour may negatively affect recovery and long-term adaptation to exercise and health (Sperlich et al., 2017). Potential identification of sedentariness could lead to a change in the view of off-training procedures (e.g., active recovery). It could stimulate health advice considering reducing the risk of sedentary-induced all-cause adverse health effects due to accustomed in-career sedentary behaviour (Sperlich et al., 2017).

Educated athletes are crucial investments for the development of the future society, especially for the skills they developed in managing challenges at educational and sport levels, such as life management, the combination of a higher education and a sports career (e.g., dual careers) (European Commission, 2012). During the forced confinement, the student-athletes maintained an active lifestyle compared to recommendations for the general population substantiating the relevant role of competitive sports participation in the maintenance of active lifestyles (Izzicupo et al., 2021).

However, an important consideration must be made regarding the nature of rest and SB: although rest can be performed in a sedentary way, it should be no more or less than the body needs to recover, while, implicitly, SB is harmful because it is over-prolonged (Izzicupo et al., 2019).

Few studies have analysed the PA and SB profiles during off-training hours, and it seems that elite athletes have higher levels of SB during waking hours compared to non-athletes (Exel et al., 2018; Mateus et al., 2021; Weiler et al., 2015).

Now, the athlete's lifestyle management is based on nothing more than simple recommendations that are not based on scientific evidence due to the paucity of indication relative to off-training PBs in athletes (Izzicupo et al., 2019).

The research on the SPA patterns and SB off-training in young canoeing sprinters undertaken during crucial phases of the preparation (i.e., National Team training camps and Competition) and its effects are not exploited.

Chapter III

Youth elite canoeing sprint athletes physiology characterization, training load and training intensity distribution of two typical national training camps

3 Youth elite canoeing sprint athletes physiology characterization, training load and training intensity distribution of two typical national training camps

3.1 Introduction

In individual sports such as canoeing sprint, is common to organize training camps aiming to optimize performance and to select athletes to compete at international events. Training camps in individual sports as canoeing have busy training periods with different levels that affect athlete's performance, presenting a great challenge to monitor. Often, training load can be intensified during training camps (Slattery et al., 2012).

The intensity distribution is probably one of the most challenging and most heavily discussed factors in training "periodization". It is documented that the VO_2 response to exercise is a function of exercise intensity in three domains: moderate, heavy and severe intensity (Fan Xu & Rhodes, 1999; Gaesser & Poole, 1996; Whipp, 1987).

The intensity of exercise and its distribution over time is essential for prescribing the training stimulus. The training intensity is typically divided into zones on the basis of parameters such as heart rate, blood levels of lactate, gas exchange, power output or velocity, and/or perceived exertion (T. Stöggl & Sperlich, 2015).

The training intensity distribution (TID) in elite endurance athletes is considered an important factor in the definition of the training load. Studies using breath-by-breath gas exchange measurements (Lucía et al., 1998, 1999) have identified two specific ventilatory changes that correspond to the aerobic (LT_1) and anaerobic (LT_2) thresholds, introduced before by Kindermann and colleagues (Kindermann et al., 1979). To monitor the training intensity distribution it is usual to perform exercise protocols to exhaustion, in order to assess the heart rate and VO_2 corresponding to ventilatory thresholds (VT_1 and VT_2), maximal oxygen consumption (VO_2max), and maximal heart rate. These measures are used to delimitate the three intensity zones: Zone 1 (Z1), Zone 2 (Z2) and Zone 3 (Z3) (Seiler & Kjerland, 2006).

The ventilatory threshold approach to define three intensity zones has been used by several groups (Boulay et al., 1997; Erez-landaluce & Rodr, n.d.; Lucia et al., 1999; Seiler, 2010; Seiler & Kjerland, 2006).

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3.1.1 Training intensity distribution models

Different training intensity distributions (TID) have commonly used the three-zone intensity model. If the major proportion of the training is low intensity (Zone 1) and typically of longer duration (volume), it is called a high-volume low-intensity training (HVLIT), performed with low (LOW) intensity [approximately 65–75% of peak oxygen uptake (VO_{2peak}) <80% of peak heart rate (HR_{peak}) or <2 mmol·L^{-1} blood lactate (Laursen & Jenkins, 2002; Seiler & Kjerland, 2006)].

High-intensity training (HIT), or "Zone 3" training, (e.g., >4 mmol lactate/L blood, >90% maximal heart rate) involves mainly interval training, intermittent intervals, or burst-training (short, high-intensity sprints) (T. Stöggl & Sperlich, 2015). In the HIT model there is a great focus on Zone 3 and minor on Zones 1 and 2.

Athletes following the HVLIT have revealed great improvements in athletic performance and related key variables of endurance (e.g., time to exhaustion, time trial performance, VO_{2peak}, maximal and submaximal running speed, running economy), both in trained and untrained individuals (Laursen & Jenkins, 2002).

Pyramidal model (TID) focuses the largest proportion of training in Zone 1, followed by a decreasing proportion in Zones 2 and 3. In the pyramidal distribution, most training is done at low intensity, with decreasing proportions of threshold and high-intensity training (Billat et al., 2001; T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2014, 2015). Inverse pyramidal training is just the opposite, with the largest proportion of the training in Zone 3, followed by Zone 2 and Zone 1 (Billat et al., 2001; T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2014, 2015).

Training performed mainly at an exercise intensity corresponding to the lactate threshold (e.g., 4mM blood lactate) or second ventilatory threshold, involves primarily continuous or intervals of moderate-intensity exercise and is often defined as "Zone 2" training (Faude et al., 2009; T. Stöggl & Sperlich, 2015). This type of "Zone 2" training has been shown to improve endurance performance, particularly in untrained participants (Denis et al., 1984; Londeree, 1997).

Polarized training has the main focus on Zones 1 and 3, with almost no training in Zone 2. As the main training is performed in the two extremes (or poles) of the intensity scale, the polarized training consists of significant proportions of both high- and low-intensity training and only a small proportion of threshold training. The distribution across low to high intensity training is often quantified as 75–80% with low intensity, 5% threshold intensity, and 15–20% as high intensity training (Billat et al., 2001; A. Fiskerstrand & Seiler, 2004; Hagan et al., 1981; Seiler & Kjerland, 2006; T. Stöggl & Sperlich, 2014, 2015). Inverse polarized TID has a greater amount of Zone 3 training compared with Zone 1 (T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2015). If all three zones are trained in equal proportion it is called uniform, even, or equal TID (T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2015).

The threshold-training model appears from some studies demonstrating significant improvements among untrained subjects training at their lactate threshold intensity, training at intensities at or very near the lactate threshold emphasized (Denis et al., 1984; Gaskill et al., 2001; Kindermann et al., 1979). On the other hand, the polarized training model appears from a limited number of published observations of international elite athletes (Seiler & Kjerland, 2006; Steinacker, 1993; Yu et al., 2012) or well-trained athletes (Esteve-Lanao et al., 2007; Neal et al., 2013; Rosenblat et al., 2019; T. Stöggl & Sperlich, 2014). It seems that relatively low-intensity training (Zone 1) is an essential part of any competitive endurance training program (Esteve-Lanao et al., 2007). The highly trained/elite distance runners typically follow a pyramidal TID approach, characterized by a decreasing training volume from Zone 1 to Zone 2 and Zone 3 (Casado et al., 2022; Haugen et al., 2022).

On the other hand, a brief review suggested that the polarized training model was consistently superior to that of the threshold training model in increasing aerobic endurance performance (Jay & Bruce, 2015). Generally, the experimental studies have shown that all of the different training methods led to improvements in the athletes' performance (T. Stöggl & Sperlich, 2014). However, in almost every study, the polarized group achieved the greatest improvements (T. Stöggl & Sperlich, 2014). Most of the experimental studies looked at the training patterns of recreational or amateur athletes. However, in recent studies on well-trained endurance athletes, also found that the polarized TID resulted in the greatest improvements in endurance performance, followed by high-intensity training (HIT), while a HVLIT or Threshold TID was not effective (T. Stöggl & Sperlich, 2014).

Both in pyramidal or polarized TID the most part of this training is in Zone 1 (70–94%), with less in Zone 2 (4–22%) and Zone 3 (2–11%) (T. Stöggl & Sperlich, 2015)

In endurance sports variable TID patterns across the training season can be used. During the preparation phase (the 5–6 months training period at the start of the training year) the focus is on high-volume, low-intensity training (HVLIT), while later it changes towards a pyramidal TID during the pre-competition period (the 1–2 months before the first competitions start). Later, during the competition phase (the 3–5 months where the main competitions take place) polarized TID takes place (T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2014, 2015).

In a study performed in twelve highly training German sprint kayakers and canoeists (7 women, 5 men), monitored during preparation periods, as well as during the period of competition (total monitoring period: 37 weeks) showed that during each period, the mean TID was pyramidal (Matzka et al., 2022).

The monthly frequency of Zone 3 sessions (high intensity) increases from preparation phase to the pre-competition phase and remains unchanged throughout the competition period, while the amount of Zone 1 decreases. Elite endurance athletes generally start their training year with a Zone 1-oriented training concept, and in the months before the first competitions start, they switch to a high proportion of Zone 1, and an increased amount of Zone 2 and Zone 3 training (T. L. Stöggl, 2018; T. Stöggl & Sperlich, 2014, 2015). Within the competition phase, they generally use polarized training (T. L. Stöggl, 2018). The change in the type of TID from pyramidal to polarized in the second half of the periodization (16 weeks) in well-trained runners have shown to induce bigger improvements compared to the simple pyramidal and polarized ones, or when compared to switching from polarized into pyramidal periodization (Filipas et al., 2021).

In young kayak sprinters, the TID and typical training loads undertaken during crucial phases of the preparation (i.e., National Team training camps) leading up to team formation and its effects have not been analyzed. A systematic review (Roos et al., 2013) suggested quantitative and qualitative data combination as the most promising approach to evaluate the training load and athletes' response to the training.

3.1.2 Monitoring training Load

It appears to be important to the training load control, along with the monitoring of the TID, to improve the interpretation of the responses of athletes. Quantifying physical effort during individual sports can be done in various ways (Hopkins, 1991). Some authors have used the training impulse (TRIMP) as a marker of training load during training and competition (Morton et al., 1990; Padilla et al., 2000). The TRIMP is calculated from both intensity (the mean exercise heart rate) and duration. It can be used to measure the training load both in individual continuous sports as in those of intermittent nature (Hopkins, 1991). The modified TRIMP by Stagno (2007) showed relationships between the mean weekly time spent engaged in the high-intensity activity and changes in VO_2max and speed at 4 $mmol^{-1}$. The modified TRIMP supports the quantitative measure of training load during non-steady-state exercise, including high-intensity, sport-specific training and competitive of a high-intensity and intermittent nature (Stagno et al., 2007).

The session rating of perceived exertion (sRPE) is a valid method to quantify internal training load in canoeing sprinters due to its high correlation with heart rate-based training impulse (Borges et al., 2014). In other sports, sRPE has been too sensitive to changes in external training load, demonstrating the training load fluctuations (Coutts, Reaburn, et al., 2007; Coutts, Slattery, et al., 2007; Freitas et al., 2014).

The main objective of this chapter is to characterize and analyse the training load intensity distribution pattern in young elite kayak athletes during two training camps of national team training camp, before an international competition (European Canoeing Championships Junior & U23).

3.2 Materials and Methods

3.2.1 Participants

Thirteen elite young athletes (6 females; age: 17.4 ± 0.4 years; training experience: 8.3 ± 1.5 years; height: 164.3 ± 3.0 cm; body mass: 61.3 ± 6.4 kg; fat %: 21.2 ± 5.7 %. 7 males; age: 17.3 ± 0.7 years; training experience: 6.6 ± 0.9 years; height: 173.4 ± 4.1 cm; body mass: 73.1 ± 6.0 kg; fat %: 11.2 ± 3.1 %) from the Portuguese National Canoeing Team (kayakers sprint) took part in this study. All the athletes had at least 5 years of experience in competitive canoeing. After receiving the detailed explanation of the purposes and procedures of the study, the legal guardians and the athletes provided their written consent. The athletes visited the laboratory one time during which they accomplished one experimental protocol - graded exercise test (GXT). The same experienced researcher performed the anthropometric measurements. In the European Canoeing Championships Junior & U23, the Portuguese National Canoeing Team participated in 10 finals and won two bronze medals. The local Ethics Committee of the Faculty of Sports Science and Physical Education, University of Coimbra (CE/FCDEF-UC/00292019) approved the procedures.

Table 1: Participants characterization, descriptive statistics (mean ± standard deviation).

	Female n=6		
	Min	Max	Mean ± SD
CA (yrs)	16.8	17.8	17.4 ± 0.4
TE (yrs)	6.0	10.0	8.3 ± 1.5
Stature (cm)	160.3	167.2	164.3 ± 3.0
BM (Kg)	50.6	69.6	61.3 ±6.4
Fat %	13.3	27.7	21.2 ± 5.7
	Men n=7		
	Min	Max	Mean ± SD
CA (yrs)	16.5	18.3	17.3 ± 0.8
TE (yrs)	5.0	8.0	6.6 ± 0.9
Stature (cm)	167.2	179.2	173.4 ± 4.1
BM (Kg)	64.6	79.0	73.1 ± 6.0
Fat %	6.8	15.1	11.2 ± 3.1

note: *CA* chronological age; *BM* body mass; *TE* training experience; *yrs* years.

3.2.2 Experimental Design

The experimental design was as followed in figure 2.

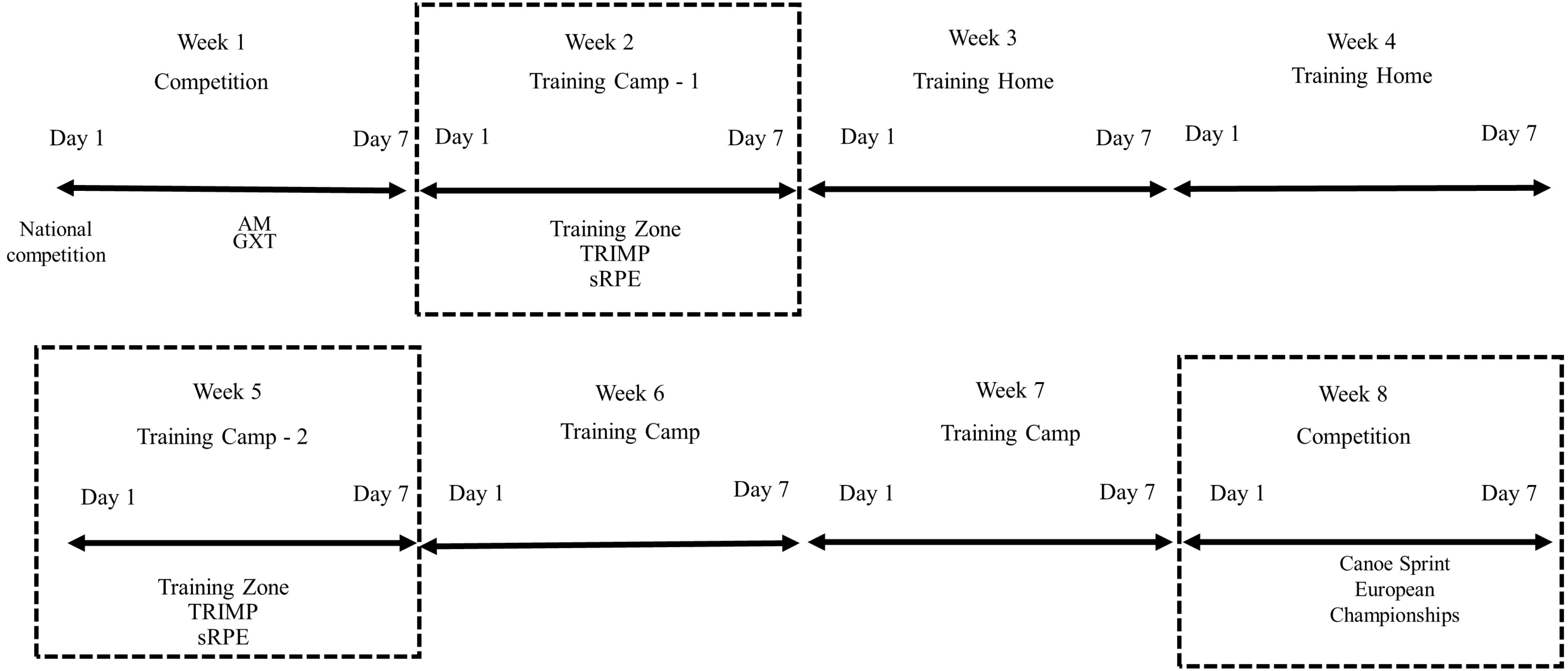

Figure 2: Experimental design

Note: AM anthropometric measurements; GXT Cardiorespiratory graded protocol assessment; TRIMP Training impulse; sRPE Session Rating of Perceived Exertion.

The training camp 1 was located six weeks before the European Canoeing Championships Junior & U23 (ECC), consisting of a week of training with the objective of selecting athletes to participate in the ECC. The training camp 2 occurred three weeks before the ECC when the team was already closed, and consisted of the last preparations for the ECC, before the tapering phase. In the competition the athletes competed in K1, K2, and K4 (1000, 500 and 200 meters).

The participants took part in a training camp and were monitored daily over two training camp at the High-Performance Centre of Montemor-o-Velho (CAR). During the training champ, the canoeists fulfilled the programs prescribed by their coaches. On average, they trained seven days/week, being nine water sessions, three strength and conditioning sessions, and three run sessions per week.

The athletes were familiar with the kayak ergometer and testing procedures applied. All testing sessions were held in the same period of the day (09 am - 1 pm). The day before testing, athletes were required to avoid fatigue accumulation; all participants were asked to abstain from intense physical exertion and only a light intensity workout 24 h prior to each testing session was allowed.

Training camp 1 had the following meteorological values of maximum air temperature at 1.5m (21.5 ± 3.5°C), minimum air temperature at 1.5m (13.0 ± 0.7°C), maximum relative humidity (98.1 ± 2.7%), minimum relative humidity (59.9 ± 16.9%), and average wind intensity (1.8 ± 0.4m/s).

Training camp 2 had the following meteorological values of maximum air temperature at 1.5m (23.2 ± 3.2°C), minimum air temperature at 1.5m (13.7 ± 0.3°C), maximum relative humidity (99.3 ± 1.5%), minimum relative humidity (60.8 ± 6.9%), and average wind intensity (2.4 ± 0.3m/s) values according by Portuguese Institute for Sea and Atmosphere (IPMA).

3.2.3 Anthropometric assessment

The anthropometric and body composition assessments were done before the GXT. Body mass was measured using a calibrated scale (Seca 770, Hamburgo, Germany) and stature and sitting height were measured using a standard stadiometer (Harpenden 98.607, Holtain, UK). Body composition was assessed through multi-frequency bioelectrical impedance analyzer (InBody770; Biospace, Seoul, Korea).

3.2.4 Cardiorespiratory graded protocol assessment

On the visit, upon arrival at the laboratory, the athletes completed a pre-test questionnaire to characterize the training and food intake in the last 24 hours. The questionnaire was adapted from Tanner & Gore 2013 (Bullock et al., 2012) and was used to verify if the athletes maintained the same advised pattern of activity and nutrition before the evaluation protocol. They also completed a symptoms questionnaire Wisconsin Upper Respiratory Symptom Survey – 21 (WURSS21) (Barrett et al., 2005). The protocol was performed in an air-braked, drag adjustable ergometer designed to assess flat-water kayakers (Kayak-Ergometer Dansprint, Hvidovre, Denmark). The athletes were familiar with the kayak ergometer and testing procedures applied. The distance from seat to foot-bar and hand position on the carbon shaft were adjusted individually and maintained constant across the tests.

Ergometer drag was adjusted for body mass of each athlete according to manufacturer's instructions (table 2) to reproduce on-water surface when on the kayak (www.dansprint.com). The warmup procedure was as follow:

- After 10' of freely chosen light stretching exercises
- They paddled for 15' at an intensity lower than 70% of their estimated HRmax, during which athletes were asked to perform 5 short sprints of 3" (Bishop et al., 2001)
- Followed by a passive rest period of 10'
- Speed started with paddling at 8 $km.h^{-1}$, with increments of 1 $km.h^{-1}$ each 2 min, until exhaustion. The data was averaged in 30 s segments.
- An active recovery on cycle ergometer lasting 15 minutes with reduced power output (35 watts (W)) at a pace of 60 rpm was performed after each kayak-specific testing protocol (Bishop et al., 2001)
- During the graded exercise test, the speed was continuously measured through the Dansprint software.

The values of temperature (24.9 ± 0.8 ºC), ambient humidity (44.3 ± 2.1 %) and pressure (763.7 ± 1.0 mmHg) were maintained constant during the tests (Oregon Instruments USA). After both tests, blood lactate (La) was determined at 1, 3, 5 and 7 minutes of recovery from capillary blood samples collected using heparinized ear-lobe tubes for determination of peak lactate value (Lactate Pro®).

Table 2: Fan resistance values calculated from the Dansprint reference manual

Weight (kg)	50.0	52.5	55.0	57.5	60.0	62.5	65.0	67.5	70.0	72.5	75.0	77.5	80.0	82.5	85.0	87.5	90.0	92.5	95.0
Fan Resistance	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10

3.2.5 Ventilatory assessments

Ventilatory parameters were monitored breath by breath with a Quark CPET COSMED® gas analyzer (Quark-CPET COSMED, Roma, Italy) calibrated before each testing session according to manufacturer's instructions.

Before testing, the gas analyzer system (Quark CPET, Cosmed, Rome, Italy) was calibrated for room and gas with known O_2 and CO_2 concentrations following the manufacturer's recommendations. The determination of ventilatory thresholds (VT_1 and VT_2) and VO_2max followed the criteria proposed by Howley et al. (Cottin et al., 2006; Howley et al., 1995). Briefly, VT_1 corresponds to the last point before the first nonlinear increase in both VE and VE/VO_2. VT_2 corresponds to the point before the second non-linear increase in both VE and VE/VO_2, accompanied by a non-linear increase in VE/VCO2. Three experienced researchers identified the ventilatory parameters and a fair agreement was obtained. Coefficients of variation (CV) between researchers ranged from 0.3 % to 2.7 %. The determined intraclass-correlations (ICC) were 0.93, 0.90 and 1 for VT_1, VT_2 and VO_2max, respectively, for the values reported by the three researchers. Accordingly, the mean of each of the value were used.

3.2.6 Heart Rate assessment

The Heart rate was monitored during every training bout using downloadable, heart rate (HR) was recorded beat-by-beat using waterproof monitors with 5-s registration intervals (Polar RS800CX, Kuopio, Finland) with the respective chest belt transmitters (Polar wearlink) was after the training session the recorded HR was downloaded on a computer using an interface configuration and ancillary software (Polar IrDA USB Adapter). The transferred data was transferred to Microsoft Excel spreadsheet, for further analysis. Athletes were provided a numbered heart watch to keep for all the study periods. A member of the research team was in charge to downloaded heart rate data files daily.

Monitoring training load

3.2.7 Training load data analysis

Training duration was determined using the heart rate records. For all the subjects, HR was continuously measured (every 5 s) during each training session. Strength training sessions were not included in the training intensity analysis. Strength training was identical for all subjects and were maintenance sessions design. Inboth weeks athletes performed the same training tasks. Training intensity distribution was quantified from heart rate, the total time-in-zone, software provided by the Polar (Polar ProTrainer 5, Polar Inc.,Kempele, Finland) was used to determine the percentage of training time spent in each of the three training zones for each individual training session. The average training time in each zone for all sessions was then determined (zone 1: HR below the HR at VT_1; zone 2: HR between the HR at VT_1 and the HR at VT_2; zone 3: HR above the HR at VT_2) (Esteve-Lanao et al., 2005; Seiler & Kjerland, 2006).

3.2.8 Session Rating of Perceived Exertion

For quantification of session training load (TL), we used the sRPE. This procedure consisted of asking to the athletes to rate their level of perceived exertion using the CR100 (Borg & Borg, 2002; Borg & Kaijser, 2006) scale 15-30 min post-exercise. This perceptual value was multiplied by the session duration in minutes (Borges et al., 2014). The sRPE results were divided by 10 to allow for comparison with previous studies that used the CR10 scale (Impellizzeri et al., 2004; Rabelo et al., 2016; Wallace et al., 2009). The 14-day training camp was separated into two 7-day (microcycle) (W1 and W2).

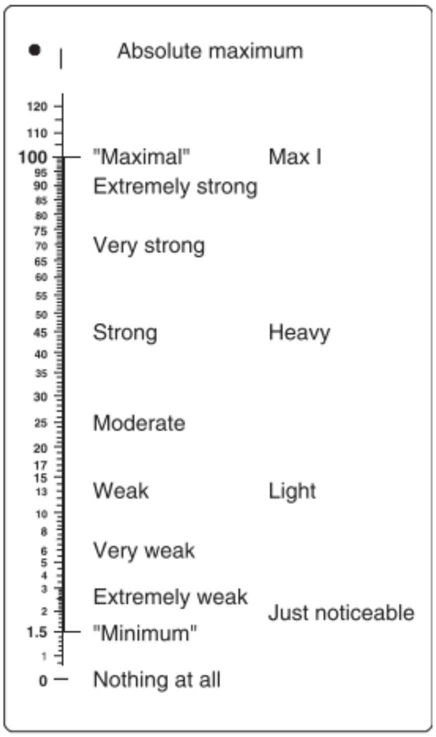

Figure 3: Borg centiMAx (CR100) scale (Borg & Borg, 2002; Borg & Kaijser, 2006)

3.2.9 Training Impulse

In each session, heart rate (HR) was recorded beat-by-beat using waterproof monitors (Polar RS800CX, Kuopio, Finland). The HR monitors' belt contains two chest electrodes wired to a monitoring device that was downloaded on a computer at the end of each session using an interface configuration and ancillary software (Polar IrDA USB Adapter) and then transferred to Microsoft Excel spreadsheet, for further analysis. Before the study period, the baseline and maximum HR were recorded, which were maintained as such throughout the study. The baseline HR was obtained after waking up with beat-by-beat monitors (Polar RS800CX, Kuopio, Finland). While subjects remained in supine position, time between adjacent R-waves (R-R intervals) were recorded for 5 minutes, and the last 2 minutes were averaged. Maximum HR was the maximal value obtained during a GXT. Previous research on trained athletes has shown that HR values at VT_1 and VT_2 determined during laboratory testing remain stable over the season (Lucia et al., 2000).

The HR and training time were recorded on the water training sessions to compute training impulse units using, all heart rate data were downloaded to a computer using the Polar Training Advisor Software package (Polar ProTrainer 5, Finland). The software allows for the determination of the aggregate training time spent in each zone. The TRIMP Stagno equation has an exponential function that best fitted to the data points, where the mean fractional heart rate elevation for each zone and e is the Napierian natural logarithm having a value of 2.712. To calculate the TRIMP Stagno (Stagno et al., 2007) we used the equation that follow:

$$TRIPMS = duration \times \frac{(HRexercise - HRrest)}{(HRmaximal - HRrest)} \times 0.1225e^{3.9434 \times \frac{(HRexercise - HRrest)}{(HRmaximal - HRrest)}}$$

Equation 1 – TRIMP Calculation Stagno et al., 2007

3.2.10 Statistical analysis

All data were present by descriptive values with data presented as means ± standard deviation. Before inferential procedures the homogeneity and normality distribution were checked through Levenne and Shapiro-Wilk tests. When normality was not confirmed the nonparametric tests were conducted. The correlation and regression analysis between TRIMP and sRPE was performed to explore eventual associations. The correlation strength values were classified according to: 0.50-1.00, large; 0.30-0.49, moderate; 0.10-0.29, small (Cohen, 1988). When the 95% CI overlapped positive and negative values, the effect was unclear. Training intensity distributions during two weeks of training camp were assessed through the Chi-Squared χ^2test. All tests were performed using the IBM SPSS Statistics (version 24) software. Significance was set at 5%.

3.3 Results

The results of graded exercise test (GXT) are present in Table 3, namely the ventilatory thresholds and VO_2max and final lactate concentration. All variables fit the assumption of normal distribution and includes results of comparisons between groups. Table 4 summarizes the training load data related to the magnitude of TRIMPs and sRPE values during the training camp. The figure 4 shows the training load intensity distribution during the training camp (zone 1, zone 2 and zone3).

3.3.1 Graded exercise test

Table 3: Descriptive values and statistical comparative analysis of GTX protocol

Variables	Female n = 6			Male n = 7			
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	*p*
VO_2max_x ($L.min^{-1}$)	2.2	2.9	2.6 ± 0.3	3.7	4.5	4.0 ± 0.3	0.001
VO_2max ($mL.Kg^{-1}.min^{-1}$)	37.3	45.6	41.7 ± 3.3	46.8	58.4	54.1 ± 3.8	0.001
HR VO_2max_x (bpm)	184.0	199.0	192.5 ± 5.5	175.0	192.0	187.2 ± 6.1	
Speed at VO_2max (Km/h)	12.0	13.0	12.5 ± 0.5	15.0	16.0	15.3 ± 0.5	0.001
VT_1 ($mL.Kg^{-1}.min^{-1}$)	23.4	30.4	26.7 ± 3.0	22.0	33.9	29.9 ± 4.0	
VT_1 VO_2max (%)	59.0	69.9	63.9 ± 4.9	47.0	62.6	55.1 ± 6.3	0.035
VT_1 speed (Km/h)	8.0	9.0	8.8 ± 0.4	10.0	12.0	10.8 ± 0.7	0.001
VT_2 ($mL.Kg^{-1}.min^{-1}$)	32.7	42.2	37.0 ± 3.6	43.7	50.9	48.0 ± 2.6	0.001
VT_2 VO_2max (%)	80.7	98.7	88.9 ± 6.1	80.9	96.8	88.9 ± 5.4	
VT_2 speed (Km/h)	10.0	12.0	11.0 ± 0.6	12.0	15.0	13.8 ± 0.9	0.001
Lactate (mmol. L^{-1})	8.0	10.9	8.7 ± 1.1	8.1	11.0	9.9 ± 1.0	

Note: HR heart rate; VT1 ventilatory threshold 1; VT2 ventilatory threshold 2.

In table 3 we can observe the GXT results of both sexes. The females group showed a mean VO_2max of 2.6 $L.min^{-1}$, at a speed of 12.5 km /h. The males showed an absolute VO_2max of 4 (L.min-1), at a speed of 15.3 Km /h. Comparing the sex results on the GXT, we verified higher values in males, in VO_2max and VT_2 ($Z=-3.00$; $p<0.001$), in VO_2max speed ($Z= -3,127$; $p<0.001$), in VT_1 speed ($Z=-3,109$; $p<0.001$), and in VT_2 speed ($Z=-3,017$; $p<0.001$).

3.3.2 Monitoring training load

Data related to the magnitude of perceived exertion (sRPE) and (TRIMPs) during the training camps is presented in table 4.

Table 4: Descriptive data of all training sessions from training camp 1 and training camp 2 (TRIMP and sRPE).

Variables	Training Camp 1			Training Camp 2			
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	*p*
TRIMP	574.5	896.7	770.3 ± 102.6	634.8	875.6	743.6 ± 75.2	0.532
sRPE	4756.1	6841.0	6048.1 ± 525.9	4585.2	7260.0	5853.0 ± 858.5	0.524

For the comparations of the training load between weeks, we analyse the athletes as a group, because no difference was found in training load considering the sex. Comparing training load between weeks, no differences were found in TRIMPs nor in sRPE in the two weeks. Identical result was found when the ratio of perceived load vs internal imposed load (sRPE / TRIMP), in TC 1 and TC 2 (p=0.792). A strong correlation between TRIMP and sRPE were found (r= 0.566; p<0.0001) and the regression model between these variables showed to be significant although moderate in the explanatory power, R^2=0.320 (y=42.27*X+3690).

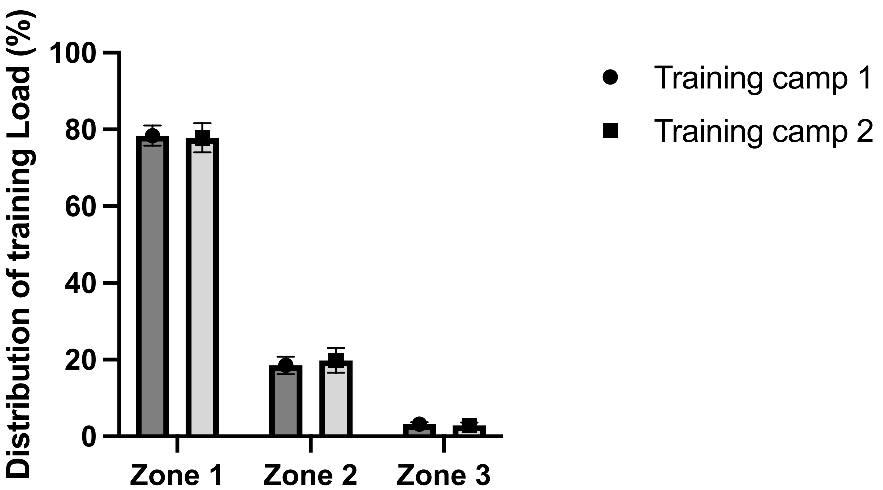

Figure 4: Training intensity distribution during two training camps

The intensity load distribution showed no differences were found between the training camp 1 in Z1 (77.86 ± 10.13), Z2 (18.92 ± 9.25), Z3 (3.26 ± 1.75) and training camp 2 in Z1(77.66 ± 10.51), Z2 (19.60 ± 8.85), Z3 (2.73 ± 1.80). Additionally, we found a high volume low-intensity training (HVLIT) in the training intensity distribution pattern (TID). The percentage of TID was performed by heart rate, which we know is a limitation to analysing the alactic anaerobic training. However, we check all the training session tasks lower than 20 seconds accomplished by the athletes and the number was not relevant.

3.4 Discussion

This study was primarily designed to characterize and analyse national team young elite kayakers training load, during two training camps. The first one located 6 weeks before an international competition and the second 3 weeks before the European Canoeing Championships Junior & U23. Additionaly, this study aimed to characterize and analyse the training intensity distribution pattern (TID).

There were several noteworthy findings. First, young elite-level canoeists appear to accumulate between 770 to 743 training impulse (TRIMP) and 6048 to 5853 au session rating of perceived exertion (sRPE) au within the seven days of a two training camp (TC) that is designed to select athletes to compete at European Canoeing Championships Junior & U23 (ECC). As expected, at selection moments additional stress can impact on athletes perceived exertion. The second TC was immediately before the start of the tapering phase preparing directly for the ECC. Moreover, in this study the athletes were all trained by the same national coach.

The weeks we followed in this study showed an average value of 59506 au, which is higher 29,9% than the average value of a typical in-season week ,42000 au, in kayak elite young athletes (Coelho et al., 2019). However, they have the same training load as young swimmers national level in a typical week, which is 57500 au (Nugent et al., 2018). The training impulse (TRIMP) reported in our study is similar to one reported in a training camp of elite swimmers (749) monitored daily, over four consecutive weeks of training (García-Ramos et al., 2015).

Second finding, a positive correlation and association between TRIMP and sRPE was found. The training load TRIMPs and sRPE were no different between TC1 and TC2, showing a non-variation of training load between two weeks of training camp with different goals and periods. It can be explained by the coach's prescription or by the pace at which the athletes chose to perform the training tasks (individual pacing strategy), as presented in professional cyclists (Rodríguez-Marroyo et al., 2009). Furthermore, a positive correlation and association between TRIMP and sRPEwas previously observed in young canoeing athletes (Borges et al., 2014).

Further, more data is required to demonstrate whether wearable technology is more valid and efficient than simple monitoring tools, such as sRPE and TRIMP, which were shown to be valid for discriminating between short-term and long-term adaptations (Foster et al., 2017). Moreover, the sRPE and/ or TRIMP have been used in previous studies in

Junior and adults canoeing athletes (Coelho et al., 2019; Garatachea et al., 2011; Nakamura et al., 2009; Borges et al., 2014). Nonetheless, coaches should know that aerobic fitness and Sprint Kayak performance are related to athletes' perception of training intensity during training. This aspect suggests that better performing and fitter athletes may have perceived the same training session to be easier than their less fit counterparts (Borges et al., 2014). The relationships between the external load of distance and speed and the session-RPE load support that both can be regarded as a practical monitoring tool for Sprint Kayak athletes (Borges et al., 2014).

The sRPE and TRIMP were demonstrated to be simple, non-invasive and effective tools appropriate to training and performance monitoring in Canoe athletes, bycoaches and sports scientists. Quantifying training load using the session-RPE method and CR 100 scale proved to be a good option to monitor the canoeist's training load, supported in the strong correlation with TRIMP as in our study (Oliveira Borges et al., 2014).

Our GXT values are similar to those achieved by GXT Portuguese national-level male young sprint kayakers in VT_1 (57%) and VT_2 (78%) (Coelho et al., 2021), and in well-trained runners in VT_1 (61%) and VT_2 (85%) (Esteve-Lanao et al., 2005). Portuguese elite male young kayakers reached the 4.0 L. min^{-1} the 15.3 km/h (VO_2max), while in another study with a Portuguese national-level male young sprint kayakers reached 3.5 L. min^{-1} the 12.5 km/h, showing the higher competitive level of the sample in our research (Coelho et al., 2021).

Third finding, the young elite canoeing athletes showed a training intensity distribution pattern (TID) of high volume low-intensity training (HVLIT). About 78.4 - 77.8 % of their training sessions were performed with essentially the entire session below the first ventilatory threshold (Z1). In 18.5– 19.75 % of training sessions, major portions of the training were performed between VT_1 and VT_2 (Z2). The remaining 3.2–2.9 % of training sessions were performed as interval bouts, with substantial periods of work above VT_2 (Z3).

The TID during the two-week type in different periods follows the HVLIT pattern, with the major proportion of the training in low-intensity Z1 and typically of longer duration (volume), in Z2 (18.5 - 19.75%) and Z3 (3.2 - 2.9%) (Laursen & Jenkins, 2002; Seiler & Kjerland, 2006). There is a possibility that the Z3 values are undervalued because of the low HR sensitivity at high intensities of short duration, and/or by the training prescription aiming at a higher training concentration in Z2 than in Z3.

On the other hand, twelve highly training German sprint kayakers and canoeist (total monitoring period: 37 weeks), showed a pyramidal TID (Matzka et al., 2022). The German team mainly showed a little less time in Z2 and more time in Z3 than our findings. Pyramidal TID has also been reported in several endurance sports such as: Esteve-Lanao and collaborators found a pyramidal TID in endurance runners training, Z1 - 71%, Z2 - 21 % and Z3 - 8% (Esteve-Lanao et al., 2005); Lucia and collaborators found also a pyramidal TID in cyclist during competition of Vuelta a España and Tour de France, Z1 - 70%, Z2 - 25 % and Z3 - 5% (Lucía et al., 2003); Muñoz and collaborators as well found a pyramidal TID in ironman athletes, Zone 1 (68%) Zone 2 (28%) and Zone 3 (4%) (Muñoz et al., 2014).

Although most of the reported TIDs presented higher total training time in Z2 and Z3, the performance of regional/national class endurance runners, in competition, did not show to be associated with total training time spent at medium or high intensities (zones 2 and 3) (Esteve-Lanao et al., 2005). The authors found a relationship between cumulative training time at zone 1 and endurance performance during events (Esteve-Lanao et al., 2005).

When comparing the training program based on intensity zones in Ironman athletes and their performance in a competition, while athletes perform with HR mainly in zone 2, better performances were associated with more training time spent in zone 1 (Muñoz et al., 2014).

A previous study analyzed two groups, one with different percentage distribution in zones 1, 2, and 3 group (G1) (80/10/10) and another group (G2) using a total percentage distribution in zones 1, 2, and 3 (65/25/10). Although performance time was significantly improved in both groups after training, the G1 elicited significantly greater performance enhancement than the G2, showing that spending more training in Z1 and less in Z2 while maintaining the same training in Z3 was beneficial for increasing performance (Esteve-Lanao et al., 2007). Performing about 75% to 80% of all training sessions at an intensity in Zone 1 combined with a certain degree of moderate to intense training was the path suggested by the authors to have success in endurance sports (Muñoz et al., 2014). The Norwegian rowers winning international medals between 1970 and 2001 increased 12% the maximal oxygen uptake when they started performing the suggested ''polarized'' pattern of training with a high volume of low intensity Zone 1 and a balanced regular application of training bouts in Zone 3 (Å. Fiskerstrand & Seiler, 2004).

Olympic Speed Skaters data indicate that in speed skating there was a shift towards polarized training over the last 38 years, which seems to be the most important factor in the development of Olympic speed skaters (Orie et al., 2014). However, no relation was found between total training hours or skating hours (Orie et al., 2014).

Additionaly, recreational athletes seem to be equally sensitive to the different modes of intensity distribution (polarized endurance training and focused endurance training) over a limited period of time (Festa et al., 2020).

With cyclists, Sylta and collaborators showed that organizing different interval sessions, in zone 3, in a specific periodized mesocycle order or in a mixed distribution has little or no effect on training adaptation when the overall training load is the same (Sylta et al., 2016).

The experimental studies lasting 6 weeks to 5 months demonstrate superior responses to polarized TID, especially when compared with TID that emphasizes THR or HVLIT (T. Stöggl & Sperlich, 2015).

One explanation for a superiority of the polarized TID could be linked to the way the body spends energy during the training workouts. Precisely, how athletes distribute their energetic resources over a competition to avoid substrate depletion or metabolite accumulation, assuring that the balance of the training stress and adaptations remains favourable. It appears that they must also perform a certain level of pacing over long periods of training (Foster et al., 2003, 2004; Lucía et al., 2003). Training in Zone 1 consumes about equal amounts of carbohydrates and fat (50 versus 50%), Zone 2 places greater demands on carbohydrates than fat (approximately 75 versus 25%), and Zone 3 almost entirely relies on carbohydrates (T. L. Stöggl, 2018). Thus, in polarized TID the athlete can train longer and spend more time in Zone 3 with about the same total energy needed but substantially lower depletion of carbohydrates when compared with a TID with a lot of Zone 2 training (e.g., the Threshold TID) (T. L. Stöggl, 2018). Another explanation is that the steady switch between Z1 and Z3 keeps the athletes from getting bored while the intense training in Z3 does less damage to the athletes' bodies when there is some variation in the intensity (T. L. Stöggl, 2018).

In addition, "training like a cave-man" is another theory referring to the polarized training, which looks back at how our ancestors lived. They either performed Z1 activities (like walking from one place to another to find water or areas with more food) or they needed to perform Z3 activities when hunting or being hunted (fight or flight) (Boullosa, Abreu, Varela-Sanz, et al., 2013; Lieberman & Bramble, 2004). Therefore, there was no need for them to spend a lot of time in Z2 (Cordain et al., 1998).

Previous research suggests a pattern across the training season, from a focus on HVLIT during the preparation phase, towards a pyramidal TID during the pre-competition period, and a polarized TID during the competition phase (T. Stöggl & Sperlich, 2014; Thomas L. Stöggl & Sperlich, 2015; Thomas Leonhard Stöggl, 2018; Casado et al., 2022; Haugen et al., 2022). Endurance runners were shown to improve performance when switching from pyramidal into polarized after 8 weeks of periodization, compared to the other forms of periodization (pyramidal, polarized and polarized followed by pyramidal) (Filipas et al., 2021). However, this pattern was not found in this team of young elite kayakers athletes, holding HVLIT TID 6 and 3 weeks before the international competition (European Canoeing Championships Junior & U23).

There are still several unanswered questions, as well as the long-term effects of some TIDs (like inverse polarized or HIT) on elite endurance athletes are still not understood. The choice of the TID also depends on the amount of time that is available for the athlete to train. In cases of limited available time, the choice of a polarized TID with a large training volume might not be possible and a more HIT-oriented training might work better for the athlete.

New approaches must be considered to compare different training intensity distributions and performance in young elite kayakers and canoeists sprint athletes, in order to understand which is best for different distances, different sexes and different boat types.

3.4.1 Limitations

This investigation had as strengths the close follow-up of the athletes throughout the intervention, as all training sessions were followed in person. In addition, the monitoring of training camps so close to the competition is extremely important and not always allowed by coaches and organizations, to avoid disturbances during the preparation of the ECC. On the other hand, as limitations, we point out having monitored only 2 training camps (weeks) in a specific period of the season, as well as not having monitored the TID performed at home by the athletes, for logistical reasons.

3.5 Conclusion

In conclusion, young elite-level kayakers showed higher training load (TRIMPs and sRPE) in two training camps that were designed to select athletes and training them to compete in European Canoeing Championships Junior & U23, in comparison with other training camps.

We found a positive correlation and association between TRIMP and sRPE. We recommend the relationships between the external load of distance, the speed, the sRPE load and TRIMP to be examined as a practical monitoring tool for Sprint Kayak athletes. Coaches could use sRPE as a non expensive and easy monitoring tool to assess the young elite-level kayakers training load.

Furthermore, the young elite kayak athletes showed a training intensity distribution pattern of high volume low-intensity training. Coaches can consider training programs with the use of the polarized training logic "U", observing the stimulus nature and the time required for recovery. Training sessions at lower intensities may be interesting to improve technique together with physical fitness development.

This chapter broadens the knowledge of young elite kayakers athletes and may be useful in planning future training programmes for important competitions of the season. Nonetheless, further studies regarding the long-term sustainability of this distribution method are required.

Chapter IV

Heart rate variability and stress-recovery responses during a training camp in elite young canoeing sprint athletes

4 Heart rate variability and stress-recovery responses during a training camp in elite young canoeing sprint athletes

4.1 Introduction

The purpose in training competitive athletes is to provide training loads that are effective in optimize and improving performance. In some cases, training load can be intensified during training camps (Slattery et al., 2012). Thus, coaches need to control stress and recovery level of athletes in order to avoid nonfunctional overreaching (Coutts, Reaburn, et al., 2007; Meeusen et al., 2013), which can increase the risk of injury and infection without providing a "supercompensation" effect to performance (Aubry et al., 2017). Therefore, development of simple, noninvasive monitoring tools that identify early fatigue accumulation is an important area within sport science. However, there is limited evidence relating to the usefulness of practical monitoring tools to control and refine the training of canoeing athletes, especially in elite youth samples.

Session rating of perceived exertion (sRPE) is a valid method to quantify internal training load in canoe sprinters due to its high correlation with heart rate-based training impulse (Borges et al., 2014). In other sports, sRPE has been shown to be sensitive to changes in external training load when training is intended to induce overreaching and performance decrement (Coutts, Reaburn, et al., 2007; Coutts, Slattery, et al., 2007; Freitas et al., 2014). On the other hand, within optimal ranges, sRPE accumulated during soccer preseasons is positively correlated with changes in intermittent performance tests (e.g., Yo-Yo intermittent recovery) (Campos-Vazquez et al., 2016). However, in young canoe sprinters, the typical training loads undertaken during crucial phases of the preparation (i.e., National Team training camps) leading up to team formation and its effects on stress markers are not documented. These typical values and the associated intersubjective variability need to be better understood to provide references to coaches and sports scientists managing the training of young canoe sprint athletes.

The analysis of stress and recovery states during different preparation phases can be performed using a multilevel approach involving psychometric responses (Steinacker et al., 2000). The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) is a practical and valid psychometric tool for monitoring self-reported responses to training (Coutts & Reaburn, 2008). The psychometric assessment of competitive rowers during intensified training periods suggests the existence of a dose–response relationship between training volume and somatic components of stress and recovery (Coutts & Reaburn, 2008). In soccer, the prolonged accumulation of stress and reduced recovery lead to a decrement in performance in adult players (Faude et al., 2011). The reported perceived imbalance is also related to reduced cardiac vagal activity in judo athletes during exposure to high training loads (Morales et al., 2014). The RESTQ-Sport has not been used in young canoe athletes, so its sensitivity to the sport-specific loading schemes has not been investigated. Also, female basketball players present lower recovery levels in some items of RESTQ-Sport than males (Di Fronso et al., 2013). However, differences between sexes in individual sports are under-reported (Leite et al., 2013; Lopes, 2015).

Resting heart rate variability (HRV) has become one of the most widely used objective monitoring tools among athletes (Plews et al., 2013). It is accepted that subtle changes in HRV (i.e., substantial increase or decrease coupled with negative changes in perceptual variables) could be a sign of excessive overload, which can impair performance and training adaptation (Faude et al., 2011; Flatt & Esco, 2015). For these purposes, the natural logarithm of the mean square difference of the successive R-Wave time instants intervals (RR)(lnRMSSD) is considered the preferred HRV metric for tracking maladaptation and performance impairment (Plews et al., 2013). For this, at least three weekly data points should be recorded for reliable indication of a microcycle's "average" vagal activity (Plews et al., 2014). On the other hand, the coefficient of variation of lnRMSSD (lnRMSSDCV) can be also calculated weekly to reflect the day-to-day variations in cardiac parasympathetic activity, providing valuable information concerning the training-induced perturbation of homeostasis (Buchheit, 2014). Athletes with lower lnRMSSDCV are more aerobically fit and seem to cope better with a given level of training load by reporting reduced perceived fatigue (Boullosa, Abreu, Nakamura, et al., 2013). However, it remains to be investigated whether lnRMSSD and lnRMSSDCV are useful markers to monitor young canoe sprinters of both sexes during training camps.

Because the lack of information regarding elite youth canoeists, the two main aims of this study were: first, we sought to identify possible sex differences in perceived training load, recovery and stress balance, and cardiac autonomic responses in elite young canoe sprint athletes during a 10-day training camp. Second, we wanted to determine whether loading pattern during the training camp can be identified in this sample of athletes based on the perceptual and HRV responses.

4.2 Materials and Methods

4.2.1 Study design

During the competitive phase a 10-day training camp was scheduled. This planned period was critical because the National Team was selected to prepare for the Olympic Hopes, based on the achievement of predefined times in different race distances. The observation period ended 23 days before the start of the competition. Hence, the study period comprised regular training without deliberate intensification to induce functional overreaching and tapering was undertaken after the study, beginning approximately 15 days before the Olympic Hopes. In this competition, the Portuguese National Canoeing Team participated in 13 finals and won three silver medals. On the first visit to the laboratory athletes accomplished the anthropometric measurements with experienced researcher, and all procedures related to the experimemtal data collection was explained.

4.2.2 Participants

Twenty-one elite young athletes (11 males age: 16.21 ± 0.62 years; height: 173.3 ± 5.4 cm; body mass: 68.5 ± 5.0 kg, and 10 females; age: 16.01 ± 0.76 years; height: 166.0 ± 6.1 cm; body mass: 61.1 ± 7.4 kg) from the Portuguese National Canoeing Team (canoe sprint) took part in this study. All the athletes had at least 4 years of experience in competitive canoeing. After receiving the detailed explanation of the purposes and procedures of the study, the legal guardians and the athletes provided their written informed consent. The local Ethics Committee of the Faculty of Sports Science and Physical Education, University of Coimbra (CE/FCDEF-UC/00292019) approved the procedures.

4.2.3 Anthropometric assessment

The anthropometric assessments were done before the GXT. Body mass was measured using a calibrated scale (Seca 770, Hamburgo, Germany) and stature and sitting height were measured using a standard stadiometer (Harpenden 98.607, Holtain, UK).

4.2.4 HRV Monitoring

The RR-interval recordings were obtained in a comfortable back straight-seated position, with open eyes and spontaneous breathing. A portable heart rate monitor (Polar Team2, Polar, Kempele Finland) was used to record RR-intervals for 2 min continuously. The first minute was discarded (stabilization period), while the second 1 min period was used to calculate lnRMSSD (Esco & Flatt, 2014), through Kubios HRV Standard 3.0.0 software (Kubios, Kuopio, Finland). This ultrashort-term HRV determination is considered valid (Pereira et al., 2016) and reliable (Nakamura et al., 2017) in sports settings. The time and the place of data collection were always the same, and athletes were asked to consume a similar breakfast and avoid stimulants (coffee, tea, and alcohol) during the study duration. This procedure was repeated every morning during the 10-day observation period, between breakfast and 30 min before the first training session of the day. The mean lnRMSSD value for each 5-day period was recorded (lnRMSSDM). Additionally, we calculated the lnRMSSDcv by the following equation; lnRMSSDcv=(SD/lnRMSSDM)*100, where lnRMSSDM corresponds to the mean value of the period during which CV was calculated (5 days).

4.2.5 Training Load

For quantification of session training load (TL), we used the session rating of perceived exertion (sRPE). This procedure consisted of asking to the athletes to rate their level of perceived exertion using the CR100 (Borg & Kaijser, 2006) scale 15–30 min postexercise. This perceptual value was multiplied by the session duration in minutes (Oliveira Borges et al., 2014). The sRPE results were divided by 10 to allow for comparison with previous studies that used the CR10 scale (Impellizzeri et al., 2004; Rabelo et al., 2016; Wallace et al., 2009). The 10-day training camp was separated into two 5-day periods (P1 and P2) to better analyse the dynamic of training and adaption throughout the overall period.

4.2.6 Recovery-Stress Questionnaire-52

The RESTQ-52 (Kellmann, 2010) was administered on the 1st (M1), 5th (M2), and 10th (M3) day of the training camp. It was fully explained before the assessment and every doubt clarified was clarified by one the researchers. The RESTQ-52 is a modified version of the RESTQ-76, with easier application due to the lower number of questions and has been reported as an appropriate tool to assess the perceived state of recovery and stress in athletes. The questionnaire had 52 questions with Likert-scale responses anchored from 0 (never) to 6 (always) for the athlete to indicate how often she/he participated in various activities during the past 3 days and nights. The questionnaire has 12 scales that assess various stressing agents (general stress and general recovery activities) and recovery agents and 7 additional sports-specific scales, with 4 questions per scale. The scores of the stress-related scales were added and divided by the number of scales to obtain a total stress score. The same procedure was used for the recovery-oriented scales, resulting in a total recovery score. This questionnaire has been widely used in previous studies (Rollo et al., 2014). The Portuguese version of this questionnaire was previously validade by (Leite et al., 2013; Lopes, 2015)

4.2.7 Statistical Analyses

The data are presented as mean ± standard deviation (SD) and 90% confidence limits (CL). A specific spreadsheet (xPostOnlyCrossover.xls) was used to compare (within-sex) the sRPE, lnRMSSDM, lnRMSSDCV, and RESTQ-52 in the different moments. The sRPE, lnRMSSDM, lnRMSSDCV, and RESTQ-52 were also analysed between sexes using another spreadsheet (xCompare2groups.xls). The third spreadsheet (xParallelGroupsTrial.xls) was used to determine the standardized differences of changes in means between-group in all variables and across the moments. The standardized differences (i.e., effect sizes or ES (Cohen, 1988)) were rated using thresholds described by Hopkins et al. (Hopkins et al., 2009): 0–0.2 was trivial, 0.2–0.6 was small, 0.6–1.2 was moderate, 1.2–2.0 was large, >2.0 was very large. The effect was deemed unclear when the CL crossed the threshold for both substantially positive (0.2) and negative (−0.2) values (Batterham & Hopkins, 2006). The quantitative changes for the aforementioned comparisons were qualitatively rated as follows; <1%, almost certainly not; 1% to 5%, very unlikely; 5% to 25%, unlikely; 25% to 75%, possible; 75% to 95%, likely; 95% to 99%, very likely; >99%, almost certain (Hopkins et al., 2009). If the change of higher or lower differences was >5%, then the true difference was assessed as unclear (Batterham & Hopkins, 2006). The RMSSD were first log-transformed (natural logarithm) to reduce bias arising from nonuniformity error.

4.3 Results

The ten days workout routine and training loads of both males and females are presented in Table 5. The ten days had the same pattern in all training sessions, warm-up, main part and cool-down. During this period, competition distances (1000 meters (m), 500 m and 200 m) and strength training (resistance and power) were prioritized, also training the general component (running).

Table 5: General description of training content (tasks) and daily training load (in arbitrary units; mean ± SD) during each of the Period 1 and Period 2 (P1 and P2), males and females athletes.

P1			
Day 1			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 10 km - SR 70-75 sRPE - 2450 ± 1227	on-water Tasks - 10 km - SR 70-75 sRPE - 1893 ± 868	strength Tasks - 6 Exercises, 5 sets, 8 reps with 80%, rest 2' sRPE - 5844 ± 1570	strength Tasks - 6 Exercises, 4 sets, 8 reps with 80%, rest 2' sRPE - 4959 ± 1204
Day 2			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - (5*1'/2') SR 95-100 + (5*45''/2') SR 105 sRPE - 6298 ± 668	on-water Tasks - (5*45''/2') SR 95-100 + (5*30''/2') SR 105 sRPE - 4744 ± 1432	run Tasks - 40 minutes sRPE - 3015 ± 386	run Tasks - 40 minutes sRPE - 2680 ± 569
Day 3			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 5*2'/3' SR 85 sRPE - 3996 ± 1489	on-water Tasks - 4*2'/3' SR 85 sRPE - 3129 ± 1360	strength Tasks - 5 Exercises, 3 sets, 8 reps with 75%, rest 2' sRPE - 1811 ± 774	strength Tasks - 5 Exercises, 3 sets, 8 reps with 75%, rest 2' sRPE - 1560 ± 746
Day 4			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 8 km SR 55-60 sRPE - 1175 ± 676	on-water Tasks - 8 km SR 55-60 sRPE - 1012 ± 719	rest	rest
Day 5			
Male morning	Female morning	Male afternoon	Female afternoon

on-water Tasks - 1*500 m 100% + 8 km SR 55-60 sRPE - 5089 ± 1918	on-water Tasks - 1*500 m 100% + 8 km SR 55-60 sRPE - 6417 ± 705	strength Tasks - 4*(10 exercises, 20 rep, with 40%, rest 20'')/3' sRPE - 3019 ± 656	strength Tasks - 3*(10 exercises, 20 rep, with 40%, rest 20'')/3' sRPE - 3033 ± 613
P2			
Day 6			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 2*1000 m SR 90 + 2*750 m SR 105 + 3*100 m SR 110 + 2*200 m SR 130 sRPE - 5425 ± 853	on-water Tasks - 2*500 m SR 95 + 2*350 m SR 110+ 3*100 m SR 110 + 2*200 m SR 130 sRPE - 4832 ± 1124	on-water Tasks - 6 km SR 60 sRPE - 1916 ± 628	on-water Tasks - 6 km SR 60 sRPE - 1900 ± 699
Day 7			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 8 km SR 65 + 5*10''/1' sRPE - 1707 ± 709	on-water Tasks - 8 km SR 65 + 5*10''/1' sRPE - 1644 ± 589	rest	rest
Day 8			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 3* 100 m/6' SR maximum + 3*200 m /6' SR 120 sRPE - 4930 ± 999	on-water Tasks - 3* 100 m/6' SR maximum + 3*200 m /6' SR 120 sRPE - 4110 ± 1133	strength Tasks - 5 Exercises, 5 sets, 8 reps with 80%, rest 2' + run 30' sRPE - 8302 ± 1832	strength Tasks - 5 Exercises, 5 sets, 8 reps with 80%, rest 2' + run 30' sRPE - 7728 ± 2394
Day 9			
Male morning	Female morning	Male afternoon	Female afternoon
on-water Tasks - 3*1000 m/ 6' SR 90 + 3*750 m/6' SR 110 sRPE - 6245 ± 415	on-water Tasks - 3*500 m/ 6' SR 95 + 3*350 m/6' SR 115 sRPE - 4275 ± 1281	on-water Tasks - 6 km SR 60 sRPE - 862 ± 567	on-water Tasks - 6 km SR 60 sRPE - 1280 ± 451
Day 10			
Male morning	Female morning	Male afternoon	Female afternoon

on-water Tasks - 3*(30''+45''+1'+1'30''+1'+45''+30'')/1'30'' SR110-100-90-80-90-100-110 sRPE - 5104 ± 1008	on-water Tasks - 3*(15''+30''+45''+1'+45''+30''+15'')/1'30'' SR120-110-100-90-100-110-120 sRPE - 3825 ± 921	rest	rest

Repetitions – reps, Stroke Rate (SR) (strokes per minute), Meters (m)

Table 6 displays the sRPE and heart rate variability variables ($lnRMSSD_M$ and $lnRMSSD_{CV}$) in male and female kayakers across the training periods (P1 and P2). When comparing sexes, sRPE tented to be higher in males than in females over the observed training period, with *possibly small* difference in P2. The within-group analyses revealed that in female athletes the sRPE, $lnRMSSD_M$ and $lnRMSSD_{CV}$ did not change between P1 and P2. In male athletes the $lnRMSSD_M$ showed a *likely small* reduction from P1 to P2.

Table 6: Session rating of perceived exertion (sRPE) and heart rate variability variables (lnRMSSDM and lnRMSSDCV) in male and female kayakers across two training periods (P1 and P2)

				Differences		
	Variable	P1	P2	Standardized (90% CL)	Chances	Qa
Male	sRPE	3024 ± 543	2982 ± 473*	-0.07	0.5/91.4/8.1 %	Likely trivial
	$lnRMSSD_M$	3.46 ± 0.52	3.28 ± 0.46	-0.32	0.6/25/74.4 %	Likely negative
	$lnRMSSD_{CV}$	10.53 ± 4.34	8.71 ± 6.38	-0.39	29.4/64.9/5.7 %	Unclear
Female	sRPE	2753 ± 493	2740 ± 499	-0.02	0.2/98.9/0.9 %	Very likey trivial
	$lnRMSSD_M$	3.38 ± 0.27	3.42 ± 0.23	0.12	38.3/49/12.7 %	Unclear
	$lnRMSSD_{CV}$	10.29 ± 3.46	9.75 ± 6.34	-0.14	29.1/24.7/46.2 %	Unclear

* Meaningful difference between sexes in P2 (Male > Female) (ES -0.23), Qa possibly negative

Figure 5 displays the RESTQ-52 scores of the total stress, total recovery male and female in the 3 time points (M1, M2 and M3). Regarding the responses to RESTQ-52 Sport, in males total stress *most likely* increased with *large* and *very large* differences between M1 and M2, and between M1 and M3, respectively. Total recovery increased across the 3 moments (*possibly and likely small* effects). In females, total stress *most likely* increased from M1 to both M2 and M3, with *moderate* effect. Similar to males, females increased total recovery across the 3 moments (*possibly* and *likely small* effects). Between sexes, total stress was *likely* higher (*small* effect) in males than in females in M3.

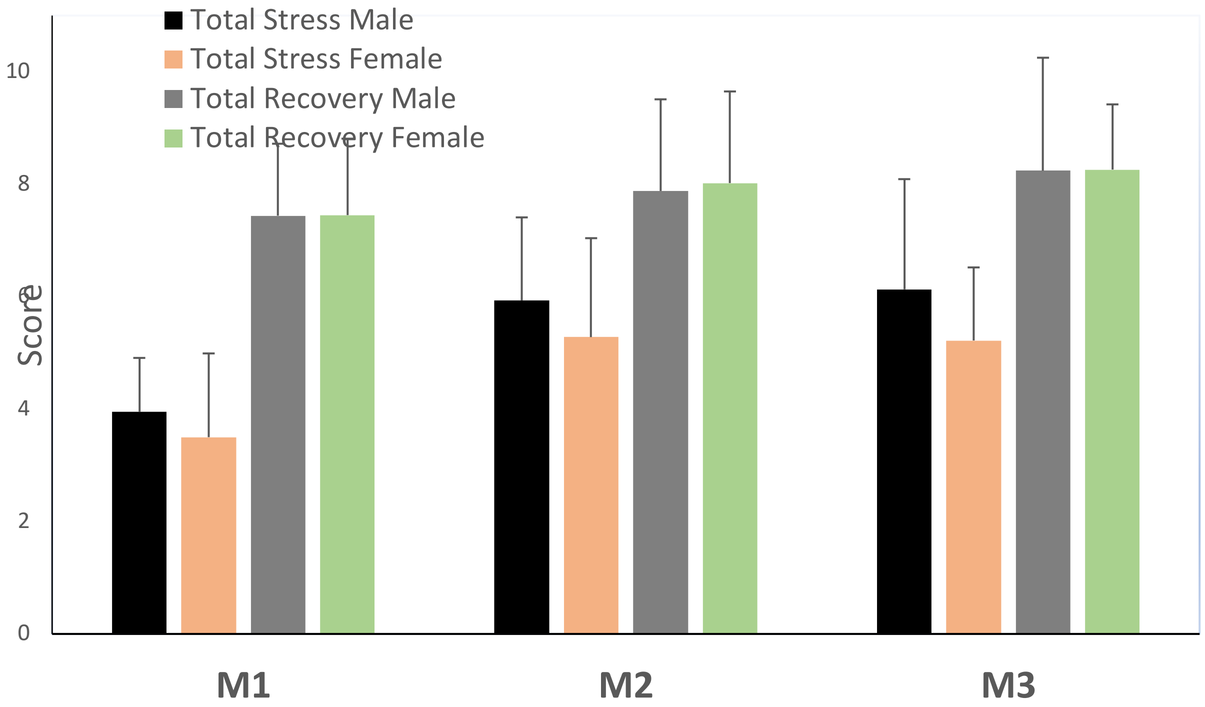

Figure 5: RESTQ-52, values total stress, total recovery male and female.

4.4 Discussion

This study was primarily designed to identify possible sex-differences in training loads, recovery and stress balance and cardiac autonomic responses in elite young canoe sprint athletes. Secondly, the study sought to determine whether loading pattern during training camps can be identified based on perceptual and HRV responses. There were several noteworthy findings. First, young elite-level canoeists appear to accumulate between 2740 to 3024 au within 5 days of a training camp that is designed to select athletes for the National Team. Second, compared to the female athletes, the male athletes undertake higher training loads and display greater levels of total perceived stress at the end of the 10-day training camp. Third, the male athletes demonstrated a decrement in $lnRMSSD_M$ at P2 compared to P1, while the female athletes showed no change in HRV between the two periods.

Responses in HRV appear to be linked to changes in external training load and training-related stress in several studies. For instance, Flatt and Esco (A. A. Flatt & Esco, 2015) suggested that $lnRMSSD_{CV}$ may be a suitable marker for reflecting the acute adjustment of weekly training load in female team-sport athletes. In addition, Le Meur et al. (Le Meur et al., 2013) found small weekly mean changes in the lnRMSSD (ES = 0.40) after overload training that resulted in functional overreaching in elite endurance athletes. Moreover, overload training was associated with a reduction in $lnRMSSD_M$ along with an increase in $lnRMSSD_{CV}$, concurrent with decrements in perceived fatigue and muscle soreness in Division-1 collegiate sprint-swimmers preceding competition, and were reversed with tapering (Flatt et al., 2016). The non-significant difference in $lnRMSSD_{CV}$ between P1 and P2 that was reported in the current study may be due to a training stimulus that lacked the daily fluctuation in training load (e.g., training peaks) that was enough to perturb homeostasis.

The male athletes displayed no meaningful change in training loads between P1 and P2, though they showed higher training loads than the female athletes (*possibly small* difference in P2). This difference could be attributed to the higher external training loads performed by males compared to females. Though $lnRMSSD_{CV}$ has been suggested as a marker of gauge the challenges to homeostasis that come with training (Flatt et al., 2016), this variable was not different between sexes. This suggests that the higher external training load in male athletes was not great enough to cause more variation of the cardiac vagal system. However, the male athletes presented a *likely negative* change in $lnRMSSD_M$

between P1 and P2. This is possibly a reflection of males accumulating a greater external training load, on average, over the entire duration of the training camp than the female athletes. Of note, the $lnRMSSD_M$ difference between P1 and P2 was greater (5.2%) than the smallest worthwhile change (3%) set in the literature for males (Buchheit, 2014). Accordingly, this temporal difference was also present in the RESTQ-52 at M3, where the males presented *likely* higher total stress than females. Hence, it appears that mean cardiac autonomic response and perceived stress responses are coherently linked in this study, as previously shown in female soccer players (Flatt & Esco, 2015).

In contrast, similar findings were not found in the current group of female athletes. In fact, no changes in either $lnRMSSD_M$ or $lnRMSSD_{CV}$ between P1 and P2 in the female athletes were found. However, this finding is supported by previous research involving female soccer players (Flatt et al., 2017). Weekly $lnRMSSD_M$ and $lnRMSSD_{CV}$ presented a dose-response relationship with training load as assessed by sRPE. The weeks with higher training loads resulted in lower $lnRMSSD_M$ and higher $lnRMSSD_{CV}$, respectively, than the weeks with lower training loads (Flatt et al., 2016, 2017). Hence, upon unchanged training loads between consecutive short-term training periods in the current study, the finding of unchanged cardiac vagal activity was expected. Interestingly, both total stress and total recovery assessed by RESTQ-52 increased from M1 to M2 and M3. This finding suggests that training loads were not excessive during the training camp, since during periods of overload, stress is increased concomitant to decreased recovery (Coutts & Reaburn, 2008; Morales et al., 2014).

There were few limitations of the study that mainly relate to the inability of the researchers to manipulate the 10-day training program or control extraneous cofactors that may influence some of the studied variables. For instance, HRV measurements were taken every morning following the consumption of breakfast and 30 minutes before the first training session. The amount and type of food consumed was not recorded for each individual athlete and may have affected HRV measurements, the athletes were encouraged to maintain a similar breakfast and to avoid stimulants during the 10 days. No females had menstruation during the 10-days. However, this was an observational investigation. Indeed, it was specifically undertaken to monitor the group of athletes during their standard training practices across the 10-day period, without the potential interferences to daily practice that may come with experimental, well-controlled designs. Observational investigations such as the current study are needed to better understand how to collect and interpret HRV in field settings. Moreover, the 10-day observational period was too short for gauging chronic responses and the variables were not obtained during a baseline week of limited training. Therefore, longitudinal investigations are needed to determine if HRV is an adequate measure for objectively tracking chronic changes in recovery status and adaptation in elite youth canoeist and similar athletes. However, the current study provides an important and novel foundation for further research.

4.5 Conclusion

In conclusion, male canoeists undertake higher training loads than female peers during National Team training camps. This difference is regarded to small but meaningful changes in the vagally-mediated HRV, which decreases during the period only in males. Accordingly, total stress assessed by RESTQ-52 is higher at the end of the training camp in males than in females. The monitoring of HRV and stress-recovery balance can help to control the undesired effects of excessive loading or other stressors in the period leading up to important competitions, in both males and females.

Chapter V

Assess of training camps and training at homes for national teams selection and Pre-competition, National Competition and Post-competition on the sleep patterns in young sprint canoe and kayak athletes

5 Assess of training camps and training at homes for national teams selection and Pre-competition, National Competition and Post-competition on the sleep patterns in young sprint canoe and kayak athletes

5.1 Introduction

Young sprint canoe and kayak athletes are exposed to multiple high physiological demands due to training sessions in their trainings at homes, training camps and in the national and international competitions. During training camp periods, athletes have to adapt to new training places. The periods before and after competitions are very critical periods that challenge their sleep patterns.

Sleep is considered the most important factor in daily recovery strategy. In addition, sleep is recognized critical for the well-being and performance of athletes (Fullagar et al., 2015; Walsh et al., 2021). However, despite its importance to psychological and physiological recovery, athletes often sleep less than recommended (Sargent, Lastella, et al., 2014).

A U-shaped association was observed between total sleep time (TST) and health outcomes (optimal health and cognitive function) and the dose–response curves showed that a total sleep time of minimum of 7 hours of sleep (Watson et al., 2015) and around 7–9 h per day was favorably associated with the health outcomes among adults aged 18 to 60-64 years (Ross et al., 2020), and 8–10 hours for teenagers (Watson et al., 2015).Experts speculate that athletes need more sleep to recover from the physical and psychological demands of the sport (Bird, 2013). The amount of sleep needed by athletes tend to increase depending on the training load, the sport and the age of the athlete (Walsh et al., 2021).

Young athletes with a TST of 8–10 hours contains approximately 57% light sleep, 22% deep sleep and 21% REM sleep; adults athletes with a sleep of 7–9 hours contains approximately 61% light sleep, 16% deep sleep and 23% REM sleep (Ohayon et al., 2004). Nonetheless, athletes usually TST for less than 7 hours (Gupta et al., 2017).

Athletes in general show a total sleep time of less than 7 hours (Roberts et al., 2018; Walsh et al., 2021), poor sleep efficiency (Walsh et al., 2021), experiencing sleep dissatisfaction, unrefreshing sleep (Tuomilehto et al., 2017), long sleep onset latency (SOL) (Schaal et al., 2011; Tuomilehto et al., 2017), day-time sleepiness (Swinbourne et al., 2016) and day-time fatigue (Sargent, Lastella, et al., 2014). Studies reporting global sleep efficiency (SE) show that 50%–78% of elite athletes experience sleep disturbance and 22%–26% suffer highly disturbed sleep (Gupta et al., 2017; Swinbourne et al., 2016).

The athletes reported the need of 8.3 hours of sleep to feel rested (self-assessed), but their average total sleep time was 6.7 hours (Sargent et al., 2021). Experts speculate that athletes need more sleep to recover from the physical and psychological demands of the sport (Bird, 2013).

During training camps, the training load can be intensified in some cases (Slattery et al., 2012) and their sleep patterns can change.

In 479 athletes, 52% of elite athletes were categorised as ‘poor sleepers’, with longer SOL and greater daytime dysfunction observed in female athletes compared with male athletes (Halson et al., 2021).

Moreover, team sport athletes reported shorter SOL, longer TST, later waking times and spent significantly more time in bed but reported lower sleep efficiency (SE) than individual sport athletes (Halson et al., 2021; Lastella et al., 2015; Sargent et al., 2021). Sleep length and its variables are unlikely to be the same for all sports (Halson et al., 2021).

Regarding the occurrence of sleeping challenges at different stages of an athletic career, the professional athletes had a higher risk of sleeping problems, especially during the competitive season than younger elite amateur athletes (Penttilä et al., 2021).

Insomnia symptomatology is high among elite athletes, with sleep efficiency appearing most vulnerable prior to major competitive events, during periods of high-intensity training and travel to competitions (Gupta et al., 2017). Athlete sleep disturbances can affect training and competition directly, through fatigue, or indirectly, through sleep-related performance anxieties (Gupta et al., 2017).

Swimmers presented an average total sleep time of 7.1 hours, higher daily training load induced an earlier bedtime and reduced total sleep time and perceived sleep efficiency, with higher sleep fragmentation (Aloulou et al., 2021).

In football players, the time of day that a game occurred has shown to have a marked influence on sleep/wake behaviour later that night, after the evening game, sleep onset was later, time in bed was shorter and total sleep time obtained was less than after the day game

(Sargent & Roach, 2016). Further, most sleep variables were not different on the night preceding the game day when compared with the after-game evening (Sargent & Roach, 2016). The competition night showed that sleep onset occurred later, time in bed was shorter and the TST obtained was less, than the following day (Sargent & Roach, 2016).

On the other hand, the impact of early-morning training revealed that on nights prior to training days, bedtimes and get-up times were earlier, time spent in bed was shorter and the TST obtained was lower, than on nights prior to rest days (Sargent, Halson, et al., 2014). These results indicate that early-morning training sessions severely restrict the TST obtained by elite athletes (Sargent, Halson, et al., 2014), showing the importance of daily training schedules.

For example, athlete sleep is influenced by sport-specific factors (relating to training, travel and competition) and non-sport factors (eg, gender, stress and anxiety). Athlete sleep is influenced by various sport-specific factors and also by societal factors (eg, pervasive use of smart phones and social media in an 'always connected' society) (Gupta et al., 2017; Halson, 2016).

Sport-specific risk factors for sleep inadequacy in athletes have broadly been identified as those pertaining to training, travel and competition (Gupta et al., 2017; Nedelec et al., 2018). More specifically, the risk factors include: high training loads (Hausswirth et al., 2014; Kölling et al., 2016); short-haul and long-haul travel (P. Fowler et al., 2015; P. M. Fowler et al., 2017); the night before competition (Erlacher et al., 2011; Juliff et al., 2015); evening competition (start times after 18:00) (Fullagar et al., 2016; Nédélec et al., 2019) and early morning training (start times before 8:00) (Sargent, Lastella, et al., 2014).

A study of trained cyclists and triathletes, showed a better endurance performance after three consecutive nights of total sleep time extension (~8.4 hours sleep each night) compared with habitual total sleep time (~6.8 hours sleep each night) (Roberts et al., 2019). Studies have shown total sleep time extension improves sport specific skill execution (Schwartz & Jr, 2015), as well as sprint performance (Mah et al., 2011). In addition, due to their habitual mental and physical exertion demands (e.g., double daily training sessions) athletes require more accumulated sleep time. In fact, extended sleep time can lead to better psychomotor performance and technical accuracy (Mah et al., 2011), likely with effects on competitive performance (Kölling et al., 2016). An individualized approach taking into account the athlete's perceived sleep needs has been recommended (Walsh et al., 2021).

The 5-item World Health Organization Well-Being Index (WHO-5) is among the most widely used questionnaires assessing subjective psychological well-being (Topp et al., 2015). The WHO-5 was used in Portuguese youth population (Simões et al., 2018). The WHO-5 Well-being Index is a short, self-administered questionnaire covering 5 positively worded items, related to positive mood (good spirits, relaxation), vitality (being active and waking up fresh and rested), and general interests (being interested in things) (Topp et al., 2015). Administering the WHO-5 Well-being Index takes 2-3 minutes.

The most advanced method for the sleep assessment in terms of accuracy is the polysomnogram (PSG), provides the most accurate and complete information about sleep, even allowing us to precisely identify the sleep stages (Pandi-Perumal et al., 2014; Robertson et al., 2014; Roomkham et al., 2018). However, it is expensive, requiring special hardware and medical assistance making it impractical for monitoring athletes in the field (Ibáñez et al., 2018), which is not very recommended for elite athletes who are training for an international competition.

On the other hand, the actigraphy was considered a valid methodology instrument in a wide variety of research settings both in children and adults (Crouter et al., 2006; Quante et al., 2015, 2018; Roomkham et al., 2018). The ActiGraph accelerometer allows to study athletes in the the same environment wherethe training and competition constexts are (J. A. Costa, Brito, Nakamura, Oliveira, et al., 2019; Fullagar et al., 2015; Halson et al., 2021; Lastella et al., 2021; M. Ohayon et al., 2017; Walsh et al., 2021).

To overcome some of these challenges, Tudor-Locke et al (2014) developed a fully automated waist-worn accelerometer algorithm for detecting children's sleep period time separate from 24-hour PA or SB. This algorithm combines the Sadeh sleep algorithm and inclinometer results to classify each epoch as sleep or awake (Tudor-Locke et al., 2014). Although some studies have reported SE ≤85% as insufficient sleep quality (Roberts et al., 2018), however according to the latest National Sleep Foundation report (M. Ohayon et al., 2017), SE ranging from 75–84% is considered uncertain for young adults/adults, whereas SE ≤74% indicates inappropriate sleep quality for the respective age category.

Other instruments as questionnaires and sleep diaries are also validated to the monitoring of sleep paterns. They are cheap, can be administered at home for long periods of time, and contain useful complementary information (eg, daily activities) (Ibáñez et al., 2018).

The Pittsburgh Sleep Quality Index (PSQI) is used to measure the quality and patterns of sleep in adults (Buysse et al., 1989). It differentiates ‘poor’ from ‘good’ sleep quality by measuring seven areas: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction over the last month (Buysse et al., 1989). Libman and collaborators illustrate the need to tailor measurement modality, retrospective or daily to the setting and the purpose of the evaluation (Libman et al., 2000). Sleep diaries are typically used in addition to objective measures (ie, PSG or actigraphy) (Carney et al., 2012). The PSQI should be administered at regular intervals due to the variability within individuals, may be useful for practitioners in guiding decision-making regarding sleep interventions in athletes (Halson et al., 2021).

Sleep diaries (SpD) are typically retrospective self-report measurements in which patients and participants record their sleep patterns and answer other questions related to their sleep on a daily basis (Dietch et al., 2019). The SLD capture night-to-night variability in sleep (ie, separately for weekdays/ weekends) demonstrated good psychometric properties, furthermore, when prospective sleep diaries are not feasible, the SLD are acceptable substitutes to retrospectively estimate sleep parameters (Bei et al., 2016; Dietch et al., 2019).

The Pittsburgh Sleep Diary (PghSD) was shown to have sensitivity in detecting differences due to weekends, age, gender and personality, and validity in agreeing with actigraph estimates of total sleep time and efficiency (Carney et al., 2012).

Incorporation of data from additional diary entries may further refine the ability to distinguish and quantify total sleep time and physical activity (Quante et al., 2015). Several studies have recommended accelerometery monitoring to be accompanied by use of self-completed activity and sleep diaries to record information about daily routines, specific activities, bedtimes, and nonwear time of accelerometers and, thus, provide the option for editing of unusual activities, naps, sleeping times, or times subjects removed the accelerometer to improve data management (Meester et al., 2011).

To our knowleged there is a complete lack of studies using simultaneously the ActiGraphy and questionary Pittsburgh Sleep Quality Index together with the daily Pittsburgh Sleep Diary, in elite young canoe and kayak athletes.

The objectives of this chapter were:

1. Analyse elite women and men young canoe and kayak athletes sleep patterns on national training camp and training home;

2. Analyse elite women and men young canoe and kayak athletes sleep patterns in two national training camps delay 1 month; to prepare an international competition (European Canoeing Championships Junior & U23).
3. Analyse elite women and men young canoe and kayak athletes sleep patterns Pre-competition, National Competition and Post-competition.

5.2 Materials and Methods

5.2.1 Participants

Fifteen elite young athletes (6 females; age: 17.4 ± 0.4 years; training experience: 8.3 ± 1.5 years; height: 164.3 ± 3.0 cm; body mass: 61.3 ± 6.4 kg; fat %: 21.2 ± 5.7 %. 9 males; age: 17.3 ± 0.8 years; training experience: 6.6 ± 0.9 years; height: 173.4 ± 4.1 cm; body mass: 73.1 ± 6.0 kg; fat %: 11.2 ± 3.1 %.) from the Portuguese National Canoeing Team (canoe sprint) took part in this study. All the athletes had at least 5 years of experience in competitive canoeing. The local Ethics Committee previously approved the investigation. After receiving the detailed explanation of the purposes and procedures of the study, the legal guardians and the athletes provided their written consent. The athletes visited the laboratory one time during which they accomplished the anthropometric measurements with experienced researcher. The local Ethics Committee of the Faculty of Sports Science and Physical Education, University of Coimbra (CE/FCDEF-UC/00292019) approved the procedures.

Tabela 7: Participants characterization, descriptive statistics (mean ± standard deviation).

	Women n=6		
	Min	Max	Mean ± SD
CA (yrs)	16.8	17.8	17.4 ± 0.4
TE (yrs)	6.0	10.0	8.3 ± 1.5
Stature (cm)	160.3	167.2	164.3 ± 3.0
BM (Kg)	50.6	69.6	61.3 ±6.4
Fat %	13.3	27.7	21.2 ± 5.7
	Men n=9		
	Min	Max	Mean ± SD
CA (yrs)	16.5	18.3	17.3 ± 0.8
TE (yrs)	5.0	8.0	6.6 ± 0.9
Stature (cm)	167.2	179.2	173.4 ± 4.1
BM (Kg)	64.6	79.0	73.1 ± 6.0
Fat %	6.8	15.1	11.2 ± 3.1

note: CA chronological age; BM body mass; TE training experience; yrs years.

5.2.2 Experimental Design

All participants asked to abstain from intense physical exertion and only a light intensity workout 24 h before beginning the training camp.

The anthropometric and body composition assessments were done on the first day of training camp. Body mass was measured using a calibrated scale (Seca 770, Hamburgo, Germany) and stature and sitting height were measured using a standard stadiometer (Harpenden 98.607, Holtain, UK). Body composition was assessed through multi-frequency bioelectrical impedance analyzer (InBody770; Biospace, Seoul, Korea). The sleeping habits of the athletes were not constrained by the study procedures, granting higher ecological validity to the research. During each training session, training load were assessed through sRPE. Well-being was assessed before each night-sleep.

They became familiar with the accelerometer device habituation period, during the 2 weeks prior to the first study, to avoid that training activities or sleep pattern could be disturbed by the equipment use. In the three studies, athletes used the accelerometer on the wrist to measure the sleep periods patterns. This study is observational. The caffeine consumption was allowed because the researcher did not want to interfere. The athletes were not free to consume caffeine during the data collection period.

The athletes were exposed three different sport preparation and competition contexts, namely, Training at Camp, Training at Home and pre and post Competition. The collection occurred in three different moments (training camp vs training home; training camp 1 vs training camp 2; pre and post competition).

Training camp and training at home

The athletes were monitored daily over two weeks. We colleted data related the athletes sleep patterns at training camp vs training at home with the routines in their homes. The training camp was held at high-performance center (HPC) with 2000 meters length, 135 meters width and 3,5 meters depth, the course has a cooling down and a warming up channel, a cycle path, and a technical area to support the training. The structure includes hangars, showers, bathrooms, sauna, Turkish bath, jacuzzi, gymnasium and polyvalent rooms. At training camp, the athletes took their meals, slept and spent most of their leisure time in two training residences, being free to stroll in the village. A small residence with one kitchen, one living room, two bathrooms and three bedrooms for four people. A big residence with one canteen, where all meals (breakfast, snacks, lunches and dinners) were held, three bathrooms, one study room, one games room, two living room with TV, one garden, one laundry, ten double rooms, two single rooms and one room for four people. At the training camp, two to four athletes slept by room. Girls and boys were accommodated in separate buildings at random. Bedtimes could be chosen freely, but the athletes were obligated to stay at their rooms at 22:30h and to keep night-time silent at 23:00h. Both residences are located in a village, with 3100 inhabitants in the central region of Portugal.

The training at home, the athletes trained on their clubs with natural water plans - rivers, lakes, and reservoirs. They slept in their homes, ate meals and leisure activities freely with the usual conditions they were familiar. During their stay in their homes, the athletes had no indication of bedtime or waking hours, leaving the athletes in their normal state of familiar behaviour. Ten of the athletes lived in the northern, three in the central and two in the southern regions of the country.

In this study he first week corresponds to the training camp at the HPC and the second week a training home on their own clubs. The canoeists completed the training programs prescribed by national coaches in training camp and the training clubs by their coaches. On average, they trained seven days/week, nine sessions water, three sessions strength and conditioning, and three sessions run per week.

The meteorological values during the training camp were: maximum air temperature at 1.5m (21.5 ± 3.5°C), minimum air temperature at 1.5m (13.0 ± 0.7°C), maximum relative humidity (98.1 ± 2.7%), minimum relative humidity (59.9 ± 16.9%), average wind intensity (1.8 ± 0.4m/s). Training at home had the following meteorological values of maximum air temperature at 1.5m (18.3 ± 1.1°C), minimum air temperature at 1.5m (12.1 ± 1.1°C), maximum relative humidity (99 ± 1.4%), minimum relative humidity (65.6 ± 5.4%), average wind intensity (2.1 ± 0.5m/s) values according by Portuguese Institute for Sea and Atmosphere (IPMA).

Training camp 1 and training camp 2

In the second study, we analyse the athletes sleep patterns in two different training camps, with one-month delay. The participants were monitored daily over two weeks with an interval of 2 weeks. Both camps were held at the same HPC with the same conditions.. The canoeists completed the training programs prescribed by the national coaches. On average, they trained seven days/week, nine sessions water, three sessions strength and conditioning, and three sessions run per week. These two training camps were part of the preparation to the european championship.

In the two weeks, athletes used the accelerometer device on the wrist to access the sleep periods.

Training camp 1 had the following meteorological values of maximum air temperature at 1.5m (21.5 ± 3.5°C), minimum air temperature at 1.5m (13.0 ± 0.7°C), maximum relative humidity (98.1 ± 2.7%), minimum relative humidity (59.9 ± 16.9%), average wind intensity (1.8 ± 0.4m/s).

Training camp 2 had the following meteorological values of maximum air temperature at 1.5m (23.2 ± 3.2°C), minimum air temperature at 1.5m (13.7 ± 0.3°C), maximum relative humidity (99.3 ± 1.5%), minimum relative humidity (60.8 ± 6.9%), average wind intensity (2.4 ± 0.3m/s) values according by IPMA.

Pre, Competition and Post phase

Considering the competition study, the five days before the competition and the three days after the competition, the athletes faced the environment described in their homes. The canoeists completed the training programs prescribed by their coaches in the five days before competition and in the three days after competition. The competition was performed in HPC facilities with the characteristics described above. Athletes on competition days slept on their own in an unconditioned way, staying in hotels or rented houses during this period. On average (8 days - 5 days before and 3 days after), they trained the eight days, seven sessions water, two sessions strength and conditioning and one session run per week.

Over all the period of ten days (pré, competition and after competition) , athletes used the accelerometer to access the sleep periods, including two days of competition. Ambient temperature normally ranged between 18–26°C.

Pre and competition phase had the following meteorological values of maximum air temperature at 1.5m (25.8 ± 1.2°C), minimum air temperature at 1.5m (16.9 ± 0.7°C), and average wind intensity (1.8 ± 0.4m/s).

Post competition phase 2 had the following meteorological values of maximum air temperature at 1.5m (25.3 ± 2.0°C), minimum air temperature at 1.5m (15.9 ± 0.7°C), and average wind intensity (2.3 ± 0.3m/s) values according by IPMA.

5.2.3 Experimental Design

The experimental design was as followed in figure 6.

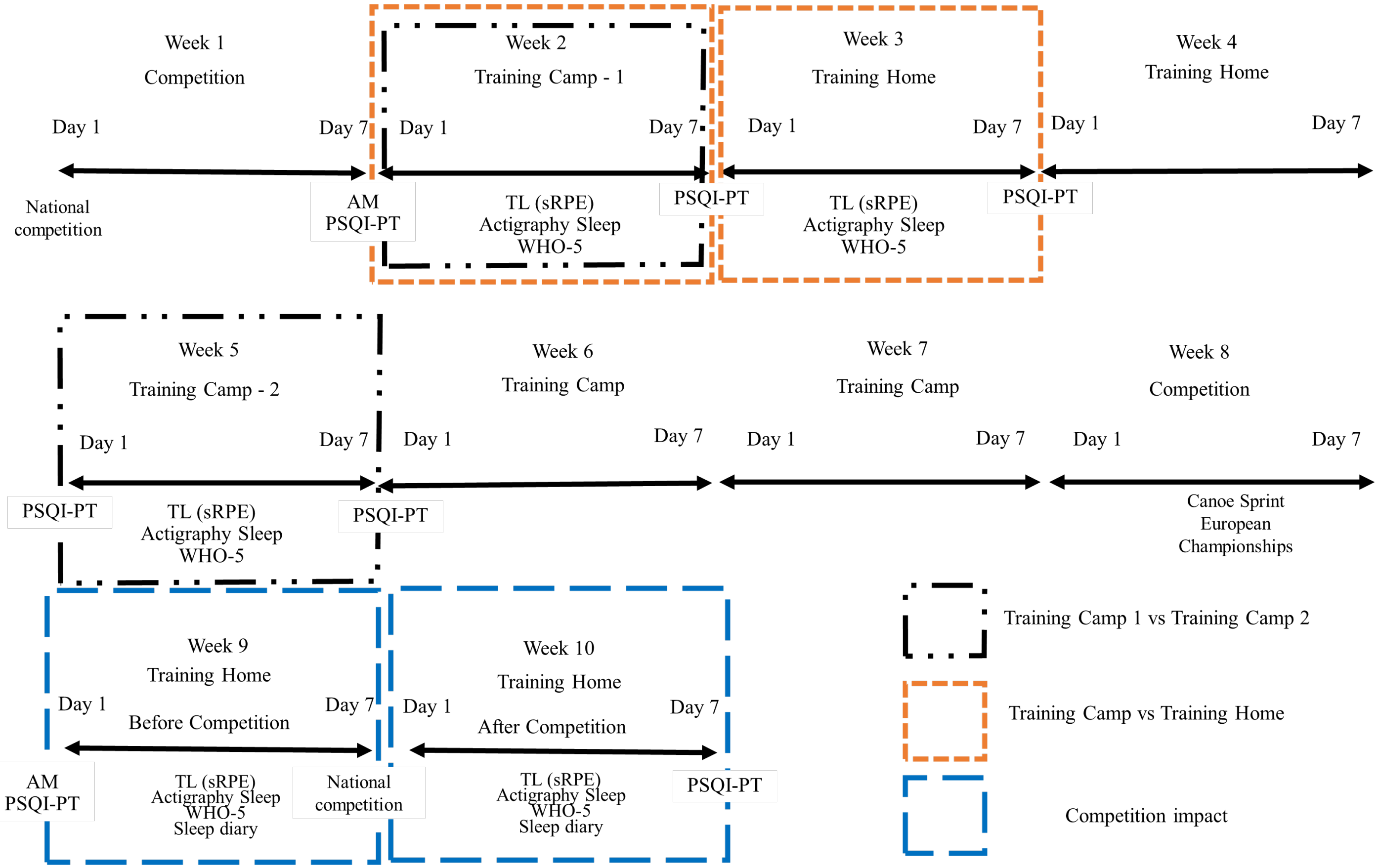

Figure 6: Experimental design

Note: TL training load; PA physical activity; WHO-5 World Health Organization Well-Being Index; AM anthropometric measurements; PSQI-PT Questionnaire Pittsburgh Sleep Quality Index – Portuguese version; sRPE Session Rating of Perceived Exertion.

5.2.4 Anthropometric assessment

The anthropometric and body composition assessments were done in the first day of training camp. Body mass was measured using a calibrated scale (Seca 770, Hamburgo, Germany) and stature and sitting height were measured using a standard stadiometer (Harpenden 98.607, Holtain, UK). Body composition was assessed through multi-frequency bioelectrical impedance analyzer (InBody770; Biospace, Seoul, Korea). All the procedures were detailed in the methodology of chapter III.

Sleep

5.2.5 Actigraphy

The night-sleep was assessed using 3-axial accelerometers (Actigraph LLC wGT3X-BT, Pensacola, USA), worn on the non-dominant wrist. Wrist-worn accelerometers have been used to monitor sleep in elite athletes (Staunton et al., 2017), and validated against polysomnography (PSG) (Alsaadi et al., 2014).

Data were analysed using corporate software (ActiLife LLC Pro software v6.13.3, Pensacola, USA). The sampling frequency was 50 Hz and the epoch of activity counts was 60 seconds (Sadeh et al., 1994). All sleep variables were determined every night during the training camp and training home using the Sadeh's algorithm (Sadeh et al., 1994). The sleep measures included total sleep time (total amount of sleep obtained), time in bed (time between lying down until getting up the next day), wake-up time (time between the last minute of sleep and getting up from bed), sleep onset time (time of the first epoch of sleep between time of trying to initiate sleep and time at wake up), wake after sleep onset (number of min awake after sleep onset), latency (time in minutes attempting to fall asleep), and sleep efficiency (percentage of time in bed that was spent asleep) (Sadeh et al., 1994).

Therefore, sleep quantity (TST) and sleep quality (SE) were analysed according to the Sleep National Foundation report (i.e., TST $<$7h; 420 min as an indicator of inappropriate sleep quantity, and SE $\leq$74% as inappropriate sleep quality) (M. Ohayon et al., 2017).

5.2.6 Questionnaire Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) is a commonly used retrospective questionnaire that assesses sleep quality during the previous month (Buysse et al., 1989). The PSQI consists of 19 self-rated questions.

The 19 self-related questions are categorised into seven (7) components, graded on a score that ranges from 0 to 3. The PSQI components are the following: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) habitual sleep efficiency, 5) sleep disturbances, 6) use of sleeping medication, and 7) daytime dysfunctions. The sum of these components yields one global score, which ranges from 0 to 21, where the highest score indicates worst sleep quality. Subjects who got PSQI global score of 5 or less were classified as 'good sleepers', and those who got more than 5 as 'poor sleepers' (Buysse et al., 1989).

A global PSQI score greater than 5 indicates major difficulties in, at least, 2 components or moderate difficulties in more than 3 components (Buysse et al., 1989).

A daily Portuguese version of the Pittsburgh Sleep Quality Index (PSQI-PT) was applied (Del Rio João et al., 2017). Athletes responded to the Pittsburgh Sleep Quality Index the day before and at the end of training camp, refilling training week at home.

The following variables were derived from the sleep diary and activity monitor data: time in bed (h:min), the period between going to bed and getting up; sleep onset (h:min), the time at which a participant first fell asleep after going to bed; sleep offset (h:min), the time at which a participant last woke before getting up; sleep period (h:min), the period between sleep onset and sleep offset; total sleep time (h:min), the amount of sleep obtained during a sleep period; sleep efficiency (%), total sleep time expressed as a percentage of the sleep period.

5.2.7 Questionnaire Sleep diary

The Pittsburgh Sleep Diary (PghSD) is an instrument with separate components to be completed at bedtime and waketime (Monk et al., 1994). Bedtime components relate to the events of the day preceding the sleep, waketime components to the sleep period just completed (Monk et al., 1994). The three VAS lines are exactly 10mm in length. Participants were encouraged to keep the instrument on their bedside table. They were urged to be consistent in keeping the diary (Monk et al., 1994).

These questions allowed for the calculation of the following quantitative variables related to sleep: time in bed (TIB), sleep latency, sleep efficiency (SE), waketime, time in bed, WASO, minutes of WASO, Sleep quality, mood of waking, alertness on waking (Monk et al., 1994).

Lastly, participants had the opportunity to provide additional information that may be relevant to their sleep in a free response comment box (eg, "I have a hot"). Out of seven possible sleep diaries, participants completed and average of 6.73 ± 0.51 for a compliance rate of 96%. Of the total sample, 76% completed all seven days of sleep diaries, 21% completed six days, and 3% completed five days.

5.2.8 Well-being

The WHO-5 can be applied ad hoc in situations where there is a need for additional information on the athletes mood (Topp et al., 2015; Ware, 1995). The athletes fill the WHO-5 after dinner and before sleep. Each of the five items is rated on a 6-point Likert scale from 0 (= not present) to 5 (= constantly present) (Topp et al., 2015). Scores are summated, with raw score ranging from 0 to 25 (Topp et al., 2015). Then the scores are transformed to 0-100 by multiplying by 4, with higher scores meaning better well-being (Topp et al., 2015; Ware, 1995).

Evidence suggests, a score of 50 or below is indicative for low mood, though not necessarily depression (Topp et al., 2015; Ware, 1995). To monitor possible changes in well-being, a 10% difference can be regarded as a significant change (Topp et al., 2015; Ware, 1995).

Microcyles monitoring training load

5.2.9 sRPE

For quantification of session training load (TL), we used the sRPE. This procedure consisted of asking to the athletes to rate their level of perceived exertion using the CR100 (Borg & Borg, 2002; Borg & Kaijser, 2006) scale 15-30 min post-exercise. This perceptual value was multiplied by the session duration in minutes (Oliveira Borges et al., 2014). The sRPE results were divided by 10 to allow for comparison with previous studies that used the CR10 scale (Impellizzeri et al., 2004; Rabelo et al., 2016; Wallace et al., 2009). All the procedures were detailed in the methodology of chapter III.

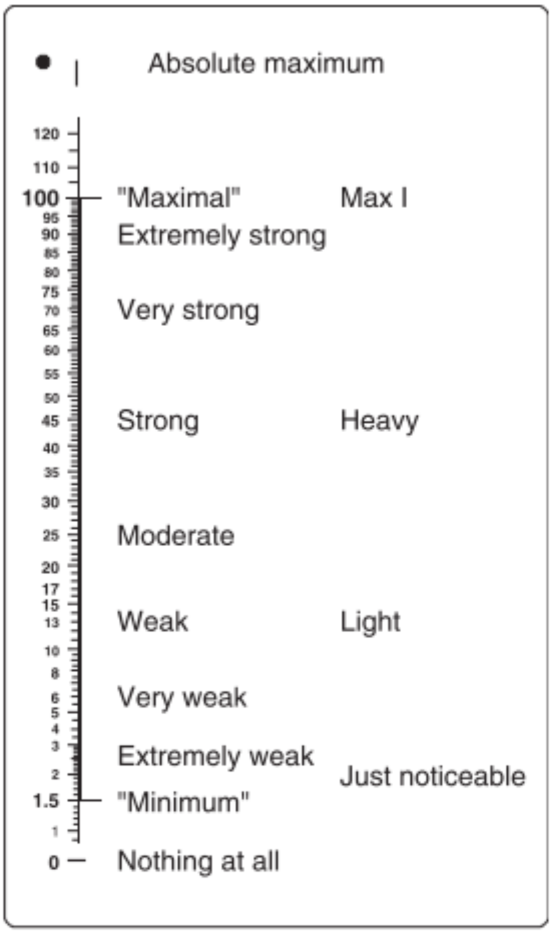

Figure 7: Borg centiMAx (CR100) scale (Borg & Borg, 2002; Borg & Kaijser, 2006)

5.2.10 Statistical analysis

The results for the groups are expressed as mean ± standard deviation. For the data analysis of actigraph, we will use the ActiLife software. The actigraph sleep data, World Health Organization Well-Being Index (WHO-5), training load and Questionnaire Pittsburgh Sleep Quality Index (PSQI), the Questionnaire Sleep diary at Pré-Competition, Competition and Post-Competition at Training Camp 1 (TC1), Training Home (TH), Training Camp 2 (TC2), Pré-Competition, Competition and Post-Competition were assessed for normal distribution using the Shapiro-wilk test.

To verify differences between sexes at TC1, TH, TC2 comparisons were analyzed using paired-sample t-test. The intra-sex differences for each TC1, TH and TC2 were analysed using three-factor ANOVA Bonferroni corrected paired-sample t-teste. The effect sized (ES) were qualitatively interpreted using the following thresholds: <0.2, trivial; 0.2-

0.6, small; 0.6-1.2, moderate; 1.2-2.0, large; 2.0-4.0, very large; >4.0, huge (Hopkins et al., 2009). The correlation relationship strength values were classified according to: 0.50-1.00, large; 0.30-0.49, moderate; 0.10-0.29, small (Cohen, 1988). When the 95% CI overlapped positive and negative values, the effect was unclear. To verify the association between the WHO-5 and sleep data, we applied a correlation between with post-hoc Spearman Ro.

To verify differences actigraph sleep data, WHO-5, training load and PSQI between sexes at Pré-Competition, Competition and Post-Competition comparisons were analyzed using paired-sample t-test. The intra-sex differences for each Pré-Competition, Competition and Post-Competition were analyzed using three-factor ANOVA Bonferroni corrected paired-sample t-tests. To verify differences the Questionnaire Sleep diary between sexes at Pré-Competition, Competition and Post-Competition comparisons were analyzed using non-parametric tests, the Mann-Whitney U test. The intra-sex differences for each Pré-Competition, Competition and Post-Competition were analyzed using the Kruskal-Wallis test. To verify the association between the WHO-5 and actigraph sleep data, the Questionnaire Sleep diary and actigraph sleep data the non parametric correlation Spearman Rho was applied. Statistical significance was set at $p<0.05$.

5.3 Results

The data related with the sleep (sleep onset time, wake up time, TIB, TST, Latency, SE to anayse, training load and well-being (WHO-5) at Training Camp 1, Training Home and Training Camp 2 and session perceived exertion (sRPE) are present in table 8. All variables fit the assumption of normal distribution.

5.3.1 Training camp 1 training at home and training camp 2

Although the variables under study showed to follows the normal distribution, the sample size (N) lead us to us for a more conservative analysis through non-parametric statistics.

Table 8: Displays actigraphy sleep data, World Health Organization Well-Being Index (WHO-5), training load and Questionnaire Pittsburgh Sleep Quality Index at Training Camp 1, Training Home and Training Camp 2

		Training Camp 1			Training Home			Training Camp 2		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Women	Sleep onset time (h:min)	22:01	01:09	23:26 ± 00:45	22:40	00:55	23:43 ± 00:32	23:0	00:47	23:48 ± 0:32
	Wake up time (h:min)	7:03	9:19	8:00 ± 00:35[a]	5:55	9:21	7:31 ± 00:49	7:20	8:50	7:52 ± 0:26 **
	TIB (hours)	6.22	10.43	8.53 ± 0.91[a]	5.50	9.42	7.64 ± 0.93**	7.00	9.32	8.07 ± 0.61**
	TST (hours)	5.27	9.63	7.50 ±0.88*[a]	4.18	8.58	6.38 ± 1.04**	4.83	8.03	6.92 ± 0.74
	WASO (min)	19	145	56.52 ± 26.49**	13	140	69.75 ± 32.09	12	123	60.86 ±
	Awakening	6	47	21.52 ± 7.46**	2	36	20.47 ± 8.00**	12	35	19.64 ± 5.67**
	Avg Awakening (min)	1	5	2.65 ± 0.91**[a]	1	8	3.66 ± 1.40**	1	6	3.14 ± 1.6
	Latency (min)	2	12	5.60 ± 1.46	4	10	6.00 ± 1.01	3	13	8.50 ± 2.62[a.b]
	SE (%)	72	95	87.90 ± 4.74**[a]	69	95	83.29 ± 7.01	69	96	85.78 ± 6.75*
	PSQI total									
	Total (AU)	2	7	4.83 ± 1.70	2	5	3.17 ± 1.47	2	8	4.00 ± 2.71
	Proportion PSQI total ≥ 5 (%)			75			33.3			25
	WHO-5 (%)	36	92	68.21 ± 13.69**	36	96	73.17 ± 15.60**	80	100	88.14 ± 5.79[a.b]
	TRIMP	15	248	100.77 ± 66.0				20	172	96.64 ± 47.96
	sRPE	1225	15390	7221.46 ± 4143.91	360	11440	3876.75 ± 2940.92**	720	13020	6717.07 ±
Men	Sleep onset time (h:min)	21:53	00:51	23:22 ± 00:27	21:35	02:56:	23:31 ± 00:52	22:3	00:18	23:30 ± 00:21
	Wake up time (h:min)	06:39	10:14	08:10 ± 00:40	06:01	12:41	07:53 ± 01:03	7:19	9:38	8:24 ± 00:36[a.b]
	TIB (hours)	6.67	12.17	8.76 ± 0.75[a]	6.17	11.90	8.32 ± 0.93	7.63	10.17	8.90 ± 0.61[a]
	TST (hours)	5.12	10.22	7.12 ± 0.93	4.88	10.47	6.95 ± 0.81	5.33	9.95	7.16 ± 0.86
	WASO (min)	13	169	92.64 ± 30.78[a]	18	138	76.78 ± 27.30	22	183	97.12 ± 37.64[a]
	Awakening	2	49	28.5 ± 7.91	10	41	26.83 ± 6.80	7	44	32.21 ± 7.2[a.b]
	Avg Awakening	2	7	3.37 ± 1.03[a]	1	5	2.83 ± 0.70	2	6	3.10 ± 1.02[a]
	Latency (min)	3	65	7.24 ± 7.12	1	7	5.85 ± 1.04	4	29	9.69 ± 5.55[d.a]
	SE (%)	66	96	81.01 ± 5.75[a]	75	95	83.61 ± 4.94	62	98	80.33 ±7.42[a]
	PSQI total									
	Total (AU)	1	11	4.61 ± 2.15	1	9	4.44 ± 2.24	2	9	4.25 ± 2.22
	Proportion PSQI total ≥ 5 (%)			50			43.4			33.3
	WHO-5 (%)	56	100	81.39 ± 11.19	48	100	82.04 ± 11.55	56	100	87.14 ± 9.54[b.c]
	TRIMP (AU)	15	226	92.50 ± 61.19				20	256.00	109.520 ± 60.6
	sRPE (AU)	800	16150	7488.35 ± 423776[a]	1750	12825	5527.98 ± 2751.96	700	19434.00	8909.640 ±

[*] Difference between sexes TC1, TH and TC2 <0.05; [**] difference between sexes TC1, TH and TC2 <0.01; [a] difference with Training Home; [b] differences with Training Camp 1; *TIB* time in bed; *TST* total sleep time; *WASO* wake after sleep onset; *SE* sleep efficiency; *WHO-5* World Health Organization Well-Being Index; *PSQI* Pittsburgh Sleep Quality Index; *AU* Arbitrary Units; *TRIMP* Training Impulse; *sRPE* Session Rating of Perceived Exertion; *min* minutes.

Results showed differences between sex in the following variables at Training Camp 1: higher values in women in TST (t(118) = 2.3; p = 0.022); *ES* small (0.45) and SE (t(118) = 6.88; p <0.001); *ES* large (1.38). In men we found higher values in WASO (t(118) = -6.65; p <0.001); *ES* large (-1.33), Awakening (t(118) = -6.65; p <0.001); *ES* moderate (-0.97), Avg Awakening (t(118) = -4.85; p <0.001); *ES* moderate (-0.79), and WHO-5 (t(118) = -5.78; p <0.001); *ES* moderate (-1.16).

At Training at Home, sex differences were found with higher values in women Avg Awakening (t(88) = 3.69; p = 0.002); *ES* very large (3.80). Higher values in men in TIB (t(88) = -3.42; p <0.001); *ES* moderate (-0.79), TST(t(88) = -2.91; p = 0.007); *ES* moderate (-0.68), Awakening (t(88) = -4.05; p <0.001); *ES* moderate (-0.94), WHO-5 (t(88) = -3.10; p = 0.005); *ES* moderate (-0.72) and sRPE (t(88) = -2.71; p = 0.008); *ES* moderate (-0.63).

At Training Camp 2 differences between sex were found in variables with higher values in women SE (t(54) = 2.43; p = 0.018); *ES* moderate (0.82). Higher values in men in Wake up Time (t(54) = -3.03; p = 0.001); *ES* very large (-2.38), TIB (t(54) = -4.43; p <0.001); *ES* large (-1.46), WASO (t(54) = -3.25; p 0.002); *ES* moderate (-1.10) and Awakening (t(54) = -5.92; p <0.001); *ES* very large (-2.03).

No sex differences were found in the proportion of good and poor sleepers (PSQI total ≥ 5 %) between TC1 and TH and TC2.

Comparaing data of the diferente constexts by each sex, in the Women group we observed differences between Training Camp 1, Training Home and Training Camp 2. We found higher values at Training Camp 1 than Training Home in Wake up time F(2,95) = 5.26; p=0.007 (p=0.005); *ES* large (1.78), TIB F(2,95) = 10.64; p=<0.001 (p=<0.001); *ES* moderate (1.06), TST F(2,95) = 15.10; p=<0.001 (p=<0.001); *ES* large (1.27) and SE F(2,95) = 6.12; p=0.003 (p=0.002); *ES* moderate (0.84). Higher values at Training Home than Training Camp 1 in Avg Awakening F(2,95) = 7.02; p=0.001 TC1≠TH (p=<0.001); *ES* moderate (0.94). Higher values at Training Camp 2 than Training Camp 1 in Latency F(2,95) = 19.51; p=<0.001 (p=<0.001); *ES* large (1.50), WHO-5 F(2,95) = 11.54; p=<0.001 (p=<0.001) TH≠TC2 (p=0.002); *ES* very large (2.08).

We found higher values at Training Camp 2 than Training Home in Latency F(2,95) = 19.51; p=<0.001 (p=<0.001); *ES* large (1.38), WHO-5 F(2,95) = 11.54; p=<0.001 (p=0.002); *ES* large (1.39) and sRPE F(2,95) = 8.74; p=<0.001 (p=0.008); *ES* moderate (0.90).

Men group differences between Training Camp 1, Training Home and Training Camp 2 were found with higher values at Training Camp 1 than Training Home in TIB (h:min) $F(2,165) = 7.75$; $p=<0.001$ ($p=0.007$); *ES* small (0.55), WASO $F(2,165) = 5.89$; $p=0.003$ ($p=0.018$); *ES* small (0.58), Avg Awakening $F(2,165) = 5.14$; $p=0.007$ ($p=0.005$); *ES* moderate (0.65) and sRPE $F(2,165) =7.99$; $p=<0.001$ ($p=0.03$); *ES* small (0.58). Higher values at Training Home than Training Camp 1 in SE $F(2,165) = 4.35$; $p=0.014$ TC1≠TH ($p=0.05$) TH≠TC2 ($p=0.025$); *ES* small (0.51). Higher values at Training Camp 2 than Training Camp 1 in Wake up time (h:min) $F(2,165) = 4.8$; $p=0.009$ ($p=<0.001$); *ES* small (0.39), Awakening $F(2,165) = 6.43$; $p=0.002$ ($p=0.032$); *ES* small (0.52), Latency $F(2,165) = 5.91$; $p=0.003$ ($p=0.065$) marginal; *ES* small (0.41) and WHO-5 $F(2,165) = 4.01$; $p=0.02$ ($p=0.022$); *ES* small (0.59). Higher values at Training Camp 2 than Training Home in Wake up time (h:min) $F(2,165) = 4.8$; $p=0.009$ ($p=0.002$); *ES* moderate (0.98), TIB (h:min) $F(2,165) = 7.75$; $p=<0.001$ ($p=0.001$); *ES* moderate (0.78), Avg Awakening $F(2,165) = 5.14$; $p=0.007$ ($p=0.025$); *ES* small (0.33), Latency $F(2,165) = 5.91$; $p=0.003$ ($p=0.002$); *ES* moderate (1.02), WASO $F(2,165) = 5.89$; $p=0.003$ ($p=0.006$); *ES* moderate (0.66), Awakening $F(2,165) = 6.43$; $p=0.002$ ($p=0.002$); *ES* moderate (0.82) and WHO-5 $F(2,165) = 4.01$; $p=0.02$ ($p=0.073$) Marginal; *ES* small (0.51). Higher values at Training Home than Training Camp 2 in SE $F(2,165) = 4.35$; $p=0.014$ TC1≠TH ($p=0.05$) TH≠TC2 ($p=0.025$); *ES* small (0.52).

We found a small correlation between WHO-5 (before bed) and the following night sleep Latency (actigraph data) ($\rho =0.157$; $p=0.010$) and Sleep on Set a small correlation ($\rho =0.183$; $p=0.003$). Other sleep variables were not correlated with WHO-5.

5.3.2 Pre, Competition and Post phase

In the table 9 we present the mean, minimum and maximum values actigraphy sleep data, training load and World Health Organization Well-Being Index (WHO-5) at Pre-competition, Competition and Post-competition. The statistical significant results in the comparative analysis by sexe and moments are also highlighted.

Table 9: Displays actigraphy sleep data and World Health Organization Well-Being Index (WHO-5) at Pre-competition, Competition and Post-competition

		Pre-Competition			Competition			Post-competition		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Women	Sleep onset time (h:min)	22:00	01:38	23:54 ± 00:45 **	22:23	00:57	23:23 ±	21:40	01:29	23:23 ± 01:00
	Wake up time (h:min)	4:58	9:33	8:17 ± 01:01[a]	6:30	9:25	7:28 ±	06:31	10:02	08:27 ± 0:49[a]
	TIB (hours)	4.63	9.92	9.94 ± 1.25**	5.55	9.25	7.90 ±	6.50	10.35	8.95 ± 1.15[c]
	TST (hours)	3.73	8.90	6.92 ± 1.17	4.90	8.08	6.84 ± 1.04	5.62	9.00	7.59± 1.09**
	WASO (min)	28	165	74.83 ± 32.19**	26	159	56.83 ±	45	108	76.39 ± 20.63**
	Awakening	4	38	24.03 ± 7.33[a]	4	32	18.17 ±	18	34	25.17 ± 4.08*[a]
	Avg Awakening (min)	2	8	3.27 ± 1.41	1	7	3.43 ± 1.77	2	5	3.02 ± 0.64
	Latency (min)	4	12	7.30 ± 2.0**	2	11	6.83 ± 2.08	4	9	6.06 ± 1.21**[d]
	SE (%)	62	93	83.65 ± 6.51**	69	93	86.79 ±	78	91	84.75 ± 3.50**
	PSQI total									
	Total (AU)	2	5	3.50 ± 1.05				2	5	3.17 ± 1.47
	Proportion PSQI total ≥ 5 (%)			16.7						33.3
	WHO-5 (%)	16	92	70.3± 17.77 **	60	92	77.67 ±	36	100	76 ± 16.58*
	sRPE	464	9838	4516.8 ± 2362.71**				1580	10490	6111.11 ± 2807.68[b]
Men	Sleep onset time (h:min)	21:00	02:38	23:27 ± 00:56	22:44	00:20	23:08 ±	22:45	02:34	23:49 ± 01:03
	Wake up time (h:min)	4:53	10:55	08:30 ± 01:02	07:15	10:20	08:12 ±	06:10	10:00	8:21 ± 00:47
	TIB (hours)	4.90	10.40	9.01 ± 1.08	8.42	11.00	9.03 ± 0.64	5.68	9.67	8.34 ± 1.06[b]
	TST (hours)	3.83	9.00	6.83 ± 1.04	5.55	7.35	6.74 ± 0.47	5.03	7.90	6.51 ± 0.71
	WASO (min)	45	248	125.2 ± 52.03	67	263	130.43 ±	26	163	101.14 ± 36.54
	Awakening	20	55	33.57 ± 8.92	14	55	34.43 ±	17	49	28.9 ± 7.36
	Avg Awakening	2	6	3.84 ± 1.269	2	5	3.87 ± 0.90	1	7	3.5 ± 1.24
	Latency (min)	3	17	9.14 ± 3.27	2	15	7.07 ± 3.05	5	23	9.33 ± 3.99
	SE (%)	58	97	76.0 ± 9.01	60	85	75.15 ± 7.44	70	94	78.61 ± 5.75
	PSQI total									
	Total (AU)	1	7	4.14 ± 2.04				0	4	2.14 ± 1.22[b]
	Proportion PSQI total ≥ 5 (%)			42.9						0
	WHO-5 (%)	56	100	80.94 ± 11.46	68	96	79.93 ± 7.78	64	100	85.1 ± 8.92
	sRPE (AU)	415	21580	6712.26± 4382.77				500	63500	8092.38 ± 130005.5

[*] Meaningful difference between sexes Pre-Competition, Competition and Post-Competition <0.05; [**] Meaningful difference between sexes Pre-Competition, Competition and Post-Competition <0.01; [a] significant difference with Competition; [b] significant differences with Pre-Competition; *TIB* time in bed; *TST* total sleep time; *WASO* wake after sleep onset; *SE* sleep efficiency; *WHO-5* World Health Organization Well-Being Index; *PSQI* Pittsburgh Sleep Quality Index; *AU* Arbitrary Units; *TRIMP* Training Impulse; *sRPE* Session Rating of Perceived Exertion; *min* minutes.

We found differences between sex in the following variables at Pre-competition with higher values in women in Sleep onset time (t(63) = 2.05; p = 0.045); *ES* large (-1.51), SE (t(63) = 3.85; p <0.001); *ES* moderate (1.01). Higher values in men in TIB (t(63) = -2.57; p = 0.013); *ES* moderate (0.87), WASO (t(63) = -4.60; p <0.001); *ES* moderate (-1.20), Latency (t(63) = -2.68; p = 0.007); *ES* moderate (-0.69), Awakening (t(63) = -4.66; p < 0.001); *ES* large (-1.23), WHO-5 (t(63) = -2.91; p = 0.005); *ES* moderate (-0.80) and sRPE (t(63) = -2.45; p = 0.013); *ES* moderate (-0.63).

At Competition sex differences were found in with higher values in women in SE (t(24) = 4.06; p < 0.001); *ES* large (1.71). Higher values in men in Wake up time (t(24) = -2.33; p = 0.029); *ES* large (-1.85), TIB (t(24) = -3.09; p = 0.009); *ES* large (-1.37), WASO (t(24) = -4.00; p < 0.001); *ES* large (-1.66) and Awakening (t(24) = -4.61; p < 0.001); *ES* large (-1.90).

At Post-competition sex differences were found in with higher values in women in TST (t(37) = 3.72; p = 0.001); *ES* large (1.32) and SE (t(37) = 3.95; p < 0.001); *ES* large (1.32). Higher values in men in WASO (t(37) = -2.54; p = 0.015); *ES* moderate (-0.85), Awakening (t(37) = -2.00; p = 0.054) marginal; *ES* moderate (-0.66), Latency (t(37) = -3.35; p = 0.002); *ES* moderate (-1.09) and WHO-5 (t(37) = -2.18; p = 0.048); *ES* moderate (-0.79).

There are differences in proportion PSQI total ≥ 5 (%) between Pre-competition and Post-competition in women. In the men group we found marginal differences in proportion PSQI total ≥ 5 (%) between Pre-competition and Post-competition (U=14.0 ;p=0.06).

Considering results by sex in difference contexts analysed the main findings were Women group differences between Pre-competition, Competition and Post-competition with Higher values at Pre-competition than Competition in Wake up time F(2.57) = 4.57; p=0.014 (p=0.033); *ES* large (1.24) and Awakening F(2.57) = 4.76; p=0.012 (p=0.030); *ES* moderate (0.90). Higher values at Pre-competition than post-competition in Latency F(2.57) = 2.63; p=0.081 (p=0.077) marginal; *ES* moderate (0.82). Higher values at post-competition than Competition in Wake up time F(2.57) = 4.57; p=0.014 (p=0.018); *ES* very large (2.26), TIB F(2.57) = 3.06; p=0.054 (p=0.069) marginal; *ES* moderate (0.99) and Awakening F(2.57) = 4.76; p=0.012 (p=0.015); *ES* large (1.35). Higher values at post-competition than Pre-competition in sRPE p= 0.04; *ES* moderate (0.67).

Men group differences between Pre-competition, Competition and Post-competition with higher values at Pre-competition than post-competition in TIB F(2.67) =

3.32; p=0.042 Pre≠Post (p=0.054); *ES* moderate (0.66) and PSQI total p= 0.045; *ES* large (1.26).

We found a small correlation between WHO-5 (before bed) and next night sleep TST (actigraph data) (ρ =-0.193; p=0.028). The remaining sleep variables were not correlated with WHO-5.

The results of the Pittsburgh Sleep Diary diary sleep data at Pre-competition, Competition and Post-competition (the sleep onset time, wake up time, TST, Latency, Sleep Quality) are present in table 10.

5.3.3 Pre, Competition and Post phase

The variables under study had a normal distribution (P>0.05). For the non-normal distribution and for N we opted for non-parametric statistics.

Table 10: Displays the Pittsburgh Sleep Diary diary sleep data at Pre-competition, Competition and Post-competition

		Pré-competition			Competition			Post-competition		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Women	Went to bed	21:00	01:00	23:15 ± 0:47	22:00	00:00	22:54 ± 00:38	23:00	01:00	23:45 ± 0:26*
	Lights out	22:00	01:40	23:31 ± 0:51	22:00	00:00	23:00 ± 00:37	23:08	02:00	23:53 ± 0:36*
	Latency (min)	1	60	11 ± 12 **	1	30	8 ± 9**	1	35	13 ± 11
	Sleep onset time (h:min)	22:25	02:50	23:48 ± 1:02**	22:10	00:31	23:31 ± 0:45	21:10	00:55	22:58 ± 0:48**
	TST (hours)	3.17	10.58	8.73 ± 1.65	6.93	9.81	8.98 ± 0.75	4.25	10.5	8.67 ± 1.48
	Wake up time (h:min)	5:00	11:24	8:33 ± 1:10	07:00	09:30	08:30 ± 00:50	04:00	9:50	07:39 ± 1:31*
	WASO (min)	0	3	0.60 ± 0.968	0	2	0.42 ± 0.67	0	2	0.17 ± 0.51
	Avg Awakening (min)	0	15	1.23 ± 3.339	0	1	0.17 ± 0.39	0	20	1.33 ± 4.75
	Sleep Quality (%)	14	100	74.77 ± 21.013	40	100	73.83 ± 18.18	49	96	75.11 ± 14.84
	Mood on final wakening (%)	15	100	70.00 ± 21.483	44	100	74.08 ± 17.28	55	96	72.33 ± 13.00*
	Alerteness on final wakening (%)	10	100	50.03 ± 24.658	14	96	63.83 ± 21.23*	7	89	56.28 ± 19.20
Men	Went to bed	21:00	02:45	23:06 ± 1:12	22:00	02:00	23:02 ± 0:58	21:00	02:15	23:14 ± 1:18
	Lights out	21:00	02:45	23:21 ± 1:08	22:00	02:00	23:10 ± 00:59	21:00	02:20	23:19 ± 1:20
	Latency (min)	5	60	19 ± 28	5	40	14 ± 9	5	35	12 ± 6
	Sleep onset time (h:min)	21:10	02:05	23:07 ± 00:49	22:05	02:25	23:49 ± 01:17	21:10	01:40	23:39 ± 00:50
	TST (hours)	4.73	11.83	9.03 ± 1.48	7.25	10.5	8.87 ± 10.08	5.75	10.42	8.9 ± 0.97
	Wake up time (h:min)	04:00	13:30	08:10 ± 01:36	06:00	09:55	08:41 ± 00:55	06:00	10:100	08:34 ± 00:59
	WASO (min)	0	3	0.66 ± 0.80	0	3	0.86 ± 1.10	0	2	0.24 ± 0.54
	Avg Awakening (min)	0	10	0.46 ± 1.74	0	2	0.36 ± 0.63	0	10	0.76 ± 2.23
	Sleep Quality (%)	3	100	63.85 ± 26.49	52	97	78.57 ± 15.51	7	96	72.57 ± 20.44
	Mood on final wakening (%)	1	100	62.91 ± 28.06	25	97	70.14 ± 19.90	14	92	57.29 ± 21.99
	Alerteness on final wakening (%)	4	100	50.79 ± 25.34	11	89	50.29 ± 21.42	14	89	54.14 ± 19.06

Meaningful difference between sexes Pre-Competition, Competition and Post-Competition <0.05; ** Meaningful difference between sexes Pre-Competition, Competition and Post-Competition <0.01

Data from the Pittsburgh Sleep Diary of Women athletes showed woke up strategy using the following methods: Pre-competition phase 56.7% using the clock/radio alarm, 33.3% ask someone to wake up and 10% wake up without any help. Competition phase 75% using the clock/radio alarm and 25% ask someone to wake up. Post-competition phase 16.7% using the clock/radio alarm, 55.6% ask someone to wake up, 5.6% some noises and 11.1% wake up without any help. Men athletes report that woke up using the following methods: Pre-competition phase 57.1% using the clock/radio alarm, 20.0% ask someone to wake up, 11.4 some noises and 11.4% wake up without any help. Competition phase 42.9% using the clock/radio alarm, 21.4% ask someone to wake up, 7.1 some noises and 28.6% wake up without any help. Post-competition phase 57.1% using the clock/radio alarm, 9.5% ask someone to wake up, 4.8% some noises and 28.6% wake up without any help.

Female athletes reported that they woke up for the following reasons: in the Pre-competition phase 13.3% to go to the toilet 1-2 times, 23.3% by noises 1-3 times, 13.3% because due to discomfort/physical cause 1 time and 10% without case 1 time. Competition phase 16.7% to go to the toilet 1 time, 8.3% by noises 1 time and 8.3% without case 1 time. Post-competition phase 12.2% because due to discomfort/physical cause 1-2 times. Men athletes reported that they woke up for the following reasons: Pre-competition phase 14.3% to go to the toilet 1-3 times, 22.9% by noises 1time, 8.6% because due to discomfort/physical cause 1-4 times and 17.1% without case 1-3 times. Competition phase 27.3% to go to the toilet 1-3 times, 21.4% by noises 1 time, 35.7% because due to discomfort/physical cause 1-3 times and 7.1% without case 1 time. Post-competition phase 9.5% because due to discomfort/physical cause 1 time and 4.8% without case 1 time.

In table 10 we present the descriptive data of the Pittsburgh Sleep Diary diary sleep data at Pre-competition, Competition and Post-competition. We found differences between sex in the following variables at Pre-competition with higher values in women in Sleep onset time (U=289; p=0.002); *ES* small (0.60). Higher values in men in Latency (U=308; p=0.003); *ES* small (-0.37).

At Competition sex differences higher values were found in women in Alerteness on final wakening (%) (U=49.5; p=0.076) marginal; *ES* moderate (0.68). Higher values in men in Latency (U=33.5; p=0.008); *ES* moderate (-0.72). At Post-competition sex differences were found with higher values in women in Went to bed (U=119; p=0.049); *ES* small (0.35), Lights out (U=116; p=0.04); *ES* small (0.38) and Mood on final wakening (%) (U=117; p=0.043); *ES* moderate (0.85). Higher values in men in Sleep onset time

(U=84; p=0.003); *ES* large (-1.77) and Wake up time (U=108; p=0.022); *ES* moderate (-1.09).

Women group differences between Pre-competition, Competition and Post-competition showed higher values at Pre-competition than Competition in Lights out Z= 5.486, p =0.019; p=0.058 marginal; *ES* moderate (0.76). Higher values at Pre-competition than post-competition in Sleep onset time Z= 12.800, p <0.001; p=0.001; *ES* large (1.24), Wake up time Z= 5.424, p =0.020; p=0.060 marginal; *ES* moderate (0.85). Higher values at post-competition than Competition

Went to bed Z= 11.808; p <0.001; p=0.002; *ES* very large (3.06) and Lights out Z= 13.889, p <0.001; p=0.001; *ES* large (1.59). Higher values at post-competition than Pre-competition in Went to bed Z= 6.817; p= 0.009; p=0.027; *ES* moderate (8.65) and Lights out Z= 6.817, p =0.009; p=0.027; *ES* small (0.55). Higher values at Competition than post-competition in Wake up time Z= 4.043, p =0.044; in the post hoc, no particular differences were identified between the analyzed pairs.

Men group differences between Pre-competition, Competition and Post-competition with higher values at Pre-competition than post-competition in WASO Z= 5.770, p =0.016; p=0.049; *ES* moderate (1.01). Higher values at Competition than post-competition in WASO Z= 3.734, p =0.053; *ES* moderate (0.65).

Comparing the actigraphy results with the Pittsburgh Sleep Diary diary sleep data (Latency, SOS, TST, Wake up time, SE and WASO) at Pre-competition, Competition and Post-competition, we found differences in latency (t(129)= -5,663, < 0.001), *ES* moderate (-0.72); TST (t(129)= -12,169, < 0.001), *ES* large (-1.71); SE (t(128)= 4,038, < 0.001), *ES* small (0.54); and WASO (t(129)= 23,181, < 0.001) *ES* very large (2.96);. No differences were founded in the SOS and Wake up Time. Spearman's correlation showed a small and negative correlation between actigraph results with Pittsburgh Sleep Diary diary Wake up Time (ρ =-0.174; p=0.47), and a moderate positive correlation on WASO (ρ =0.243; p=0.005).

5.4 Discussion

This chapter was primarily designed to characterize and analyse young elite women and men canoe and kayak athletes' sleep patterns when participanting in national training camps (TC) and training homes (TH). Secondly, we characterize and analyse the sleep patterns in two national training camps during 1 month, in athletes undergoing preparation for an international competition (European Canoeing Championships Junior & U23). Thirdly, we characterize and analyse the sleep patterns considering the preparation period: Pre-competition (Pre-C), National Competition (NC) and Post-competition (Post-C). There were several noteworthy findings. First, the young elite-level canoeists and kayakers showed sleep patterns that vary between sexes at TCs and TH, Pre-C, NC and Post-C. Second, athletes showed different sleep patterns in the different places and environments studied, possibly due to changes in places and sleep conditions.

In elite athletes of various sports (Rio 2016 Olympic Games) no differences were found between sexes inwaking time, TST, SE, Sleep onset Latency (SOL) and Waso (Narciso et al., 2020). Nonetheless, in training camp 1 (TC1), differences were found between sexes, the women having higher time sleep (TST) and higher sleep efficiency (SE) than men. On the other hand, men showed a higher WASO, Awakening and Avg Awakening than women. Males showed a higher perception of well-being (WHO-5) than females, although they slept worse than the women. However, in the Questionnaire Pittsburgh Sleep Quality Index (PSQI) 75% of women proved to be good sleepers, in the case of men only 50% of men were good sleepers.

Athletes in their training homes also showed differences between the sexes, with women sleeping worse than men, presenting higher Avg Awakening. Men in TH slept longer (TST), spent more time in their beds (TIB), showed higher well-being, although they were awakened more often and trained (sRPE) more than women. The PSQI at TH showed that only 33.3% of women were good sleepers, while this percentage was 43.4%in men, an inversion compared to TC1.

In training camp 2 (TC2), differences were found between sexes, with women presenting better SE than men. However, men on TC2 spent more time in their beds (TIB) and woke up later than women. The PSQI at TC2 showed that only 25% of women were good sleepers, while 33.3% of men were good sleepers. Athletes' perceptions went down from TC1 to TH and from TH to TC2. Halson and collaborators reported (PSQI data) sleep onset latencies and greater daytime dysfunction in female athletes compared with male athletes, in TH and TC2, male athletes showed better sleep than women (PSQI). To aid actigraphy, the individual questionnaire items or components may be useful for practitioners to guide decision making and recommendations for specific sleep interventions in athletes (Halson et al., 2021).

Analysing the intrasex pattern in TC1 and TH, we found that the females had higher TIB, TST, SE (better sleep) and wake up time at TC1 than TH, even training more lightly (sRPE) in TC1 than in TH, although without statistical differences. The males showed also higher TIB in TC, yet, showed a higher sleep fragmentation (WASO and Avg Awakening) at TC1 than TH. TH men showed higher SE than TC1, even though men trained less (sRPE) in TH than in the TC1. We highlight that the male and female athletes in the TH performed the training program of the clubs' coaches. Club coaches seem to prescribe training programs with less load than national canoeing coaches. Nevertheless, maybe because of the impact of early-morning training (Sargent, Halson, et al., 2014) or school activities on bedtimes and get-up times were earlier, time spent in bed was shorter and the TST obtained was less than on nights at TC. In elite swimmers, the early-morning training revealed that bedtimes and get-up times were earlier, TIB was shorter and the amount of sleep obtained was less than on nights before rest days (Sargent, Halson, et al., 2014). These results indicate that early-morning training sessions severely restrict the TST by elite athletes (Sargent, Halson, et al., 2014), showing the importance of controlling training and off-training schedules.

Comparing the two TCs, we found that in training camp 2 (TC2), 4 weeks after TC1, female athletes SE better than men, the men woke up later, spent more time in bed, showed higher WASO and more Awakening. The rowing athletes reported that sleep might have been less restful during higher training load and intensity at training camp compared to usual TH (Kölling et al., 2016). In our study, the young female athletes showed better SE when they increased their training load. Contrarily, the adult female athletes displayed increased TST and worse SE in response to stress compared with males (Aloulou et al., 2021). Possibly the athletes do not change their sleep architecture by the schedules and routines that are applied at the training camp. The male athletes presented higher sleep fragmentation at TC1, TH and TC2 than female athletes. Men on TC2 took longer to fall asleep and had greater awakenings than on TC1, possibly the athletes relaxed in TC2 as their participation in the European Canoe Championship was guaranteed, giving less importance to sleep habits. Contrary to Aloulou's study, in these periods women had SE better sleep indicators than men in TC (Aloulou et al., 2021).

We found that female athletes in TC1 wake up later, show less Avg Awakening, spent more time in bed (TIB), slept longer (TST) and better SE than in TH, even training less in average values in TH.

The Aloulou et al study showed that, independently of the practiced sport, higher training loads were accompanied by earlier bedtimes, lower total sleep times, reduced subjective sleep efficiency, and increased sleep fragmentation (Aloulou et al., 2021). However, in our study this was not found. Intead, female athletes with more training load (TL) showed better SE and TST. Women presented TST at 7.5 hours at TC and 6.38 hours at TH, showing values lower than 7.1 hours reported by Aloulou in TH. Therefore, we consider that these findings are correlated with the context factor, place where they slept, and routines they had in the TH. Possibly, training load was insufficient to causechanges. Female athletes presented values between 83% and 87% of SE, which are considered appropriate for this age group (M. Ohayon et al., 2017). However, the females athletes showed TST <7h at TH and TC2 an indicator of inappropriate total sleep time by (M. Ohayon et al., 2017).

On the other hand, male athletes with higher TL in TC1, spent more time in bed (TIB), and presented greater sleep fragmentation than in TL with lower TL. At training home, they showed better SE with lower TL as shown by (Aloulou et al., 2021). Male athletes presentedvalues between 80.33% and 83.61% of SE, which are considered uncertain for this age group (M. Ohayon et al., 2017). The males athletes showed (6.95 hours) at TH, presented TST <7h, an indicator of inappropriate total sleep time (M. Ohayon et al., 2017).

Women present as TST at TC 7.5 hours (hr) and at TH 6.38 hours, showing values lower than 7.1 hr reported in swimmers (Aloulou et al., 2021) at TH but values higher than 7.1 hr at TC1. On the other hand, boys maintain similar values of 7.12 in TC1hr and 6.95 in TH, similar to swimmers (Aloulou et al., 2021). However, they showed higher TST than the 6.7 hours reported in 175 elite athletes from 12 individual and team sports, less time than the athletes reported (8.3 hours) as needed to feel rested (Sargent et al., 2021).

Comparing the two TC, we found in female athletes that in TC2 the latency was higher and that they slept slightly less TST than in TC1, possibly due to the approach of international competition. In the case of men, they had later awaken hours, greater sleep fragmentation and greater SOL in TC2 than in TC1. However, both sexes showed a greater perception of well-being in the TC2. A correlation was found between WHO-5 and SOL

(TC1, TH, TC2) where athletes who felt greater well-being during the day were also those who had the lowest latency time.

After characterizing the TC and TH of young canoeing athletes, we sought to understand how the sleep pattern of athletes behaved during the period of Pre-competition (Pre-C), National Competition (NC) and Post-competition (Post-C). In Australian Athletes (various sports, including Canoeing) a sleep survey questionnaire about important competitions showed no differences between sexes (Juliff et al., 2015). Nonetheless, in Pre-C, NC and Post-C sexes differences were found. In Pre-C women fell asleep later but slept more efficiently than men. Men spent more time in bed, showed higher WASO, took longer to fall asleep, more awakenings, however showed a higher perception of well-being and higher training load than women before the NC. During the 2 days of NC, female athletes showed higher SE than males. Male athletes in NC woke up later than females, spent more time in bed (TIB), higher WASO and more Awakening than females. In Post-C, female athletes slept more minutes and with higher SE than men. Male athletes in Post-C showed higher WASO, higher Awakening, took longer to fall asleep (Latency) and felt higher well-being than females.

Analysing the intrasex pattern in Pre-C and NC, we found that the females woke up later during the Pre-C period than in the NC, because in the NC they had to complete the competition program, and they also presented greater sleep fragmentation in Pre-c than in the NC. In Post-C and NC, we found that female athletes woke up later, spent more time in bed and more sleep fragmentation in Post-C than in NC. Comparing Pre-C and Post-C, we found that female athletes had higher latency and lower TL (sRPE) in Pre-C than in Post-C. In addition, women preferred the alarm clock as a method of waking up in Pre-C and NC, decreasing this method in Post-C.

Analysing the male athletes pattern, we found no differences between Pre-C and NC, NC and Post-C. We only found differences between Pre-C and Post-C.Although men did not sleep more, they spent more time in bed, and perceived worse sleep quality on the Pittsburgh Sleep Quality Index (PSQI) in Pre-C than in Post-C, showing the impact of NC on sleep pattern. Perceived daily training load was higher in Post-C than in Pre-C. In addition, men preferred the alarm clock as a method of waking up in Pre-C and NC and also Post-C.

Insomnia symptomatology reported by (Gupta et al., 2017) is high among elite athletes, with sleep quality appearing most vulnerable prior competitive events, the athlete sleep disturbances can affect competition directly, through fatigue, or indirectly, through sleep-related performance anxieties (Gupta et al., 2017).

While sleep is recognized as critical for the well-being and performance of athletes, particularly in the competitive season (Fullagar et al., 2015; Walsh et al., 2021), especifically to psychological and physiological recovery, athletes often sleep less than recommended (Sargent, Lastella, et al., 2014), as we found in our study.

Women presented TST 6.92 hours in the Pre-C, 6.84 hours in the NC and 7.59 hours in the Post-C, showing values lower than 7.1 hours, unlike reported by Aloulou (2021) in Pre-C and NC. The females athletes presented TST lower than7h, an indicator of inappropriate sleep quantity (M. Ohayon et al., 2017) (6.92-6.84) at Pre-C and NC. Therefore, we found that before and during the competition, women slept less than after the competition, showing the impact of competition, travel and overnight stays away from home, as reported by (Walsh et al., 2021). Female athletes presented uncertain sleep efficiency (83.65-84.75%) in Pre-C and Post-C, even though they showed 86.79% in the NC, considered appropriate SE values as reported by (M. Ohayon et al., 2017). Women showed no differences in PSQI score although they reported better well-being (WHO-5) values in Post-C than in Pre-C.

Men athletes presented TST 6.83 hours at Pre-C, 6.74 hours at NC and 6.51 hours Post-C, having in the three periods values lower than the 7 hours advised by (Gupta et al., 2017; Roberts et al., 2018; Sargent et al., 2021; Swinbourne et al., 2016; Walsh et al., 2021; Watson et al., 2015). Moreover, they presented TST <7h, an indicator of inappropriate sleep quantity by (M. Ohayon et al., 2017) (6.83-6.74-6.51) at Pre-C, NC and Post-C. Unlike women, men had less sleep time after competition than in the Pre-C and NC period. Male athletes presented SE values from (75.15-78.61%) in Pre-C, NC and Post-C, considered uncertain for sleep efficiency for young people as reported by (M. Ohayon et al., 2017). Although they present 78.57 in the NC, their SE values are low. On the other hand, men showed differences in the PSQI score, interpreting that they slept better and felt higher well-being in Post-C than in Pre-C.

It is important and advisable to ensure sufficient sleep times, in anticipation of competitions, however, when failed, a period of sleep extension might be a beneficial measure (Kölling et al., 2016). As there is a large degree of inter-individual variability (Staunton et al., 2017), an individual approach to monitor sleep, training loads and competition can lead to better understanding of how athletes cope with highly demanding competitions, and therefore it is necessary, as suggested by (J. Costa et al., 2019).

The competition program was distributed with morning and afternoon events, with the last competition ending at 5 pm. Therefore, the timing of the various competitions does not seem to be relevant in the analysis of the sleep pattern in these athletes, however its influence was not verified on the contraryas presented by (Sargent & Roach, 2016; Staunton et al., 2017)

Checking the results of our study and sleep timing recommendations, we see that: The athlete's sleep is usually characterised by habitual sleep durations of less than7 hours and poor sleep quality (eg, sleep fragmentation) as described by (Gupta et al., 2017; Roberts et al., 2018; Sargent et al., 2021; Swinbourne et al., 2016; Walsh et al., 2021; Watson et al., 2015). Some of the athletes have presented sleep dissatisfaction, unrefreshing sleep, or were categorized as 'poor sleepers' (PSQI) at TCs, TH and Pre-C, as reported by (Halson et al., 2021; Tuomilehto et al., 2017). On the other hand, our athletes did not show long SOL, contrary to what has been shown by (Schaal et al., 2011; Tuomilehto et al., 2017), nor day-time sleepiness (Swinbourne et al., 2016) andday-time fatigue (Sargent, Lastella, et al., 2014).

At the ages most relevant to aspiring and established athletes, as our sample, a sleep of 8–10 hours for an adolescent (aged 15-17 years) is advised and appropriate (M. Ohayon et al., 2004; Watson et al., 2015). However, experts speculate that athletes need more time to recover from the physical and psychological demands of the sport (Bird, 2013). In our studies on TC1, TH and TC2, female and male athletes presented values very close to 7 hours, and sometimes less than 7 hours, which is lower than recommended time. In the period before the competition (5 days before) and during the competition, the athletes slept less than recommended, not taking advantage of the benefits that a night's sleep could bring.

Although the effect of a restricted night can be characterized as short-term, training plans should consider appropriate buffers for such instances (Kölling et al., 2016). Alternatively, possible deteriorations in performance together with mood disturbances should be anticipated when such detrimental circumstances cannot be avoided (Kölling et al., 2016).

Moreover, habitual sleep duration proved to be shorter in athletes from individual sports than in athletes from team sports, despite their similar sleep needs (Halson et al., 2021; Sargent et al., 2021). Further studies to better understand the differences between team and individual sports are needed.

Although the athletes reported the need of 8.3 hours of sleep to feel rested, they just slept 6.7 hours (Sargent et al., 2021).

Nevertheless, we think it is important to highlight the strategies that focus on improving the sleep environment (removal of light, technology and noise, 17°C–22°C temperature) may increase sleep duration (Bonnar et al., 2018). The naps offer a suitable strategy to supplement lost sleep, with 20–30 min naps improving sprint (Waterhouse et al., 2007) and peak jump velocity performance (O'Donnell et al., 2018). The nap durations of <20 minutes on competition-day may be beneficial for athletic performance. Competition day napping may be used to alleviate sleep debt and sleepiness that can occur from the night prior to competition (O'Donnell et al., 2018). Athletes could sleep 30 min (napping) to reduce sleep inertia prior to training or competition to obtain better performance outcomes (Lastella et al., 2021).

In addition to the Actigraphy, we also applied the Pittsburgh Sleep Quality Index (PSQI) retrospective questionnaire and the Pittsburgh Sleep Diary (PghSD), to cross-reference information whenever necessary and to compare the results obtained by the different instruments.

The PSQI retrospective questionnaire was sensitive to changes in the sleep pattern of female and male athletes, compared with data collected by sleep actigraphy data. The PSQI was administered on a regular basis, as suggested by (Halson et al., 2021), considering the variability between individuals and the defined objectives.

Comparing the actigraph sleep data results with PghSD (Latency, SOS, TST, Wake up time, SE and WASO) at Pre-C, NC and Post-C, we found differences in latency, TST, SE and WASO, overestimated results in both sexes as presented by (Walsh et al., 2021). However, no differences were founded in the SOS and Wake up Time between instruments data.

On the other hand, the PghSD gave a perceived perception of sleep efficiency, the hours they turned off the lights, the number of times they woke up, why they woke up and the method they used to wake up. This information may be important to understand the patterns of athletes, and their possible relationship with the night's sleep. Furthermore, the actigraphy does not allow this information to be collected.

The main advantage of questionnaires is that they do not require any device or any sleep context of the patient (Ibáñez et al., 2018), being a validated and inexpensive tool for coaches, sports scientists and researchers to apply to athletes. We must take into consideration that sleep diaries has the advantage of allowing the breakdown of the different days of the week, capture night-to-night variability in sleep while in retrospective questionnaires this is not possible (Bei et al., 2016; Carney et al., 2012; Dietch et al., 2019).

In addition, the application of the PSQI and the PghSD can be useful to administer with actigraphy for any doubts about the actigraphic data or data that the actigraphy does not collect.

5.4.1 Limitations

The athlete sleep is influenced by sport-specific factors (relating to training, travel and competition) and non-sport factors (eg, gender, stress and anxiety) and also by societal factors (eg, pervasive use of smart phones and social media in an 'always connected' society) (Gupta et al., 2017; Halson, 2016; Walsh et al., 2021).

Several factors were not included in the present study. As exampes, the chronotype, core body temperature, hormones (e.g., menstrual cycle), level of light exposure during daytime, and food intake before bedtime were not measured/controlled, although they were suggested. We recognize this as a limitation of the study. Therefore, the mechanisms underlying the changes in the sleep patterns observed can only be speculated.

5.5 Conclusion

In conclusion, women and men athletes showed different patterns of sleep and well-being at training camps, training at homes and Pre-Competition, Nacional Competition and Post-Competition. Female and male athletes presented sleep patterns that vary differently to training and overnight location, competition period and training load. Based on these differences, we suggest analysing the sleep data of men and women separately.

The athlete's sleep patterns were found characterised usually by habitual sleep durations of less than 7 hours and poor sleep quality. Both sexes showed inappropriate total sleep time and uncertain sleep efficiency at training camps and training at home, Pre-Competition, National competition and Post-Competition, comparing to what is recommended for their age. Possibly it will be important to monitor the sleep patterns of athletes, adapting training schedules and travel to competition. We think it is important to highlight the strategies that focus on improving the sleep environment, in which the naps could offer a suitable strategy to supplement lost sleep.

In training at home, both sexes spent less time in their beds and less total sleep time, even training less than in training camps. Possibly because of their off-training schedules (school, morning training, travel, etc). Sport scientists, coaches and family must pay attention and give importance to controlling training and off-training schedules and its influence on athletes' sleep patterns. In these situations, we suggest that athletes adjust their schedule by anticipating the time to go to bed, but also by compensating through naps.

Male athletes presented higher sleep fragmentation at TC1, TH and TC2 than female athletes. Moreover, they showed no differences between the 3 periods of competition in their sleep patterns.

Some of the athletes have presented sleep dissatisfaction, unrefreshing sleep, or were categorized as 'poor sleepers' (PSQI) at TCs, TH and Pre-C. The athletes did not show long sleep onset, nor day-time sleepiness andday-time fatigue.

The PSQI retrospective questionnaire was sensitive to changes in the sleep pattern of female and male athletes, compared with data collected by sleep actigraphy data. Comparing the actigraph sleep data results with PghSD no differences were founded in the sleep onset and Wake up Time. In addition, the application of the PSQI and the PghSD can be useful to administer with actigraphy for answering any doubts about the actigraphic data or data that the actigraphy does not collect.

Chapter VI

Assess of training camps and training at homes for national teams selection and Pre-competition, National Competition and Post-competition on daily physical behaviours patterns off-training in young sprint canoes and kayakers athletes

6 Assess of training camps and training at homes for national teams selection and Pre-competition, National Competition and Post-competition on daily physical behaviours patterns off-training in young sprint canoes and kayakers athletes

6.1 Introduction

Young athletes are currently subjected to a lot of pressure from their daily routines (school, family and training schedules) in their daily lives. Athletes frequently plan in their schedule their training and off-training for months in advance, to ensure progressive adaptation and prevent fatigue, boredom, and injury (Sperlich et al., 2017). A fundamental goal is to distribute exercise and off-training effectively over a certain period to achieve optimal adaptation.

Past investigations focused on analysing and optimizing the quality of training (Fiskerstrand and Seiler, 2004; Stoggl and Sperlich, 2015), however very little is known about the intensity and volume of physical activity (PA) performed by elite athletes during their off-training time (Sperlich et al., 2017) , which accounts for more than 80% of awaken time. Therefore, 83% of the remaining awaken time can be spent in activities that may improve recovery (~ 13 hours) (Sperlich et al., 2017).

Hence, it is crucial to highlight the importance of an all-day, 24-h integrative perspective on training, emphasizing the fact that conditions outside training significantly modulate adaptation, thereby complicating analysis of the distribution of training intensity (Izzicupo et al., 2019; Sperlich et al., 2017). Considering the illustration of the final conceptual model of movement-based terminology arranged around a 24-h period (Tremblay et al., 2017), the 66.6% of the full day is spent in awaken activities (~ 16 hours).

For example, the elite rowers invest a considerable amount of time for their training averaging >1,000 h per year (Fiskerstrand and Seiler, 2004) i.e., approximately 17% of awaken time in training (~ 2 – 3 hours) (A. Fiskerstrand & Seiler, 2004). Nevertheless, a great proportion of available time is not spent for training but for recovery including activities of daily living, such as studying, working, traveling etc (Izzicupo et al., 2019). Moreover, common recovery strategies need from minutes to 1-2 hours (massages, cold water immersion, active recovery) (Sperlich et al., 2017). All of these activities modulate psycho-biological responses to training (Sperlich et al., 2017).

In days without sport practice children did not meet national PA recommendations (Ala-Kitula et al., 2019). The daily moderate to vigorous physical activity was twice as high on days with training, as compared to days without training both on weekdays and on weekend (Ala-Kitula et al., 2019). Furthermore, PA preceding soccer practice had a positive correlation with all PA intensity levels during practice (Ala-Kitula et al., 2019).

The university athletes have similar PA levels of non-athletes, mainly in the case of sedentary behaviour (Clemente et al., 2016). The comparison between recreational and competitive master athletes showed contrasting results (Exel et al., 2019; McCracken & Dogra, 2018). Master amateur runners and footballers presented enough levels of sustained MVPA and vigorous activity regarding what is recommended by the WHO, however, they also presented risky prolonged sedentary time (Exel et al., 2019). Furthermore, different sports influenced on different distributions of PA levels in adults (Exel et al., 2019). Moreover, the PA profiles were shown to be shaped by school time and activities (Mateus et al., 2021).

In physically active males runners, the high amount of habitual daily light-intensity PA together with prescribed endurance training was associated with good training response (Hautala et al., 2012). However, the recommendations for PA were not reached, showing 4.8 min p/day of moderate to very high PA (Hautala et al., 2012).

Professional football players showed 1.16 h per day of moderate or vigorous activity off-training (Weiler et al., 2015), more than what current public health guidelines recommend. However, even though players have reached the recommendations for PA, they showed alarming SB values of 500.6 min p/day (8.3 hours - 79% of waking hours) (Weiler et al., 2015). The national elite German rowers presented moderate or vigorous activity 1.27 h per day during the week and 1.12 h per day on the weekend, with a tendency to be higher on the weekdays than on weekends (Sperlich et al., 2017).

The female athletes showed moderate or vigorous activity 0.86 h per day and male athletes 0.97 h per day (Clemente et al., 2016), not achieving WHO recommendations.

Master athletes in amateur sports (male and female runners and male footballers) showed moderate or vigorous activity 1.31 h to 1.52 h per day (Exel et al., 2019; McCracken & Dogra, 2018). Regional level under-15 male outfield soccer players showed moderate or vigorous activity of 1.52 h per day (Mateus et al., 2021). Boys' Junior soccer team (12-13-year-old) and football practice were accounted in the PA data, showing 2.38 h of moderate or vigorous activity per day at training days and 1.27 h per day at non training days (Ala-Kitula et al., 2019).

Although some studies have shown that athletes achieve the PA recommendations off-training, the recommendations are not always achieved. On the other hand,the collection and analysis methodologies are not similar and comparable. Furthermore, the information we found in young athletes is very limited to non-existent in canoeing athletes.

Indeed, when the PA recommendations are reached in off-training, most of the time they present concerns SB values. In addition, there is a lack of evidence in scientific literature about the percussions of off-training PBs in competitive athletes on recovery, training adaptations and performance, as well as on short and long-term effects in their career (Izzicupo et al., 2019).

Physical Behaviours while awake affect the bodily systems (e.g., vascular system, endocrine system, and immune system), metabolic pathways (i.e., glucose and lipids), systemic and local inflammation, mood, fatigue and cognition (Pedersen & Saltin, 2015). Furthermore, the lifestyle changed significantly in the last years, and accelerometry micro-technology progressed enormously in recent years (Freedson, 2018).

For example, the Active Couch Potato phenomenon showed that metabolic consequences of time spent watching TV are adverse, even among those considered to be sufficiently physically active to reduce their chronic disease risk (Owen et al., 2010). This finding reinforces the potential importance of the deleterious health consequences of prolonged sitting time, which may be independent of the protective effect of regular moderate-intensity physical activity (Owen et al., 2010).

On the other hand, studies analysing breaks in sedentary time (as distinct from the overall volume of time spent being sedentary) have shown they have beneficial associations with metabolic biomarkers, including body mass index and triglycerides (Healy et al., 2008). In fact, adult people that interrupted their sedentary time more frequently had, on average, a 6cm smaller waist circumference than people that didn't break, independently of total sedentary time, moderate-to-vigorous intensity activity time and mean intensity of activity.

In this context, sedentary off-training behaviour may negatively affect recovery and long-term adaptation to exercise and health (Sperlich et al., 2017).

Young soccer players revealed alarming SB patterns, with long-periods of SB during off-training periods (Mateus et al., 2021).

Comparison between athlete and non-athlete university students suggested proximity between PA levels, mainly in the case of sedentary behaviour (Clemente et al., 2016). The female athletes showed sedentary time of 12.17 h per day and male athletes 12.29 h per day (Clemente et al., 2016).

Male and Female Masters and Recreational Athletes showed for male of sedentary time 4.72 h per day and female 5.63 h per day (McCracken & Dogra, 2018).

Júdice and collaborators reported 7.70 h per day of sedentary behaviour in elite Portuguese athletes from different sports and disciplines (Avergae age of 21.8years) (Júdice et al., 2014). Similarly, to what occurs in the general population, individuals with high levels of moderate-to-vigorous physical activity presented a positive association between time spent in sedentary behaviour and total as well as abdominal fat, regardless of exercise training volume (Júdice et al., 2014).

The elite professional footballers showed sedentary time of 8.34 h per day (Weiler et al., 2015). The national elite rowers sedentary time was 11.63 h per day during the week and 12.49 h per day on the weekend, with a tendency to be higher on the weekend compared to weekdays (Sperlich et al., 2017).

All the studies that assessed SB reported worrisome levels of sedentariness and no difference emerged when competitive athletes were compared to non-athletes or recreational athletes. The effect of the remaining 10-13 hours of awaken time was investigated in a restricted number of studies. We do not know of studies with the application of the Off training (SPA and SB) in canoeing on specifically elite young canoe and kayak athletes. However, we hypothesize that they also have high times in sedentary behaviour and that they may not reach the off-training MVPA recommendations.

The objectives of this chapter were:

1. Characterize and analyse Off-training in elite women and men young canoe and kayak athletes SPA and SB patterns on national training camp and when training at home;
2. Characterize and analyse Off-training in elite women and men young canoe and kayak athletes SPA and SB patterns in two national training camps; in preparation for an international competition (European Canoeing Championships Junior & U23).

3. Characterize and analyse Off-training elite women and men young canoe and kayak athletes SPA and SB patterns in Pre-competition and Post-competition.

6.2 Materials and Methods

6.2.1 Participants

Fifteen elite young athletes (6 females; age: 17.4 ± 0.4 years; training experience: 8.3 ± 1.5 years; height: 164.3 ± 3.0 cm; body mass: 61.3 ± 6.4 kg; fat %: 21.2 ± 5.7 %. 9 males; age: 17.3 ± 0.8 years; training experience: 6.6 ± 0.9 years; height: 173.4 ± 4.1 cm; body mass: 73.1 ± 6.0 kg; fat %: 11.2 ± 3.1 %.) from the Portuguese National Canoeing Team (canoe sprint) took part in this study. All the athletes had at least 5 years of experience in competitive canoeing. After receiving the detailed explanation of the purposes and procedures of the study, the legal guardians and the athletes provided their written consent. The athletes visited the laboratory one time during which they accomplished the anthropometric measurements with experienced researcher. The local Ethics Committee of the Faculty of Sports Science and Physical Education, University of Coimbra (CE/FCDEF-UC/00292019) approved the procedures.

Table 11: Participants characterization, descriptive statistics (mean ± standard deviation).

	Women n=6		
	Min	Max	Mean ± SD
CA (yrs)	16.8	17.8	17.4 ± 0.4
TE (yrs)	6.0	10.0	8.3 ± 1.5
Stature (cm)	160.3	167.2	164.3 ± 3.0
BM (Kg)	50.6	69.6	61.3 ±6.4
Fat %	13.3	27.7	21.2 ± 5.7
	Men n=9		
	Min	Max	Mean ± SD
CA (yrs)	16.5	18.3	17.3 ± 0.8
TE (yrs)	5.0	8.0	6.6 ± 0.9
Stature (cm)	167.2	179.2	173.4 ± 4.1
BM (Kg)	64.6	79.0	73.1 ± 6.0
Fat %	6.8	15.1	11.2 ± 3.1

note: CA chronological age; BM body mass; TE training experience; yrs years.

6.2.2 Experimental Design

The day before the beginning of the study, athletes were required to avoid fatigue accumulation; all participants asked to abstain from intense physical exertion and only a light intensity workout 24 h before beginning the training camp.

The anthropometric and body composition assessments were done before the training camp started. Body mass was measured using a calibrated scale (Seca 770, Hamburgo, Germany) and stature and sitting height were measured using a standard stadiometer (Harpenden 98.607, Holtain, UK). Body composition was assessed through Multi-frequency bioelectrical impedance analyzer (InBody770; Biospace, Seoul, Korea). The off-training (SPA and SB) of the athletes were not constrained by the study procedures, assuring higher ecological validity to the investigation. During each training session, training load were calculated through sRPE were assessed. Well-being were assessed before each night-sleep.

They became familiar with the accelerometer device habituation period, during the 2 weeks prior to the first study, athletes were familiarized with the devices used during the investigation to avoid training activities or off-training pattern being disturbed by the equipment. In the three studies, athletes used the accelerometer on the waist to measure SPA and SB patterns. The athletes were not free to consume caffeine during the data collection period.

The athletes were exposed three different sport preparation and competition contexts, namely, Training at Camp, Training at Home and pre and post Competition. The collection occurred in three different moments (training camp vs training home; training camp 1 vs training camp 2; pre and post competition).

Training camp and training at home

We analyse the athletes SPA and SB patterns at training camp (routines of training camp) vs training at home (with the routines in their homes without the constraints of a training camp) the athletes were monitored daily over two weeks.

The training at training camp the athletes performed at high-performance center (HPC) with 2000 meters length, 135 meters width and 3,5 meters depth, the course has a cooling down and a warming up channel, a cycle path, and a technical area to support the training. The structure includes hangars, showers, bathrooms, sauna, Turkish bath, jacuzzi, gymnasium and polyvalent rooms. At training camp, the athletes were meals and slept and spent most of their leisure time in two training residences, with athletes being able to stroll freely in the village. A small residence with one kitchen, one living room, two bathrooms and three bedrooms for four people. A big residence with one canteen, where all meals (breakfast, snacks, lunches and dinners) were held, three bathrooms, one study room, one games room, two living room with TV, one garden, one laundry, ten double rooms, two single rooms and one room for four people. At the training camp, two to four athletes slept in one room. Girls and boys were accommodated in separate buildings. Bedtimes could be chosen freely, but the athletes were obligated to stay at their rooms at 22:30 h and to keep night-time peace at 23:00 h. Both residences are located in a village, with 3100 habitants in the central region of Portugal.

The training at home, the athletes trained on their clubs with natural water plans - rivers, lakes, and reservoirs. They slept in their homes, ate meals and leisure activities freely with the usual conditions they were familiar. During their stay in their homes, the athletes had no indication of bedtime or waking hours, leaving the athletes in their normal state of familiar behaviour. Ten of the athletes lived in the northern, three in the central and two in the southern region of the country.

The first week at a training camp at the HPC and the second week a training home on their own clubs. The canoeists completed the training programs prescribed by national coaches in training camp and the training clubs by their coaches. On average, they trained seven days/week, nine sessions water, three sessions strength and conditioning, and three sessions run per week.

Training at camp had the following meteorological values of maximum air temperature at 1.5m (21.5 ± 3.5°C), minimum air temperature at 1.5m (13.0 ± 0.7°C), maximum relative humidity (98.1 ± 2.7%), minimum relative humidity (59.9 ± 16.9%), average wind intensity (1.8 ± 0.4m/s). Training at home had the following meteorological values of maximum air temperature at 1.5m (18.3 ± 1.1°C), minimum air temperature at 1.5m (12.1 ± 1.1°C), maximum relative humidity (99 ± 1.4%), minimum relative humidity (65.6 ± 5.4%), average wind intensity (2.1 ± 0.5m/s) values according by Portuguese Institute for Sea and Atmosphere (IPMA).

Training camp 1 and training camp 2

In the second study, we analyse the athletes SPA and SB patterns in two different training camps, with one-month delay. The participants were monitored daily over two weeks with an interval of 2 weeks. First week a training camp on the same HPC. Second week a training camp in the same HPC with the same conditions to the first week. The canoeists completed the training programs prescribed by the national coaches. On average, they trained seven days/week, nine sessions water, three sessions strength and conditioning, and three sessions run per week. These two training camps were part of the preparation to the European Championship.

In the two weeks, athletes used the accelerometer device on the waist to measure the SPA and SB over two training camps.

Training camp 1 had the following meteorological values of maximum air temperature at 1.5m (21.5 ± 3.5°C), minimum air temperature at 1.5m (13.0 ± 0.7°C), maximum relative humidity (98.1 ± 2.7%), minimum relative humidity (59.9 ± 16.9%), average wind intensity (1.8 ± 0.4m/s).

Training camp 2 had the following meteorological values of maximum air temperature at 1.5m (23.2 ± 3.2°C), minimum air temperature at 1.5m (13.7 ± 0.3°C), maximum relative humidity (99.3 ± 1.5%), minimum relative humidity (60.8 ± 6.9%), average wind intensity (2.4 ± 0.3m/s) values according by IPMA.

Pre, post and competition phase

At the competition, the five days before the competition and the three days after the competition, the athletes faced the environment described in their homes. The canoeists completed the training programs prescribed by their coaches in the five days before competition and in the three days after competition. The competition was performed in HPC facilities with the characteristics described above. Athletes on competition days slept on their own in an unconditioned way, staying in hotels or rented houses during this period. On average (8 days - 5 days before and 3 days after), they trained the eight days, seven sessions water, two sessions strength and conditioning and one session run per week.

In the ten days, athletes used the accelerometer to measure the SPA and SB over ten days, also the two days of competition. Ambient temperature normally ranged between 18–26°C.

Pre and competition phase had the following meteorological values of maximum air temperature at 1.5m (25.8 ± 1.2°C), minimum air temperature at 1.5m (16.9 ± 0.7°C), and average wind intensity (1.8 ± 0.4m/s).

Post competition phase 2 had the following meteorological values of maximum air temperature at 1.5m (25.3 ± 2.0°C), minimum air temperature at 1.5m (15.9 ± 0.7°C), and average wind intensity (2.3 ± 0.3m/s) values according by IPMA.

6.2.3 Experimental Design

The experimental design was as followed in figure 8

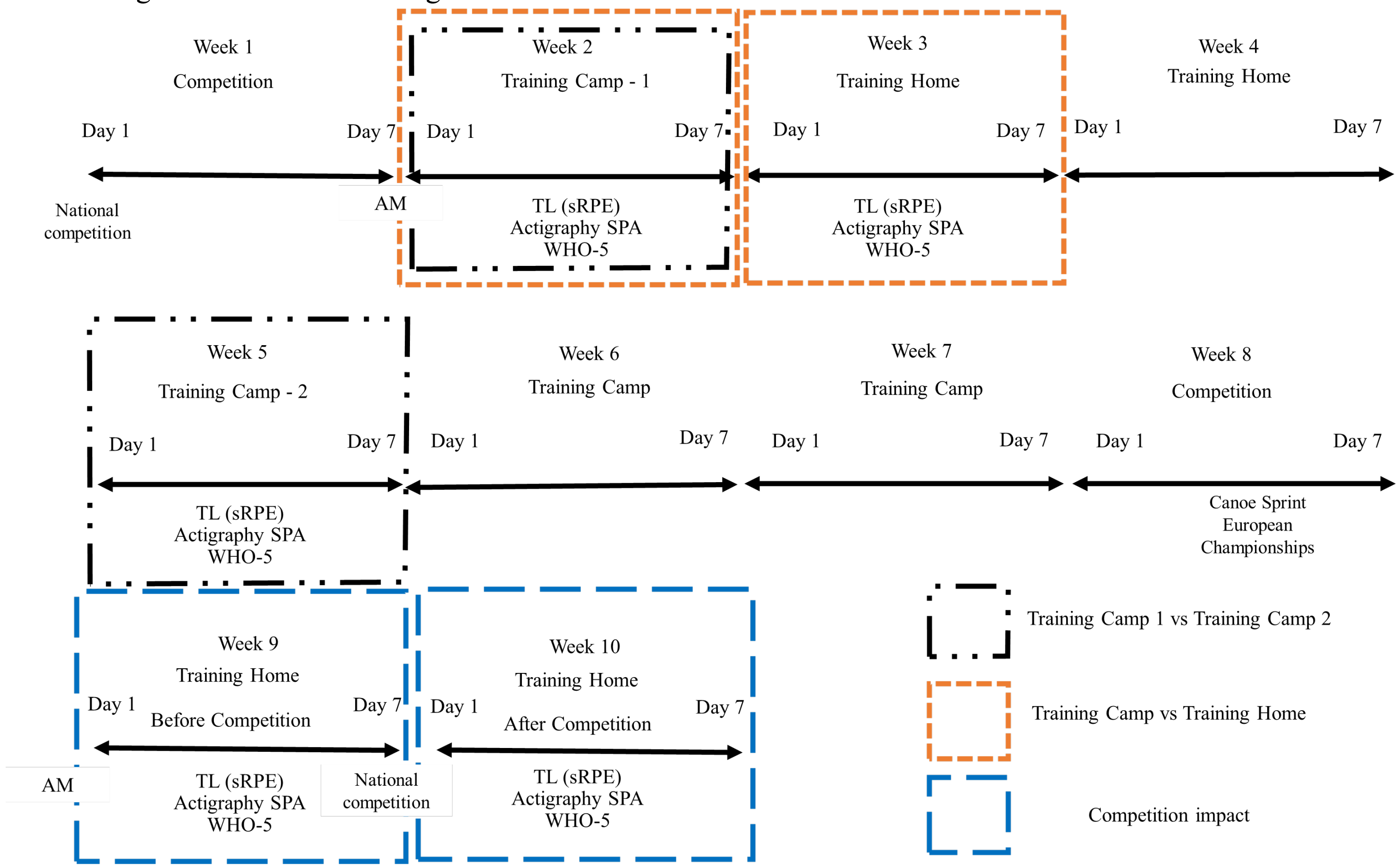

Figure 8: Experimental design

Note: *SPA* spontaneous physical activity; *TL* training load; *WHO-5* World Health Organization Well-Being Index; *AM* anthropometric measurements; *sRPE* Session Rating of Perceived Exertion.

6.2.4 Spontaneous physical activity and Sedentary behaviour

To measure SPA and SB patterns we used the GT3X+ (ActiGraph, Pensacola, FL), a device of increasing use in a wide variety of research settings in children and adults (Crouter et al., 2006). Athletes used the accelerometer only during non-training time, as well as the instructions of how to use it. The athletes wear the monitor in the dominant side of their hip fixed at the waist and positioned on the anterior axillary line at the iliac crest level of the right or left hip (Romanzini et al., 2014), and only removing it for scheduled training sessions and showering. After to finish the collect data, athletes turned to laboratory to remove the accelerometer.

These accelerometers were programmed to start recording at midnight of the day following the exam and to record activity. The triaxial acceleration recorded by the monitoring device at 30 Hz of sampling frequency was processed using ActiLife® 6.10 software (ActiGraph LLC, Fort Walton Beach, FL, USA). The data were chunked in 15 seconds epochs. Sixty or more minutes of zero accelerometer counts were considered non-wear time, therefore excluded from analysis.

The hours spent in each physical activity category were calculated for every valid day of data recorded, where a valid day consists of at least 600 minutes (10 hours) of accelerometer wear time per day during waking hours of the non-training period in correspondence with (Sievänen & Kujala, 2017; Trost et al., 2005) and a minimum of five weekdays of data were considered to represent an athlete's weekly profile. In adolescents, <4–9 days of monitoring are normally considered appropriate to obtain reliable estimates of physical activity (PA) which is in accordance with recommendations given (Trost et al., 2005). Data classified as time in bed and invalid days were excluded from the analyses (Sperlich et al., 2017).

We apply the Choi algorithm an improvement of the Troiano algorithm and is intended to more accurately estimate time spent in sedentary and active behaviour (Choi et al., 2011; Quante et al., 2015). To calculate the variables associated to each PA intensity were used the algorithm was based on Romanzini et al. for adolescents (Romanzini et al., 2014).

The SPA and SB was considered 0–180 counts min−1, light PA was 181–756 counts min−1, moderate PA was 757–1111 counts min−1, and vigorous PA was ≥1112 counts min−1. The sedentary behaviour was analysed through the ActiGraph®

inclinometer measures (Exel et al., 2018; Sperlich et al., 2017). The thresholds used in this study were selected based on available evidence and the best judgment of the authors.

The sample, initially consisted of 16 athletes, after applying the criteria, at least 600 minutes wear time validation, 1 athlete was eliminated of first training camp.

The Actilife software allowed to extract the total daily and hourly counts per minute (cpm) of sedentary time (minutes per day), light PA (minutes per day), moderate PA (minutes per day) and vigorous PA (minutes per day) and number of steps per day.

6.2.5 Well-being

The 5-item World Health Organization Well-Being Index (WHO-5) is among the most widely used questionnaires assessing subjective psychological well-being (Topp et al., 2015). The WHO-5 was used in Portuguese youth population (Pereira Simões et al., 2018). The WHO-5 Well-being Index is a short, self-administered questionnaire covering 5 positively worded items, related to positive mood (good spirits, relaxation), vitality (being active and waking up fresh and rested), and general interests (being interested in things). Administering the WHO-5 Well-being Index takes 2-3 minutes. The WHO-5 can be applied ad hoc in situations where there is a need for additional information on the athlete's mood. The athletes fill the WHO-5 before sleep. Each of the five items is rated on a 6-point Likert scale from 0 (= not present) to 5 (= constantly present). Scores are summated, with raw score ranging from 0 to 25. Then the scores are transformed to 0-100 by multiplying by 4, with higher scores meaning better well-being. Evidence suggests, a score of 50 or below is indicative for low mood, though not necessarily depression. To monitor possible changes in well-being, a 10% difference can be regarded as a significant change.

Quantification Training Load

6.2.6 sRPE

For quantification of session training load (TL), we used the sRPE. This procedure consisted of asking to the athletes to rate their level of perceived exertion using the CR100 (Borg & Borg, 2002; Borg & Kaijser, 2006) scale 30 min post-exercise. This perceptual value was multiplied by the session duration in minutes (Oliveira Borges et al., 2014). The sRPE results were divided by 10 to allow for comparison with previous studies that used the CR10 scale (Impellizzeri et al., 2004; Rabelo et al., 2016; Wallace et al., 2009). The 14-day training camp was separated into two 7-day (microcycle) (W1 and W2).

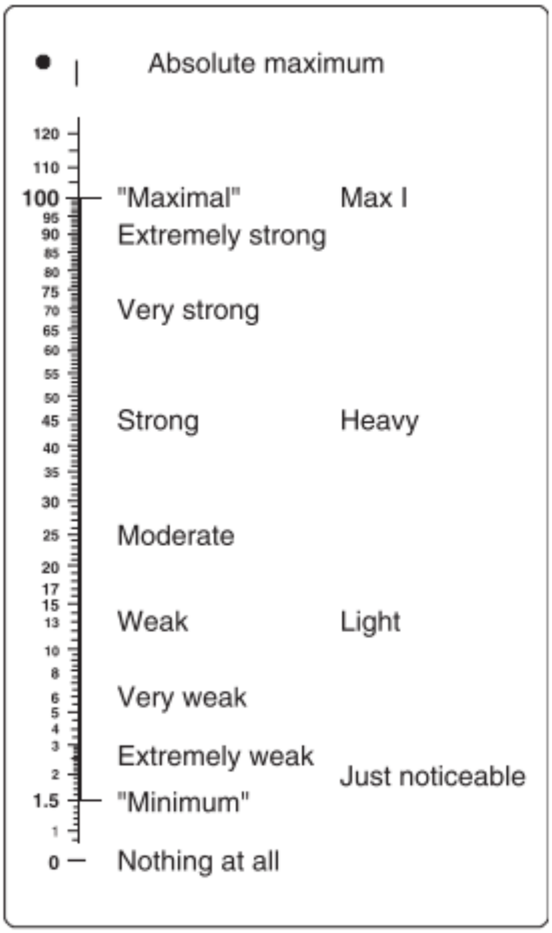

Figure 9: Borg centiMAx (CR100) scale (Borg & Borg, 2002; Borg & Kaijser, 2006)

6.2.7 Statistical analysis

All data will be present by descriptive values (mean, standart deviation, minimum and maximum). For the data analysis of actigraph, we will use the ActiLife software. The actigraph PA and SB data, World Health Organization Well-Being Index (WHO-5) and training load at Training Camp 1 (TC1), Training Home (TH), Training Camp 2 (TC2), Pré-Competition, Competition (Pre-C) and Post-Competition (Post-C) were assessed for non-normal distribution using the Shapiro-wilk test.

To verify differences between sexes at TC1, TH, TC2 comparisons were analysed using Mann-Whitney U test. The intra-sex differences for each TC1, TH and TC2 were analysed using three-factor ANOVA Bonferroni corrected paired-sample t-teste.

To verify differences actigraph SPA and SB data, WHO-5 and training load between sexes at Pre-Competition and Post-Competition comparisons were analysed using

Mann-Whitney U test. The differences the Pré-Competition and Post-Competition were analysed using Wilcoxon signed rank test.

The effect sized (ES) were qualitatively interpreted using the following thresholds: <0.2, trivial; 0.2-0.6, small; 0.6-1.2, moderate; 1.2-2.0, large; 2.0-4.0, very large; >4.0, huge (Hopkins et al., 2009).

The correlation relationship strength values were classified according to: 0.50-1.00, large; 0.30-0.49, moderate; 0.10-0.29, small (Cohen, 1988). When the 95% CI overlapped positive and negative values, the effect was unclear. To verify the association between the sRPE and Sedentary behaviour data, we applied a correlation between with post-hoc Spearman Ro.

Statistical significance for all procedures was set at $p<0.05$.

6.3 Results

The results of physical activity, sedentary behaviour, wear time, training load and well-being at Training Camp 1, Training Home and Training Camp 2 are present in table 12.

6.3.1 Training camp 1 training, at home and training camp 2

The variables under study showed a non-normal distribution which leads us toopted for non-parametric statistics.

Table 12: Displays actigraphy Sedentary Behaviour, Ligth PA, Moderate PA and Vigorous PA in both sexes at Training Camp 1, Training Home and Training Camp 2

		Training Camp 1			Training Home			Training Camp 2		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Women	Wear time per day (minutes)	601	925	808.8 ± 82.64	713.0	925.0	849.7 ± 56.6	702.0	902.0	818.1 ± 76.7
	Sedentary behaviour (minutes)	374.5	701.8	495.7 ± 78.5	387.0	660.3	534.5 ± 68.4	388.0	589.5	464.1 ± 63.6
	Light PA (minutes)	122.8	297.3	209.4 ± 37.01*[a]	150.8	347.8	217.4 ± 46.4	173.5	305.8	231.2 ± 40.7*
	Moderate PA (minutes)	14.8	53.8	32.7 ± 8.6*	18.0	60.8	29.7 ± 7.9	23.0	59.8	38.7 ± 10.4*
	Vigorous PA (minutes)	32.0	135.3	71.1 ± 24.4	35.8	121.3	68.3 ± 19.4*	60.3	114.0	84.2 ± 19.9
	MVPA (minutes)	53.0	177.0	103.9 ± 29.3	60.0	145.0	98 ± 20.4**	85.0	165.0	123.0 ± 28.5
	Sedentary behaviour (%)	48	76	61.2 ± 6.1*	45.0	73.0	62.8 ± 5.9	48.0	67.0	56.7 ± 6.1
	Light PA (%)	16.0	34.0	25.9 ± 4.0	17.0	40.0	25.5 ± 5.3	23.0	34.0	28.1 ± 3.6
	Moderate PA (%)	2.0	6.0	4.1 ± 0.9*	2.0	7.0	3.6 ± 0.9	3.0	7.0	4.9 ± 1.3
	Vigorous PA (%)	4.0	16.0	8.9 ± 3.1	4.0	14.0	8.1 ± 2.4*	7.0	13.0	10.3 ± 2.1
	MVPA (%)	6.0	22.0	12.9 ± 3.7	7.0	16.0	11.5 ± 2.5	10.0	20.0	15.1 ± 3.1
	Steps per day	3991.0	14775.0	7628.1 ± 2690.0	3587.0	11896.0	7708.1 ± 2068.9	5234.0	11265.0	7922.1 ± 1907.8
	WHO-5	36	92	69.14 ± 14.00**	36	96	73.2 ± 15.6*[a]	80	100	88.1 ± 5.8[b]
	sRPE (AU)	1225	15390	7112.38 ± 4416.53	360	11440	3876.8 ± 2940.9**	720	13020	6717.1 ± 3892.7*
Men	Wear time per day (minutes)	601.0	926.0	799.5 ± 95.3	600.0	927.0	806.8 ± 110.1	616.0	918.0	779.0 ± 83.3[b]
	Sedentary behaviour (minutes)	280.0	656.0	463.1± 77.2	252.0	700.1	493.8 ± 94.5	253.8	695.0	473.0 ± 94.0
	Light PA (minutes)	122.5	327.0	225.5 ± 42.6	94.8	387.3	229.7 ± 68.9	104.8	256.3	199.0 ± 35.6[b]
	Moderate PA (minutes)	14.0	58.0	37.0 ± 8.9[a]	10.5	46.5	27.2 ± 9.1	11.3	62.0	32.3 ± 9.3[b]
	Vigorous PA (minutes)	32.8	110.8	74.0 ± 18.4[a]	23.5	112.5	56.2 ± 21.2	44.5	119.0	74.9 ± 16.6[a]
	MVPA (minutes)	51.0	169.0	111.0 ± 24.1[a]	38.0	133.0	83.5 ± 26.1	67.0	168.0	107.2 ± 22.3
	Sedentary behaviour (%)	41.0	71.0	57.9 ± 6.2	35.0	81.0	61.2 ± 9.1	41.0	79.0	60.3 ± 7.6
	Light PA (%)	19.0	43.0	28.2 ± 5.1	15.0	54.0	28.3 ± 7.7	12.0	40.0	25.8 ± 5.3
	Moderate PA (%)	2.0	7.0	4.6 ± 1.1[a]	2.0	6.0	3.4 ± 1.0	1.0	7.0	4.2 ± 1.3
	Vigorous PA (%)	5.0	15.0	9.2 ± 2.0[a]	3.0	15.0	7.1 ± 2.8	6.0	15.0	9.7 ± 2.2[a]
	MVPA (%)	8.0	21.0	13.9 ± 2.6[a]	5.0	18.0	10.4 ± 3.2	7.0	21.0	13.9 ± 3.1[a]
	Steps per day	4295.0	12318.0	8076.1 ± 1763.8[a]	1449.0	12085.0	6504.3 ± 2595.6	4543.0	10973.0	7225.0 ± 1744.4[b]
	WHO-5	56	100	82.3 ± 11.2	48	100	82.1 ± 12.2	56	100	87.1 ± 9.5
	sRPE (AU)	800	16150	7338.3 ± 4493.9	1750	12825	5563.1 ± 2818.8	700	19434	8909.6 ± 5439.3[a]

* Difference between sexes TC1, TH and TC2 <0.05; ** difference between sexes TC1, TH and TC2 <0.01; [a] difference with Training Home; [b] differences with Training Camp 1; *PA* Physical Activity; *WHO-5* World Health Organization Well-Being Index; *sRPE* Session Rating of Perceived Exertion; *min* minutes.

Descriptive data values of SB and PA: Ligth PA, Moderate PA, Vigorous PA and Moderate and Vigorous Physical Activity (MVPA) express in minutes and percentage at Training Camp 1, Training Home and Training Camp 2 is presented in the table 12. We found differences between sex in the following variables at Training Camp 1: With higher values in women in % SB (U = 721.000; p = 0.034); *ES* small (0.542). Higher values in men in WHO-5 (U = 597.500; p = 0.000); *ES* moderate (-1.071), Light PA (U = 735.00; p = 0.046); *ES* small (-0.401), Moderate PA (U=701.000; p = 0.023); *ES* small (-0.495), % Moderate (U = -720.000; p = 0.025); *ES* small (-0.492).

At Training Home sex differences were found with higher values in women Vigorous PA (U = 417.500; p = 0.011); *ES* small (0.599), MVPA (U = 397.000; p = 0.005); *ES* moderate (0.614), % Vigorous PA (U = 466.000; p = 0.043); *ES* small (0.384). Higher values in men in WHO-5 (U = 579.000; p = 0.010); *ES* moderate (-0.659), sRPE (U = 553.500; p = 0.005); *ES* small (-0.594).

At Training Camp 2 differences between sex were found in variables with higher values in women Light PA (U = 176.500; p = 0.026); *ES* moderate (0.889) and Moderate PA (U = 182.500; p = 0.035); *ES* moderate (0.681). Higher values in men in sRPE (U = 186.000; p = 0.041); *ES* small (-0.437).

Considering results by sex in different contexts, the main findings were in the Women group differences between Training Camp 1, Training Home and Training Camp 2. We found higher values at Training Camp 1 than Training Camp 2 in WHO-5 (Z= 13.835; P=0.001, Z=-1.091); P=0.001; *ES* small (-0.283). We found higher values at Training Home than Training Camp 1 in Light PA (minutes) (Z= 6.500; P=0.039, Z=0.875; P=0.040); *ES* trivial (-0.196). The Moderate PA (%) presented differences between moments without presenting in the Post-Hoc analysis.

The men group differences between Training Camp 1, Training Home and Training Camp 2 were found with higher values at Training Camp 1 than Training Home in Moderate PA (minutes) Z= 21.756; P<0.001, Z=1.136; P<0.001; *ES* moderate (1.102), in Vigorous PA (minutes) Z= 14.970; P=0.001, Z=0.939; P<0.001; *ES* moderate (0.915), in MVPA (minutes) Z= 17.515; P<0.001, Z=1.030; P<0.001; *ES* moderate (1.112), Moderate PA (%) Z= 19.153; P<0.001, Z=0.985; p<0.001; *ES* moderate (1.146), Vigorous PA Z= 10.529; P=0.005, Z=0.697; p=0.014; *ES* moderate (-0.993), in MVPA (%) Z= 13.159; P=0.001, Z=0.803; p=0.003; *ES* large (1.230), in Steps per day Z= 11.636; P=0.003; Z=0.727; p=0.009; *ES* moderate (0.734).

Higher values at Training Home than Training Camp 1 in Vigorous PA (minutes) Z= 14.970; P=0.001, Z=-0.606; P=0.041; *ES* moderate (0.892).

Higher values at Training Camp 1 than Training Camp 2 in Moderate PA (minutes) Z= 21.756; P<0.001, Z=0.682; P=0.017; *ES* small (0.523), in Light PA (minutes) Z= 16.545; P<0.001, Z=1.00; P<0.001; *ES* moderate (0.673), Wear time per day (minutes) Z= 6.606; P=0.037; Z=0.576; p=0.058; *ES* small (0.229), in Steps per day Z= 11.636; P=0.003; Z=0.727; p=0.009; *ES* small (0.490).

Higher values at Training Camp 2 than Training Home in Vigorous PA (%) Z= 10.529; P=0.005, Z=-0.621; p=0.035; *ES* moderate (-1.043), in MVPA (%) Z= 13.159; P=0.001; Z=-0.697; p=0.014; *ES* moderate (-1.124), in sRPE Z= 10.048; P=0.007; Z=-0.690; p=0.005; *ES* moderate (0.784).

We found a moderate negative correlation between sRPE and Sedentary behaviour (ρ =-0.358; p<0.001), a small negative correlation between Sedentary behaviour and MPVPA (ρ =-0.199; p=0.003) and a moderate correlation between MPVPA and Light PA (ρ =-0.328; p<0.001). The remaining variables were not correlated with sRPE (training load).

The results of physical activity data, training load and well-being at Pre-competition, Competition and Post-competition are present in the table 13.

6.3.2 Pre-Competition and Post-Competition phase

Table 13: Displays actigraphy Sedentary Behaviour, Ligth PA, Moderate PA and Vigorous PA in both sexes at Pre-competition, Competition and Post-competition

		Pre-Competition			Post-competition		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD
Women	Wear time per day (minutes)	600.0	958.0	798.2 ± 97.7	618.0	914.0	805.2 ± 76.3
	Sedentary behaviour (minutes)	337.8	648.3	503.7 ± 77.6	348.5	707.8	526.0 ± 98.8
	Light PA (minutes)	109.8	330.0	223.7 ± 60.3	149.5	264.3	205.2 ± 30.8*
	Moderate PA (minutes)	10.3	47.8	28.5 ± 8.5	15.5	41.5	27.5 ± 6.6
	Vigorous PA (minutes)	8.3	89.8	42.4 ± 19.1	8.8	103.8	46.6 ± 26.8
	MVPA (minutes)	19.0	121.0	70.9 ± 24.9	24.0	140.0	74.1 ± 32.4
	Sedentary behaviour (%)	43.0	81.0	63.3 ± 7.4	51.0	77.0	65.0 ± 7.9
	Light PA (%)	17.0	42.0	27.8 ± 5.6	18.0	36.0	25.7 ± 4.2
	Moderate PA (%)	2.0	6.0	3.6 ± 1.2	2.0	5.0	3.3 ± 1.1
	Vigorous PA (%)	1.0	13.0	5.4 ± 2.6	1.0	14.0	5.9 ± 3.8
	MVPA (%)	3.0	18.0	9.0 ± 3.4	3.0	19.0	9.4 ± 4.7
	Steps per day	2274.0	12167.0	5558.3 ± 3284.8	1744.0	12641.0	5932.8 ± 4188.1
	WHO-5	16	92	70.3 ± 17.8*[a]	36.0	100.0	76.0 ± 16.6
	sRPE (AU)	464	9838	4516.8 ± 2362.712* [a]	1580.0	10490.0	6111.1 ± 2807.7
Men	Wear time per day (minutes)	612.0	920.0	795.4 ± 80.1	652.0	903.0	814.0 ± 65.1
	Sedentary behaviour (minutes)	360.3	781.5	529.4 ± 99.6	55.5	667.8	508.2 ± 123.1
	Light PA (minutes)	87.8	312.0	202.7 ± 67.7	163.5	425.3	235.3 ± 53.4
	Moderate PA (minutes)	2.5	37.8	23.5 ± 8.3	14.5	83.3	28.3 ± 13.7
	Vigorous PA (minutes)	11.8	98.5	39.9 ± 22.7	9.8	90.0	42.3 ± 22.7
	MVPA (minutes)	17.0	132.0	63.4 ± 29.2	27.0	171.0	70.6 ± 32.7
	Sedentary behaviour (%)	46.0	88.0	66.6 ± 10.4	9.0	74.0	61.9 ± 13.2
	Light PA (%)	10.0	39.0	25.4 ± 7.7	19.0	65.0	29.3 ± 9.2
	Moderate PA (%)	0.0	5.0	3.0 ± 1.2	2.0	13.0	3.5 ± 2.3
	Vigorous PA (%)	1.0	12.0	5.1 ± 2.9	1.0	13.0	5.3 ± 3.0
	MVPA (%)	2.0	16.0	8.0 ± 3.7	3.0	26.0	8.8 ± 4.9
	Steps per day	1334.0	13551.0	5333.4 ± 3299.7	3299.0	15189.0	6957.9 ± 3699.8
	WHO-5	56	100	80.9 ± 11.5 [a]	64.0	100.0	85.1 ± 8.9
	sRPE (AU)	415	21580	6712.3 ± 4382.8 [a]	500.0	63500.0	8092.4 ± 13005.5

[*] Meaningful difference between sexes Pre-Competition and Post-Competition <0.05; [a] significant difference with Post-Competition; *PA* Physical Activity; *WHO-5* World Health Organization Well-Being Index; *sRPE* Session Rating of Perceived Exertion; *min* minutes.

The descriptive collected by actigraphy related to Sedentary Behaviour, Ligth PA, Moderate PA and Vigorous at Pre-competition and Post-competition are presente in the table 13.

We found differences between sex in the following variables at Pre-competition with higher values in men in WHO-5 ($U = 333.00$; $p=0.011$); *ES* moderate (-0.73) and sRPE ($U = 355.00$; $p = 0.025$); *ES* moderate (-0.62). At Post-competition sex differences was found in with higher values in men in Light PA ($U = 117.00$; $p = 0.043$); *ES* moderate (-0.70).

However, as no differences were found, in addition to Light PA, in the variables of SPA and SB between sexes, we chose to analyse the data of both sexes together.

Considering results difference phases analysed the main findings were differences between Pre-competition and Post-competition with Higher values at Post-Competition than Pre-competition in WHO-5 ($Z = -2.280$; $p = 0.023$) and sRPE ($Z = -2.610$; $p = 0.009$).

We found a large negative correlation between Sedentary behaviour and MPVPA ($\rho =-0.560$; $p<0.001$) and a moderate correlation between MPVPA and Light PA ($\rho =-0.437$; $p<0.001$). The remaining variables were not correlated with sRPE (training load).

6.4 Discussion

This chapter was primarily designed to characterize and analyse elite women and men young canoe and kayak athletes' Off-training (spontaneous physical activity (SPA) and sedentary behaviour (SB)) patterns on national training camps (TC) and training homes (TH). Secondly, we characterized and analysed the Off-training patterns in two national training camps over 1 month, in which athletes were aiming to prepare for an international competition (European Canoeing Championships Junior & U23). Thirdly, we characterized and analysed the Off-training patterns considering the preparation period: Pre-competition (Pre-C) and Post-competition (Post-C). To our knowledge this is the first research conducted in this domain among elite women and men's young canoe and kayak athletes.

There were several noteworthy findings. First, the findings in the TC1, TC2 and TH showed SPA differences (light, moderate and vigorous physical activity (MVPA)) between the female and male athletes. Interestingly, a study aimed to analyse regular athletes' physical activity (PA) levels did not find gender differences in sedentary time and SPA (light PA, Moderate and Vigorous PA) (Clemente et al., 2016). However, in this study, the athletes presented 200 minutes more (approximately) of SB than our findings. Male athletes showed better perceptions of well-being than women in TC1 and TH, although in TC2 no differences were found.

In our study, women had less time in light PA and moderate PA at TC1 than men. However, women spent more time in moderate to vigorous physical activity (MVPA) in TH, as well as in light PA and moderate PA in TC2 than men.

Female athletes showed similar sedentary behaviour (SB) off-training than male athletes. The time spent by young kayakers and canoeists in SB was less than the data reported by the national elite German U23 rowers (Sperlich et al., 2017). Contrarily, concerning both light PA and MVPA, the values found in our study were higher than those reported by Sperlich et al. 2017 in national elite German U23 rowers.

Male athletes perceived a higher training load than female athletes in all periods (TC1, TH and TC2), as reported previously for young sprint canoeing athletes (Coelho et al., 2019). In addition, the athletes in our study had higher training load values than those reported by Coelho et al. (2019), whereas the athletes we investigated were 1 year older. Respecting the principle of progression of training loads, older adolescent athletes train more than younger ones.

Our findings showed lower steps per day than the 9257 found in athletes by Clemente et al. (2016) in female athletes. The same was found in male athletes, TC1-TH-TC2, lower than the 10228 steps per day found by Clemente et al. (2016) in male athletes. It should be noted that Clemente et al. (2016) also performed the accounting of training steps, unlike our methodology, in which only the time outside the training sessions was counted. The athletes in our study approached 10,000 daily steps (a threshold commonly used to recommend daily levels of PA) (Hultquist et al., 2005; Iwane et al., 2000; Le Masurier et al., 2003; Tudor-locke & Jr, 2004), and 10,000-11,700 steps/day for adolescents (Tudor-Locke et al., 2011), revealing that even in off-training the studied athletes showed active behaviour.

Analyzing by sex, we found that female athletes showed fewer minutes in light PA in TC1 than in TH, in their family environment and in their daily routines without the conditioning of a training camp. In the TCs, the type of transportation used to travel to trainingmay have conditioned the time in light PA. We found that female athletes reported better well-being at TC2 than at TC1, possibly because they were better integrated into the routines and habits of TC2, and because at TC2 the team that would be present at the Canoe sprint European championship had already been decided, which removed a stress component from TC2.

On the other hand, in male athletes we found that they had more minutes in light PA in TC1 than in TC2. They also showed more moderate PA minutes in TC1 than in TH and TC2, showing more SPA in the first TC compared to the weeks that followed. Regarding vigorous PA, male athletes presented more minutes in the TCs than in the TH, possibly due to the conditioning of the school environment in the TH. The MVPA was different and higher in TC1 than in TH. On the other hand, the steps per day reached the highest value in TC1 and TC2 than in TH, supporting a conclusion that the athletes were more active (more SPA) in the periods they stayed in TCs than in the period in their homes, schools, and clubs. In addition, male athletes also showed a greater perception of the training load in TC2 than in TH, showing that they train more in the TCs of the national team than in their clubs. This analysis should consider that the main goal of the planning was the Canoe sprint European Championship.

Female and male athletes reached WHO recommendations during TC1, TH and TC2 (Bull et al., 2020; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). In fact, athletes at TCs nearly doubled the 60 daily MVPA recommendation (84 to 123 minutes per day). The recommendations for adolescents are to reduce the time in SB, which remained high during the periods of TCs and TH (Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020).

We found a moderate negative correlation between those training load (sRPE) and time spent in SB. Whoever presented more training load in TC1, TH and TC2 presented less time in SB off-training. The Ala- Kitula et al. (2019) in soccer also found the same correlation with all PA intensity levels during practice. We also found a negative correlation of SB with MVPA and a positive correlation of MVPA with time in light PA. This result suggests that there might be interdependence between off-training practices and training load.

To verify how behavioral patterns are affected by competition we monitored 5 days before (Pre-Competition) and 3 days after the competition (Post-Competition). Findings during the Pre-Competition (Pre-C) and Post-Competition (Post-C) periods showed differences in Light PA, WHO-5 and sRPE between the female and male athletes. In Pre-C and Post-C, most variables did not show differences between sexes, similarly to a study analyzing regular athletes (PA) levels, which did not differ between genders in sedentary time and SPA (Clemente et al., 2016).

Although most variables did not show differences between women and men, men had a higher perception of well-being, and a higher training load than women in the period before the Competition. In addition, men had a longer time in light PA than women, in the Post-C period.

The time spent by young kayakers and canoeists in SB was less than the data reported by the national elite German U23 rowers (11.64 to 12.49 hours) by Sperlich et al., (2017). The canoeing athletes showed higher light PA than reported by Sperlich et al. (2017) in national elite German U23 rowers (74 to 40 minutes). Nonetheless, they showed the similar MVPA as in reported by Sperlich et al. 2017 in national elite German U23 rowers.

Male athletes perceived a higher training load than female athletes at Pre-C, as reported in young sprint canoeing athletes (Coelho et al., 2019). However, on Post-C they perceived the same training load. In addition, the athletes in our study had higher training load values than those reported by Coelho et al. (2019), even before the competition.

Our findings showed steps per day in Pré and Post Competition lower than found in athletes by Clemente et al. (2016) in female-male athletes. However, it should be noted that Clemente et al. (2016) also performed the accounting of training steps, unlike our methodology, which only counted the time the off-training sessions.

Athletes, female and male, showed no differences in the pattern of SB and SPA in the 5 days before the competition and in the 3 days after the competition. Contrary to what was verified in training camps and training home, in these places the athletes showed differences in their SB and SPA patterns. Possibly, athletes display reproducible patterns in their family environment (TH) , while they do not adapt to the competition context.

On the other hand, the athletes showed a higher perception of well-being and training load in the post-competition period than before the competition. These data are possibly explained by the stress that precedes the competition (WHO-5) and by the tapering period that precedes the competitions (sRPE) (Flatt et al., 2016).

Female and male athletes met WHO recommendations Pre and Post competition. However, they were close to the minimum recommended value of 60 minutes daily of MVPA, reaching almost 50% less than in TCs (Bull et al., 2020; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). Competition appears to have influenced the time spent in MVPA during Pre and Post Competition, possibly due to competition dynamics, stress, travel, competition preparation or others. More detailed data is required in the future. The recommendations for adolescents are to reduce the time in SB (Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020), which remained high, with slightly higher values than in TCs. Female and male athletes showed less daily SB and more daily MVPA while in training camps.

We found a large negative correlation between SB and MVPA patterns. Whoever presented more SB pattern in Pre and Post Competition also presented less time in MVPA. In addition, it was found that athletes with high MVPA levels also had more Light PA patterns. The PA preceding soccer practice had a positive correlation with all PA intensity levels during practice (Ala-Kitula et al., 2019). This result also suggests that there might be interdependence between off-training practices and training load.

Young canoe and kayak athletes achieved the World Health Organization recommendations for PA of at least 60 minutes daily of MVPA in off-training (Bull et al., 2020; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). This is contrary of what has been previously reported in studies of young footballers , in which the recommendations were not reached in non-training days, (Ala-Kitula et al., 2019). However, in elite footballers (Weiler et al., 2015) and in elite rowers (Sperlich et al., 2017) the MVPA recommendations in off-training were achieved. Nonetheless, in both studies athletes showed excessive time in SB.

The runners who did more spontaneous physical activity had a greater increase in O2 consumption (Hautala et al., 2012). It has been suggested that a recovery period in which athletes perform more low intensity activities may help promote optimum recovery (Izzicupo et al., 2019).

The recommendations are to reduce total time spent in sedentary pursuits and interspersing short bouts of physical activity and standing between periods of sedentary activity (Garber et al., 2011; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). Breaks in sedentary time provide intriguing preliminary evidence on the likely metabolic-health benefits of regular interruptions to sitting time (Healy et al., 2008; Owen et al., 2010).

The time spent in SB is related to athletes' body composition, regardless of sex, age, weekly training time, and sport type (athletes from more than 25 different sport disciplines) (Júdice et al., 2022). The SB can compromise total and regional body composition regardless of high training time (Júdice et al., 2014, 2022). The SB in off-training may negatively affect recovery and in a long-term adaptation to exercise and health (Sperlich et al., 2017). Therefore, it is crucial that sport federations and coaches control SB during athletes' recovery time (Izzicupo et al., 2019; Júdice et al., 2022).

We propose an individual feedback to PA to assist in neutralizing exaggerated sedentariness. In that way, adverse health outcomes due to accustomed in-career sedentary behaviour could be prevented.

Smooth transport (bicycle and walking) for training, meals and other activities could be a strategy to increase time in light PA, promoting the break of SB and possibly contributing to improving recovery and adaptation to training. Moreover, to increase physical activity among young people may be necessary to direct a greater focus on active living, such as active transport policies and environmental infrastructure that is conducive to recreational and incidental physical activity, in addition to sports (Koorts et al., 2019).

We advocate further research and wider provision of education and support for young elite canoe sprint athletes in their lifestyle management.

Retirement from elite sport is likely to further imbalance activity and sedentary behaviour. Promoting regular periodic light to moderate leisure-time activity could be beneficial. Further research is required in this area.

From this perspective, future investigations may aim to answer the question whether the manipulation of off-training PA may be beneficial or harmful for recovery processes and long-term performance development in elite athletes.

6.5 Conclusion

In conclusion, young canoe and kayak athletes showed differences in spontaneous physical activity (SPA) patterns (light, moderate-to-vigorous physical activity (MVPA)) and sedentary behaviour (SB) patterns between sexes in training camp 1 (TC1), training home (TH) and Training camp 2 (TC2).

Our findings showed less than 10,000 daily steps off-training in all periods. Young canoe and kayak athletes achieved the World Health Organization recommendations for PA of at least 60 minutes daily of MVPA in off-training in all periods. Nonetheless, the athletes consistently showed high values of sedentary behaviour.

Male athletes showed a higher training load than female athletes at training homes and Training camp 2. The athletes that presented more training load in TC1, TH and TC2 presented less time in SB off-training patterns.

In the Pre-Competition (Pre-C) and Post-Competition (Post-C) periods, most variables did not show SPA and SB pattern differences between sexes.

The athletes showed a higher well-being and training load in the post-competition period than before the competition. Competition appears to have influenced the time spent in MVPA during Pre and Post Competition.

Athletes showed less daily SB and more daily MVPA while in training camps than in their homes and during competition periods. Athletes presented more SB than SPA patterns in Pre and Post Competition. It was found that athletes with high MVPA levels also had more Light PA patterns.

We propose individual feedback to PA to assist in neutralizing exaggerated sedentariness. Sports federations and coaches must control SB during athletes' recovery time. We advocate further and longer research and wider provision of education and support for young elite canoe and kayak sprint athletes in their lifestyle management.

Chapter VII

Discussion and conclusion general

7 Discussion and conclusion general

7.1 Discussion general

This doctoral thesis aimed to analyse the daily routine of young elite athletes and, therefore, the patterns of physical behaviours and sleep quality and quantity in elite young canoeing sprint athletes. Our thesis starts with quantifying the usual training load (TL) to assess the total training stimuli and training intensity distribution (TID) in a representative sample of athletes of a defined age group. In a second study, we followed markers of stress and recovery when the sample underwent participation in particular national training camps (TC). Then we intended to determine the effect of usual and special contexts of training over the recognised best-known recovery strategy (sleep). The last study aimed to assess the daily physical behaviour patterns (spontaneous physical activity and sedentary behaviour) in different training contexts (training camps, training at home (clubs), Pre-Competition and Post-Competition).

To improve recovery and performance, the athlete should carefully consider the 24 hours preceding and following the training or competition. More than simple recommendations are necessary, due to the paucity of guidelines relative to off-training physical behaviours (PBs) in athletes (Izzicupo et al., 2019).

7.1.1 Training intensity distribution

The first step was to quantify and analyse how athletes perform (training load) and training intensity distribution pattern (TID) during typical training camps before an international competition (European Canoeing Championships Junior & U23).

The athletes accumulated between 770 to 743 training impulse (TRIMP) arbitrary units of load *(aul)* and 60481 to 58530 session rating of perceived exertion (sRPE) *aul* within seven days of a training camp that is designed to select athletes and to compete at the European Canoeing Championships Junior & U23 (ECC). The TCs showed 29,9% load (sRPE) increment in comparison with the average value of a typical week in kayak elite young athletes (Coelho et al., 2019). Possibly due to emotional factors, such as the stress associated with the process of selection of athletes in the national teams.

Furthermore, the training load (TL) TRIMPs and sRPE were not different between TC1 and TC2, showing a non-variation of training load between two training camps with different goals. It was found a positive association between TRIMP and sRPE, as verified in Canoeing sprint and other modalities (Cesanelli et al., 2021; Foster et al., 2017; Borges et al., 2014; Roos et al., 2018; Sanders et al., 2018).

Our results about young elite canoeing athletes showed a high-volume low-intensity training (HVLIT) TID pattern, in the 6 and 3 weeks before the international competition (European Canoeing Championships Junior & U23) (Laursen & Jenkins, 2002; Seiler & Kjerland, 2006). About 78.4 - 77.8 % of their training sessions were performed mostly below the first ventilatory threshold (Z1), 18.5– 19.75 % of training sessions conducted between VT1 and VT2 (Z2) and 3.2–2.9 % periods of work above VT2 (Z3).

Similar findings were found in endurance runners training (Esteve-Lanao et al., 2005), cyclists during competition of Vuelta an España and Tour de France (Lucía et al., 2003) and Ironman athletes (Muñoz et al., 2014). However, several authors of different sports (rowers, athletics, speed skaters, recreational athletes, cyclists) suggested the polarised training pattern with higher training time in Z1 (75% to 80%) balanced against the regular application of training bouts Z3 (Festa et al., 2020; Å. Fiskerstrand & Seiler, 2004; Muñoz, Seiler, et al., 2014; Orie et al., 2014; Sylta et al., 2016).

Contrarily to what was previously described, appears to be a better TID pattern across the training season, from a focus on HVLIT during the preparation phase, towards a pyramidal TID during the pre-competition period, and a polarised TID during the competition phase (T. Stöggl & Sperlich, 2014; Thomas L. Stöggl & Sperlich, 2015; Stöggl, 2018).

7.1.2 Stress-recovery responses

In addition to the quantification of TL and TID, we look at the heart rate variability (HRV) and stress-recovery as markers of training response during a training camp (divided into 2 microcycles - P1 and P2) in elite young canoeing sprint athletes. They accumulated between 2740 to 3024 aul within two microcycles of 5 days that were designed to select athletes for the National Team.

The male athletes demonstrated a decrement in the logarithm of the root mean square of successive differences ($lnRMSSD_M$) at P2 compared to P1, while the female athletes showed no change in HRV between the two microcycles.

The male athletes undertook higher TL and displayed greater levels of total perceived stress at the end of TC than female athletes. In addition, both total stress and recovery assessed by Recovery-Stress Questionnaire for Athletes (RESTQ-52) increased over the moments. This finding suggests that training loads were not excessive during the TCs, since during periods of overload, stress is increased and concomitant to a decrease in recovery (Coutts & Reaburn, 2008; Morales et al., 2014).

Responses in HRV appear to be linked to changes in external training load and training-related stress in several studies, Flatt and Esco (2015) suggested that lnRMSSD coefficient of variation ($lnRMSSD_{CV}$) may be a suitable marker for reflecting the acute adjustment of weekly TL. An increase in training was associated with a reduction in $lnRMSSD_{M}$ along with an increase in $lnRMSSD_{CV}$ (Flatt et al., 2016).

The male athletes showed higher TL (sRPE) than the female athletes. However, the male athletes presented a likely negative change in lnRMSSDM between P1 and P2. This is possibly a reflection that men accumulated a higher external training load, over the entire duration of the TC in comparison to women.

To emphasize this autonomic behaviour, the $lnRMSSD_{M}$ difference between P1 and P2 was more significant (5.2%) than the least worthwhile change (3%) set in the literature for males (Buchheit, 2014). Accordingly, this difference was also present in the RESTQ-52 at Moment 3 (M3), where the males presented likely higher total stress than females. Therefore, it appears that mean cardiac autonomic response and perceived stress responses are coherently linked in this study (Flatt & Esco, 2015).

For female athletes no changes were found in $lnRMSSD_{M}$ or $lnRMSSD_{CV}$ between P1 and P2. Identical results were found by previous research involving female soccer players (Flatt et al., 2017). Weekly $lnRMSSD_{M}$ and $lnRMSSD_{CV}$ showed a dose-response relationship with training load assessed by sRPE. The weeks with higher training loads resulted in lower $lnRMSSD_{M}$ and higher $lnRMSSD_{CV}$ (Flatt et al., 2016, 2017).

7.1.3 Sleep patterns

During the training camp periods, athletes must adapt to different training contexts and the sleep patterns can be affected. Sleep is considered the most important and accessible daily recovery strategy for athletes (Fullagar et al., 2015; Walsh et al., 2021).

The sleep chapter was designed primarily to characterize and analyze elite women and men young canoe and kayak athletes' sleep patterns in national Training Camps and Training Home, Pre-C, National Competition and Post-C. We found difference insleep patterns between sexes in Training Camp 1, Training Home and Training Camp 2, Pre-C, National Competition and Post-C.

In our study, we found that at training camp 1 (TC1), training home (TH) and training camp 2 (TC2), women presented higher total sleep time (TST), less sleep fragmentation and higher sleep efficiency (SE) than male athletes. On the other hand, at TH women showed a higher Avg Awakening than men. Males in their homes spent more time in their beds (TIB), showed higher well-being and trained more than women. Men at TC2 spent more time in their beds and woke up later than the women. Halson et al. (2021) also reported sleep onset latencies and more significant daytime dysfunction in female athletes compared with male athletes.

Female athletes at TC1 woke up later, spent more time in bed (TIB), displayed better SE and slept longer (TST) than at their training home, showing values lower than what was reported by Aloulou (2021) in their homes. Interestingly, female athletes reported more TL and showed better sleep, which is the opposite of reported by Aloulou (2021). On the other hand, male athletes with higher TL in TC1 spent more TIB and presented greater sleep fragmentation than in TH with lower TL. They showed better SE with lower TL at their homes, as shown by (Aloulou et al., 2021). The early-morning training seems to impact sleep at TH (Sargent, Halson, et al., 2014) or school activities on bedtimes and get-up times were earlier, time spent in bed was shorter and the amount of sleep obtained was less than on nights at TCs. These results indicate that early-morning training sessions can restrict the amount of sleep received by elite athletes, as previously reported (Sargent, Halson, et al., 2014).

Comparing the both training camps, we found that at TC2 both sexes presented higher latency, slept slightly less time and displayed higher sleep fragmentation than TC1. A plausible explanation might be that athletes relaxed at TC2 as their participation in the European Canoe Championship was guaranteed, giving less importance to sleep patterns. In our study, the young female athletes showed better SE when they increased their TL, which is the opposite to what was previously found in adult female athletes (Aloulou et al., 2021) and rowing athletes (Kölling et al., 2016).

Female athletes at TH and TC2 presented SE values considered appropriate for this age group, but, showed inappropriate sleep quantity (M. Ohayon et al., 2017). On the other hand, male athletes presented SE values considered uncertain for this age group, yet, showed inappropriate sleep quantity (M. Ohayon et al., 2017). Our athletes showed TST fewer than 8.3 hours, reported in 175 elite athletes from 12 sports as needed to feel rested (Sargent et al., 2021). A correlation was found between WHO-5 and latency (TC1, TH, TC2), as athletes who presented higher well-being values also presented lower latency.

Furthermore, we characterized and investigated the sleep patterns in the different phases of a national competition: Pre-Competition (Pre-C), National Competiton (NC) and Post-Competition (Post-C). We did not find differences in this periods between sexes. Female athletes woke up later during the Pre-C period than in the NC, and Post-C than national competition. They spent at Post-C more time in bed but showed more sleep fragmentation than in national competition. Comparing Pre-C and Post-C, we found that female athletes at Pre-C presented higher latency and fewer TL than in Post-C.

Women presented at Pre-C and NC total sleep time values lower than reported by Aloulou (2021). The female athletes at Pre-C and NC presented TST inappropriate sleep quantity (M. Ohayon et al., 2017). Therefore, we found that before and during the competition, women slept less than after the competition as reported by (Walsh et al., 2021).

Female athletes presented uncertain SE at Pre-C and Post-C, although, they presented appropriate SE values in NC as reported by (M. Ohayon et al., 2017). Women showed at Post-C better well-being (WHO-5) values than in Pre-C.

Analysing the sleep pattern of male athletes, we found no differences between Pre-C and NC, NC and Post-C. However, we found differences between Pre-C and Post-C, as they spent more time in bed at Pre-C, and perceived worse sleep quality than Post-C. The training load at Post-C also was higher than Pre-C, as previously found in female athletes (Ref?).

The men athletes presented values lower than the advised 7 hours of sleep during five days before competition (Gupta et al., 2017; Roberts et al., 2018; Sargent et al., 2021; Swinbourne et al., 2016; Walsh et al., 2021; Watson et al., 2015), an indicator of inappropriate sleep quantity by (M. Ohayon et al., 2017).

Unlike women, after competition men showed less sleep time than in the Pre-C and NC periods. Male athletes presented sleep efficiency at Pre-C, NC and Post-C considered uncertain for young people as reported by (M. Ohayon et al., 2017). On the other hand, men at Post-C reported higher well-being than Pre-C.

Checking the results of our sleep patterns study and sleep timing recommendations, we see that: Athletes' sleep was usually characterised by habitual sleep durations of less than 7 hours, along withpoor sleep quality (eg, sleep fragmentation) as described by (Gupta et al., 2017; Roberts et al., 2018; Sargent et al., 2021; Swinbourne et al., 2016; Walsh et al., 2021; Watson et al., 2015). Some of the athletes at TCs, TH and Pre-C have presented sleep dissatisfaction, unrefreshing sleep, or were categorised as ‘poor sleepers’ (PSQI) as reported by (Halson et al., 2021; Tuomilehto et al., 2017). On the other hand, our athletes did not show long sleep onset latency contrary to what have been shown by (Schaal et al., 2011; Tuomilehto et al., 2017), nor day-time sleepiness (Swinbourne et al., 2016) and day-time fatigue (Sargent, Lastella, et al., 2014).

At the ages most relevant to aspiring and established athletes, as our sample, a sleep of 8–10 hours for an adolescent (aged 15-17 years) is advised and appropriate (M. Ohayon et al., 2004; Watson et al., 2015). Although, experts speculate that athletes need more to recover from the physical and psychological demands of the sport (Bird, 2013; Sargent et al., 2021).

However, in our studies on TC1, TH and TC2, female and male athletes presented values very close to 7 hours, sometimes less than 7 hours, which is lower than the recommended time. In the period before the competition (5 days before) and the competition, the athletes also slept less than recommended, not taking advantage of the benefits that a night's sleep could bring.

7.1.4 Physical behaviours patterns

After analysing the sleep pattern of athletes in different contexts, we moved on to what the athletes performed the rest of the day until completing the 24 hours.

The chapter was designed to characterise and analyse elite women and men young canoe and kayak athletes Off-training patterns (spontaneous physical activity (SPA) and sedentary behaviour (SB)) patterns in national training camps 1 and 2, training homes, Pre-competition and Post-competition.

The main findings at the TC1, TC2 and TH showed SPA differences (light, moderate to vigorous physical activity (MVPA)) between the female and male athletes. Contrarily, regular athletes' physical activity (PA) levels did not find sex differences in SPA (Clemente et al., 2016). In our study, women at TC1 presented less time in light PA and moderate PA than men. However, women at TH showed more time in moderate to vigorous physical activity (MVPA), as well as at TC2 in light PA and moderate PA than men.

Athletes showed similar SB off-training. However, they spent in SB less than the data reported by the national elite German U23 rowers (Sperlich et al., 2017). Young canoeing athletes spent 26-28% in light PA, 12-15% MVPA (women) and 10-14% MVPA (men). In both light PA and MVPA, the values found in our study were higher than those reported by Sperlich et al. 2017 in national elite German U23 rowers.

Analysing by sex, we found that at TC1 female athletes showed fewer minutes in light PA than TH, in their family environment and their daily routines without the conditioning of a training camp.

On the other hand, for the male athletes at TC1, we foundmore minutes in light PA than in TC2. They also showed at TC1 more moderate PA minutes than Training Home and TC2. Male athletes presented at TCs higher vigorous PA minutes than in the TH, possibly due to the conditioning of the school environment at TH. The athletes at TC1 showed higher MVPA than at TH, indicating that the athletes were more active in the periods they stayed in TCs than in the period at their homes.

Female and male athletes during TC1, TH and TC2 reached WHO recommendations (Bull et al., 2020; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). Although there is no evidence to quantify the SB reference time, the recommendations for adolescents are to reduce the time in SB, which remained high (7.7 to 8.9 hours) during the periods of TCs and TH (Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020).

The athletes showed a moderate negative correlation between sRPE and the time spent in SB. In addition, the athletes at TC1, Training Home and TC2 that presented more training load also showed less time in SB off-training. Likewise, we found a negative correlation of SB with MVPA and a positive correlation of MVPA with time in light PA. The PA preceding soccer practice presented a positive correlation with all PA intensity levels during practice (Ala- Kitula et al. 2019). Our result also suggests that there might be interdependence between off-training practices and training load during training, as reported with children (Fairclough et al., 2012).

We verified the competition period and how behavioural patterns are affected by competition at Pre-Competition and Post-Competiton. At Pre-C and Post-C, most variables did not show differences between sexes, as reported in the study with regular athletes in sedentary time and SPA (Clemente et al., 2016), contrarily to what was verified at training camps and training homes. In Post-C period men had a long time in light PA than women.

Possibly, athletes have patterns in their family environment (TH) that they reproduce and do not adapt to the competition. The time spent by young athletes in SB was less than the data reported by the national elite German U23 rowers by Sperlich et al., (2017). They also showed 25-29% light PA, and 12-15% MVPA. The athletes showed higher light PA than reported by Sperlich et al. (2017) in national elite German U23 rowers. Nonetheless, they showed a similar MVPA described by Sperlich (2017).

Competition appears to have influenced the time spent in MVPA during Pre and Post Competition, possibly due to competition dynamics, stress, travel, competition preparation or others. Young canoeists and kayakers achieved the WHO recommendations for PA in off-training, yet, reaching almost 50% less than in TCs (Bull et al., 2020; Chaput et al., 2020; DiPietro et al., 2020; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). Contrary to what was found in other studies, in which at non-training days the recommendations were not reached, like with young footballers (Ala-Kitula et al., 2019). However, in elite footballers (Weiler et al., 2015) and elite rowers (Sperlich et al., 2017) the MVPA recommendations for off-training were achieved.

An important note, the runners who did more spontaneous physical activity had a more significant increase in O2 consumption (Hautala et al., 2012).

In addition, the time spent in SB is related to athletes' body composition, regardless of sex, age, weekly training time, and sport type (Júdice et al., 2014, 2022), and may negatively affect recovery and long-term adaptation to exercise and health (Sperlich et al., 2017). Sports federations and coaches must control SB during athletes' recovery time (Izzicupo et al., 2019; Júdice et al., 2022).

The recommendations are reducing total time spent in SB pursuits and interspersing short bouts of physical activity and standing between periods of sedentary activity (Garber et al., 2011; Okely et al., 2022; Ross et al., 2020; World Health Organization, 2020). Moreover, breaks in sedentary time provide intriguing preliminary evidence on the likely metabolic-health benefits of regular interruptions to sitting time (Healy et al., 2008; Owen et al., 2010).

We propose individual feedback to PA to assist in neutralizing exaggerated sedentariness. We could stimulate the reducing the risk of sedentary-induced adverse health outcomes due to accustomed in-career sedentary behaviors. Smooth transport (bicycle and walking) for training, meals and other activities could be a strategy to increase time in light PA, promoting the break of SB and possibly contributing to improving recovery and adaptation to training. Moreover, increasing physical activity among youth may need to focus more on active living, such as active transport policies and environmental infrastructure conducive to recreational and incidental physical activity, in addition to sports (Koorts et al., 2019).

We advocate further research and wider provision of education and support for youth elite canoe sprint athletes in lifestyle management. Retirement from elite sports is likely to further imbalance activity and sedentary behaviour. Promoting regular periodic light to moderate leisure-time activity could be beneficial. Further research and provision of education and support for athletes are required in this area.

From this perspective, a future investigation may aim to answer the question of whether the manipulation of off-training PA may be beneficial or harmful for recovery processes and long-term performance development in elite athletes.

7.2 Conclusion general

In conclusion, in chapter II the young elite-level kayakers showed a training intensity distribution pattern (TID) of high-volume low-intensity training (HVLIT). However, coaches can consider training programs using polarised training, keeping the time required for recovery. Training sessions at lower intensities may be interesting to improve technique together with physical fitness development.

These findings broaden the knowledge of young elite kayak athletes and may be helpful in planning future training programmes. Nonetheless, further studies regarding the long-term sustainability of this distribution method are required. Taking into consideration the positive correlation between TRIMP and sRPE found in our study, we recommend that sRPE and TRIMP measures should be considered as a practical monitoring tool for Sprint Kayak and Canoe athletes. Coaches could use sRPE as a simple monitoring tool to assess the young elite-level kayakers' training load.

In Chapter III, we verified that monitoring of HRV and stress-recovery balance can help to control the undesired effects of excessive loading or other stressors in the period leading up to important competitions, in both males and females.

In chapter IV, we found differences between sexes in sleep patterns and well-being according to the environmental context of the athletes. Female and male elite athletes reacted differently to changes in training and sleeping location, competition period and TL. Based on our differences, we suggest analysing the sleep data of men and women separately.

The females slept longer and more efficiently than the men at both training camps. The males in their training homes slept longer, possibly because they trained more than the females. Males showed higher sleep fragmentation at TC1, TH and TC2 than females.

Differences in context and schedules seem to influence more the sleep patterns of female than male athletes. Female athletes presented appropriate SE whilst male athletes presented uncertain SE. The female athletes slept inappropriately sleep quantity at TH and TC2, while the male athletes slept inappropriately sleep quantity at TH, which was found lower than recommended for their age.

Sports scientists, coaches and families must pay attention to controlling training and off-training schedules and their influence on athletes' sleep patterns. In these situations, we suggest that athletes adjust their schedule by anticipating the time to go to bed.

Considering the preparation period of Pre-competition, National competition and Post-competiton differences between sexes were not found. Women woke up later during NC and Post-C and showing more latency Pre-C than the Post-C. Men did not show differences between the 3 periods of competition regarding their sleep patterns.

Women slept less than 7 hours in Pre-C and NC, consistently less than recommended, inappropriate sleep. Similarly, men consistently slept less than 7 hours, also less than the recommended sleep time, and inappropriate sleep.

Female athletes presented uncertain SE at Pre-C and Post-C, although they presented appropriate SE values at national competition. Male athletes presented SE in Pre-C, NC and Post-C considered uncertain for SE. Possibly it will be important to monitor the individual sleep patterns of athletes, and take them into account into training schedules and travel.

Analysing our studies, the athlete's sleep is characterised usually by habitual sleep durations of less than 7 hours and poor sleep quality.

The PSQI retrospective questionnaire was sensitive to changes in the sleep pattern of female and male athletes, compared with data collected by sleep actigraphy data. In addition, the application of the PSQI and the PghSD should be collected with actigraphy in order to monitor aspects that that the actigraphy does not control.

In chapter V, we found differences in spontaneous physical activity (SPA) patterns (light, moderate-to-vigorous physical activity (MVPA)) and sedentary behaviour (SB) patterns between sexes in TC1, TH and TC2. Female and male athletes showed 57-63% SB, 26-28% light PA, 12-15% MVPA (women) and 10-14% MVPA (men) off-training at TC1-TH-TC2.

Female and male athletes reached WHO recommendations during TC1, TH and TC2 to MVPA. Nonetheless, the athletes showed high values of SB 7.7 to 8.9 hours. However, the athletes that presented more TL in TC1, TH and TC2 presented less time in SB off-training patterns.

At the Pre-Competition and Post-Competition periods, most variables did not show SPA and SB pattern differences between sexes. Both sexes showed 63.3% to 65% in SB, 25-29% light PA, and 12-15% MVPA.

Competition appears to have influenced the time spent in MVPA Pre, during and Post Competition. However, the athletes showed 8.3 to 8.2 hours in SB, with slightly higher values than in TCs.

Athletes showed less daily SB and more daily MVPA while in training camps. Aditionally, we observed that athletes with high MVPA levels also had more Light PA patterns.

Young canoeists and kayakers at Pre-C and Post-C achieved the World Health Organization recommendations for PA of at least 60 minutes daily of MVPA in off-training.

We propose individual feedback to PA to assist in neutralising exaggerated sedentariness. Sports federations and coaches must control SB during athletes' recovery time. We advocate further research and wider provision of education and support for young elite canoe sprint athletes in their lifestyle management.

This research could contribute to a new approach that includes the influence of off-training physical behaviours and sleep patterns, therefore optimising best behaviour patterns.

7.3 Methodological considerations

Some methodological considerations need acknowledgement: First, we only observed a short period within the season of competitive canoeing athletes. We cannot judge whether the PA profile during off- and pre-season would be different. Secondly, since our kayakers were among the best athletes in Portugal, we cannot estimate whether the result is also true for recreational, or older kayakers.

Also, the position of the waist device could have an error in the calculation of SPA. Although we instructed all kayakers to wear the actigraph always in the same position we cannot be sure if this was the case all the time. Also, from a methodological point of view, the number of kayakers and canoeists in the present pilot study was relatively small and more participants would have allowed greater statistical power.

However, the 15 kayakers and canoeists were among the best of their age group in Portugal and increasing the sample size would have meant integrating “weaker” kayakers thereby confounding the interpretation of the data for the “elite” canoeing youth population. Further research is warranted, and the present results should be viewed carefully until the data is confirmed in other populations.

8 Bibliography

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9 Appendix

9.1 Ethical approval

Ethical approval for the prospective monitoring conducted in this thesis was granted by the Ethics Committee of the Faculty of Sports Science and Physical Education, University of Coimbra, Portugal (CE/FCDEF-UC/00292019).

Ethical approval was obtained for prospective monitoring prior to the beginning of this Ph.D., given by the Ethics Committee of the Faculty of Sports Science and Physical Education, University of Coimbra, Portugal. This approval provides the ability to prospectively collect data which may be utilized in research studies such as those completed in this thesis.

9.2 Índice de qualidade do sono de Pittsburgh – versão portuguesa (PSQI-PT)

Nome:____ Idade:______
Data:____/____/____

*As questões a seguir são referentes à sua qualidade de sono apenas durante o **mês passado**. As suas respostas devem indicar o mais correctamente possível o que aconteceu na **maioria** dos dias e noites do último mês. Por favor responda a todas as questões.*

1) Durante o mês passado, a que horas se deitou à noite na maioria das vezes?
Horário de deitar:______h______min

2) Durante o mês passado, quanto tempo (em minutos) demorou para adormecer na maioria das vezes?
Minutos demorou a adormecer: ________min

3) Durante o mês passado, a que horas acordou (levantou) de manhã na maioria das vezes? Horário de acordar: _____h______min

4) Durante o mês passado, quantas horas de sono por noite dormiu? (pode ser diferente do número de horas que ficou na cama). Horas de noite de sono: _____h______min

Para cada uma das questões seguintes, escolha uma única resposta, a que lhe pareça mais correta. Por favor, responda a todas as questões.

5) Durante o mês passado, quantas vezes teve problemas para dormir por causa de: a) Demorar mais de 30 minutos para adormecer:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

b) Acordar ao meio da noite ou de manhã muito cedo:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

c) Levantar-se para ir à casa de banho:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

d) Ter dificuldade para respirar:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

e) Tossir ou ressonar alto:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

f) Sentir muito frio:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

g) Sentir muito calor:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

h) Ter sonhos maus ou pesadelos:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

i)Sentir dores:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

j) Outra razão, por favor, descreva:

____

____

_____ Quantas vezes teve problemas para dormir por esta razão, durante o mês passado?

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

6) Durante o mês passado, como classificaria a qualidade do seu sono?

( ) Muito boa	( ) Boa	( ) Má	( ) Muito Má

7) Durante o mês passado, tomou algum medicamento para dormir receitado pelo médico, ou indicado por outra pessoa (farmacêutico, amigo, familiar), ou mesmo por sua iniciativa?

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

8) Durante o mês passado, teve problemas em ficar acordado durante as refeições, ou enquanto conduzia, ou enquanto participava nalguma atividade social?

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

9) Durante o mês passado, sentiu pouca vontade ou falta de entusiasmo para realizar as suas atividades diárias?

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

10) Vive com um(a) companheiro(a)?

( ) Não	( ) Sim, mas em outro quarto	( ) sim, no mesmo quarto mas, não na mesma cama	( ) sim, na mesma cama

Se tem um(a) companheiro(a) de cama ou quarto, pergunte-lhe se, no mês passado, **você teve**: a) Ronco alto:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

b) Pausas longas na respiração durante o sono:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

c) Movimentos de pernas durante o sono:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

d) Episódios de desorientação ou confusão durante o sono:

( ) Nunca	( ) Menos de 1x/semana	( ) 1 ou 2x/semana	( ) 3x/semana ou mais

e) Outros sintomas na cama enquanto dorme, por favor, descreva:

____

9.3 Índice de bem-estar OMS (cinco) (WHO-5), versão de 1998

Indique, por favor, para cada uma das cinco afirmações, a que se aproxima mais do modo como se tem sentido nas últimas duas semanas. Note que os números maiores indicam maior bem-estar.

Exemplo: Se ao longo das últimas duas semanas se sentiu alegre e bem-disposto/a durante mais de metade do tempo, coloque uma cruz no quadrado com o número 3

	Durante as últimas duas semanas	Todo o tempo	A maior parte do tempo	Mais de metade do tempo	Menos de metade do tempo	Alguma s vezes	Nunca
1	Senti-me alegre e bem-disposto/a	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
2	Senti-me calmo/a e tranquilo/a	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
3	Senti-me ativo/a e enérgico/a	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
4	Acordei a sentir-me fresco/a e repousado/a	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
5	O meu dia-a-dia tem sido preenchido com coisas que me interessam	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0

9.4 RESTQ – 52 DESPORTO

RESTQ – 52 DESPORTO

Número: ________

Nome (Escreves as iniciais do primeiro e último nome): ____________________

Data:___________ Hora: _________ Idade: _________ Sexo: ____________

Desporto / Evento(s): ____

Este questionário apresenta uma séria de perguntas. Estas podem descrever o bem-estar mental, emocional ou físico, ou as atividades que realizou durante os passados dias e noites.

Por favor seleciona a resposta que melhor reflete os teus pensamentos e atividades, indicando com que frequência cada afirmação se aplica a si nestes últimos dias.

As afirmações relacionadas com o teu rendimento em competição devem ter em conta o rendimento durante a competição bem como durante os teus treinos.

Para cada uma das perguntas existem sete respostas possíveis.

Por favor seleciona SOMENTE UMA resposta apropriada marcando com um "X" ou círculo em cima do número.

Exemplo:

NOS PASSADOS (3) DIAS / NOITES

… eu li um jornal.

0	1	2	3	4	X	6
Nunca -	**raramente**	**algumas vezes**	**com frequência**	**mais frequentemente**	**com muita frequência**	**sempre**

Neste exemplo, o número 5 foi escolhido. Isto significa que tu leste um jornal muito frequentemente nos últimos três dias.

Por favor não deixes nenhumas perguntas em branco, e se estiveres em dúvida quanto a uma resposta, seleciona espontaneamente aquela que mais se adequa.

Por favor vira a folha e responde a todas as perguntas por ordem e sem interrupção.

Obrigado

NOS PASSADOS (3) DIAS / NOITES...

1) Vi televisão

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

2) Ri à gargalhada

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

3) Estive de mau humor

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

4) Senti-me fisicamente calmo(a)

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

NOS PASSADOS (3) DIAS / NOITES...

5) Senti-me bem (psicologicamente/mentalmente)

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

6) Tive dificuldade em concentrar-me

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

7) Preocupei-me com problemas por resolver

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

8) Passei bons momentos com os amigos.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

9) Tive uma dor de cabeça

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

10) Senti-me cansada(o) devido ao trabalho.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

11) Tive sucesso naquilo que fiz.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

12) Senti-me desconfortável.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

13) Fui incomodado(a) pelos outros (atletas, amigos, etc.)

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

14) Senti-me em baixo, infeliz.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

15) Dormi bem.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

NOS PASSADOS (3) DIAS / NOITES...

16) Estava farto(a) de tudo.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

17) Estive bem-disposto(a).

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

18) Estava exausto(a).

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

19) Dormi mal (sem descansar).

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

20) Estava incomodado(a).

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

21) Senti-me como se pudesse fazer tudo.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

22) Estava chateado.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

23) Adiei as decisões.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

24) Tomei decisões importantes.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

25) Senti-me pressionado(a).

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

26) Partes do meu corpo doíam-me.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

NOS PASSADOS (3) DIAS / NOITES...

27) Não consegui descansar durante os intervalos/ pausas.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

28) Estava convencido que conseguia alcançar os meus objetivos durante os treinos/competições.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

29) Recuperei bem fisicamente.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

30) Fiquei esgotado com a prática do meu desporto.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

31) Consegui fazer coisas importantes na minha modalidade desportiva.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

32) Preparei a minha cabeça para os treinos e competições.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

33) Senti os meus músculos rijos durante os treinos / competições.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

34) Tive a impressão de que houve poucas pausas.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

35) Estava convencido(a) que conseguia aumentar o meu desempenho a qualquer momento.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

36) Eu lidei muito bem com os problemas dos meus colegas de equipa.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

37) Estive em boa condição (forma) física.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

NOS PASSADOS (3) DIAS / NOITES...

38) Dei o máximo.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

39) Senti-me emocionalmente exausto após o desempenho.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

40) Senti dores musculares após o(s) exercício(s).

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

41) Fiquei convencido(a) que executei bem o(s) exercícios(s).

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

42) Foi-me exigido demasiado durante os intervalos / pausas (na competição e treino) .

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

43) Preparei-me mentalmente para os treinos e competições.

0 1 2 3 4 5 6

Nunca raramente algumas vezes com frequência mais frequentemente com muita frequência sempre

44) Senti que queria abandonar o desporto.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

45)Senti-me com muita energia.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

46) Facilmente compreendi como os meus colegas se sentiram (na competição e treino).

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

47) Estava convencido(a) que tinha treinado bem.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

48) Os intervalos/ pausas não foram no momento certo.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

NOS PASSADOS (3) DIAS / NOITES...

49) Senti-me vulnerável/sensível a lesões.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

50) Eu defini objetivo durante o treino e competição.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

51) Senti o meu corpo forte.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

52) Senti-me frustrado(a), desapontado(a) ou descontente com o meu desporto.

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

53) Lidei calmamente com os problemas emocionais do meu desporto

0	1	2	3	4	5	6
Nunca	raramente	algumas vezes	com frequência	mais frequentemente	com muita frequência	sempre

9.5 Pittsburgh Sleep Diary

Diário de Sono - **<u>Preencher já na cama</u>** Estudo ID________

Preencher imediatamente **<u>antes de dormir à noite</u>**.
Dia______ Data__________ Iniciais__________

Horas a que tomou as seguintes refeições: Pequeno-almoço________
(se não tomou, escreva "não") Almoço________
Jantar________

Dos seguintes produtos, quais tomaste em cada um dos momentos mencionados?
(Caso não o tenha feito, deixe em branco)

	Antes ou com o pequeno almoço	Após pequeno almoço, antes/com o almoço	Após almoço, antes/com jantar	Após Jantar
Bebidas com Cafeina				
Bebidas Alcoólicas				
Cigarros				
Charutos				

Que medicamentos tomou hoje?
(Prescrito ou sem receita)

Nome	Hora de toma	Dose

Que exercício fez hoje? *(Caso não tenha feito qualquer exercício escreva aqui: ___________)*

Inicio______ Fim_______ Tipo____________________________________

Quantas sestas fez hoje? *(Caso não tenha feito escreva" 0")*_________
Inicio__________ Fim__________ Inicio_________ Fim___________

Diário de Sono – **<u>Preencher ainda na cama</u>** Estudo ID________

Preencher imediatamente **<u>após o acordar</u>**.
Dia______ Data__________ Iniciais__________

Horas que se deitou__________
Luzes apagadas__________

Minutos até adormecer________

Hora que acordou_________
Acordou por: *(escolha 1)* Alarme relógio/Rádio___________
Pedi a alguém para me acordar___________
Barulhos___________
Acordei sem nenhuma ajuda___________

Depois de adormecer acordei durante a noite *(círculo)*
0 1 2 3 4 5 ou mais

Número total de minutos acordado__________________
- Acordei para usar a casa de banho *(colocar um círculo no nº de vezes)*
0 1 2 3 4 5 ou mais

- Acordei por barulhos/crianças /colega de cama ou quarto *(colocar um círculo no nº de vezes)*
0 1 2 3 4 5 ou mais

- Acordei devido a desconforto ou queixa física *(colocar um círculo no nº de vezes)*
0 1 2 3 4 5 ou mais

-Acordei sem causa identificável *(colocar um círculo no nº de vezes)*
0 1 2 3 4 5 ou mais

Classificações (faça uma cruz na linha representando a intensidade da questão)
Qualidade de sono:
Muito mau ____ Muito bom
Humor ao acordar:
Muito tenso ____ Muito calmo
Estado de Alerta ao acordar:
Muito sonolento ____ Muito alerta