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A PRACTICAL STRATEGY FOR INDIVIDUALIZED TRAINING MONITORING: TRAINING LOAD, CARDIAC AUTONOMIC FUNCTION, JUMP HEIGHT, AND MOOD IN YOUNG DIVING ATHLETES

UMA ESTRATÉGIA PRÁTICA PARA MONITORAMENTO INDIVIDUALIZADO DE TREINO: CARGA DE TREINO, FUNÇÃO AUTONÔMICA CARDÍACA, ALTURA DE SALTO, E HUMOR EM ATLETAS JUVENIS DE SALTOS ORNAMENTAIS

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Para minha família (pra quem tudo faço).

TABLE OF CONTENTS

ABSTRACT

Purpose: to propose a statistical framework for an Athlete Monitoring System for junior Diving athletes that can be reliable, integrated, and individualised, using variables from the Orthostatic Stress Test (OST), Repeated Jumps Test (RJT), Brunel Mood Scale (BRUMS), Session Rating of Perceived Exertion (s-RPE) and Acute:Chronic Workload Ratio (ACWR). **Methods:** male and female athletes (n = 10) underwent two pre-season and six in-season assessments as they restarted training after the off-season in 2020. Baseline data to assess test-retest reliability were collected on two days, on the week before return to training. In-season data to assess correlation between variables were collected every seven days, before training sessions. Individualized ranges to assess True Change in variable behaviour were derived from the reliability results. **Results:** Average Height had the highest reliability, followed by Average Supine R-R intervals (RRi), Fatigue, Average Orthostatic RRi, Minimum Orthostatic Stress (OS) RRi, and Vigour. Jump Height results correlated negatively with RRi values, and positively with Vigour. The Fatigue Index correlated negatively RRi values, Vigour, and positively with Fatigue. Fatigue correlated negatively with training load and RRi values. ACWR correlated negatively with RRi values. Individual signs of fatigue were identified using True Change ranges. **Conclusions:** Subjective and averaged variables presented with high reliability, and ratio variables with low. There were significant correlations between OST, RJT, BRUMS, s-RPE and ACWR variables. Establishing individualized variable behaviour ranges based on group statistics is a possible solution to identify fatigue in adolescent diving athletes.
Keywords: training load; autonomic; jump height; mood; athlete monitoring system.

RESUMO

Objetivos: propor uma estrutura estatística de um Sistema de Monitoramento de atletas, para ser implementado em atletas juvenis de Saltos Ornamentais, que possa ser reprodutível, integrado, e individualizado, usando variáveis do Teste de Estresse Ortostático (OST), Teste de Saltos Repetidos (RJT), Escala de Humor de Brunel (BRUMS), Escore da Percepção do Esforço da Sessão (s-RPE), e a Razão das Cargas Aguda:Crônica (ACWR). **Métodos:** atletas masculinos e femininos (n = 10) passaram por duas avaliações pré-temporada e seis em temporada, em período de reinício dos treinos após férias de 2020. Dados baseline para avaliação da reprodutibilidade teste-reteste foram coletados em dois dias, na semana imediatamente antes do retorno aos treinos. Os dados em temporada para avaliação da correlação entre variáveis foram coletados a cada sete dias, antes das sessões de treinamento. Amplitudes individualizadas para avaliação da Mudança Real no comportamento das variáveis foram derivadas dos resultados de reprodutibilidade. **Resultados:** A Altura de Salto Média apresentou a maior reprodutibilidade, seguida pelo Intervalo R-R (iRR) Médio em Supino, Fadiga, iRR Médio Ortostático, iRR Mínimo do Estresse Ortostático (OS), e o Vigor. As medidas de Altura de Salto se relacionaram negativamente com os valores de iRR, e positivamente com o Vigor. O Índice de Fadiga se relacionou negativamente com os valores de iRR e o Vigor, e positivamente com a Fadiga. A Fadiga se relacionou negativamente com s-RPE e os valores iRR. A ACWR se correlacionou negativamente com os valores iRR. Sinais individuais de fadiga foram identificados utilizando amplitudes de Mudança Real. **Conclusões:** Variáveis subjetivas e em formato de média apresentaram reprodutibilidade alta, e variáveis em formato de razão apresentaram baixa. Houve correlações significativas entre variáveis do OST, RJT, BRUMS, s-RPE e ACWR. Estabelecer amplitudes individualizadas de comportamento das variáveis com base na estatística do grupo é uma solução possível para identificar fadiga em atletas juvenis de Saltos Ornamentais. **Palavras-chave:** carga de treino; autonômico; altura de salto; humor; sistema de monitoramento de atletas.

ABBREVIATIONS

ACWR	Acute:Chronic Workload Ratio
AMS	Athlete Monitoring Systems
ANS	Autonomic Nervous System
BCa	Bias Corrected and Accelerated
BMI	Body Mass Index
BRUMS	Brunel Mood Scale
CI	Confidence Intervals
CR-10	Category-Ratio 10
ECG	Electrocardiogram
GPS	Global Positioning System
HRV	Heart Rate Variability
ICC	Intraclass Correlation Coefficient
IS	In-Season
LoA	Limits of Agreement
OS	Orthostatic Stress
OST	Orthostatic Stress Test
PS	Pre-Season
RJT	Repeated Jumps Test
RPE	Rating of Perceived Exertion
RRi	R-R Interval
s-RPE	Session Rating of Perceived Exertion
SEP	Standard Error of Prediction
Sig	Significance
$\dot{V}O_2max$	Maximal Oxygen Uptake

1. INTRODUCTION

Physical training is the main activity through which Sports Performance is built[1]. As major competitions get increasingly specialised, so do the different methods to apply and evaluate the effects of Training Load[2]. Nowadays, Athlete Monitoring Systems (AMS) are ubiquitous tools, employed in high-end scenarios to measure both the external training loads – the sports activity work performed by an individual in training – and the internal training loads – the effects of said work as it impacts psycho-physiological systems[3].

Diving is a complex-coordination sport that demands high-levels of physical abilities, achieved through arduous work. Like other gymnastics-derived activities, training and specialisation can start at an early age – even before physical maturation begins – and carry on through adulthood[4]. For this reason, adopting monitoring procedures is paramount to protect athletes from unnecessary risks, assist their development, and guide multidisciplinary interventions[5].

The adoption of AMS is justified based on two main reasons: a) it increases control over the application of workloads, while predicting performance or even results; b) it identifies and measures training stress, enabling risk factors associated with such activities to be lowered[2]. Thus, monitoring strategies have been associated with safer sports development, impacting injury, burnout, and overtraining indices[6,7], especially in youth athletes[8].

The interaction between training load and stress forms the foundation of AMS. The application and manipulation of training load elicit a psycho-physiological response that explains the progressive performance improvement in competition sports[1]. In effect, as described in the Fitness-Fatigue model of athletic development, the load stimuli need to be sufficiently large to induce stress, which, if followed by appropriate recovery, can promote adaptation and increase performance – a phenomenon typically referred to as "Supercompensation"[9].

Measuring the training response is of particular importance, as it is specific and individual: stimuli of different configurations can provoke stress of different nature, and the same load can induce effects that are not the same on different athletes[1]. At the same time, a proportional relationship between the magnitude of the load applied and the magnitude of the stress felt is expected, but that is not always the case; states of fatigue and/or poor recovery can result in an unbalanced stress response, one that could lead to maladaptation and increased risks[10]. Studies have shown associations between poor load management and injury, low immunity response, non-functional overreaching, burnout, and overtraining syndrome[8,10,11]. Additionally, if improved sports performance is the main goal of training, then the relative psycho-physiological stress imposed by the workload should determine the optimal external stimuli necessary to promote adaptation[12].

Monitoring athletes can be as simple as observing the characteristics of the training load implemented (for instance, its volume and intensity), but can also include a plethora of different assessments commonly used in sports settings, ranging from wellness and psychological questionnaires, to measures of performance using GPS or force platforms, and heart rate activity and biochemical markers[10]. There is no single marker that solves all monitoring needs; multidisciplinary approaches that include several markers are currently the most recommended athlete monitoring strategies[11]. The selection of the most appropriate methods depends mostly on a thorough context evaluation, which should consider the technology available, the primary characteristics of the sports modality, the nature of the resulting stress, and the overall configuration of training structures[12].

Schelling & Robertson[14] proposed a framework for developing Decision Support Systems in Sport, of which athlete monitoring is a fundamental process. Of the multiple criteria proposed by the authors to evaluate said systems, those related to measurement error, quality of data, and practicality are of paramount importance.

Firstly, the inherent error of the measuring process has tremendous impact on its precision, accuracy, and sensitivity[14]. Quantifying each variable's random variance and systematic error could dictate the system's capacity to detect what most likely is a change in a marker, and separate it from noise – ultimately facilitating decisions[15]. To differentiate random variation from an actual response in selected markers, several mathematical methods have been proposed, ranging from the adoption of arbitrary cut-off points to the use of the Coefficient of Variation[16]. Weir[17] devised a statistical approach using group reliability results to establish a subject's baseline True Score, around which a Confidence Interval can be estimated; any follow-up measures that fall outside these intervals can be said to have undergone True Change.

Secondly, clarifying the direction of association between variables impacts AMS' predictive capabilities and helps select pertinent markers that could lower uncertainty and optimise complexity – system characteristics referred as "Meaning" and "Integration"[14]. These criteria are especially necessary when operationalising and measuring broad phenomena, such as "fatigue"[10].

Lastly, the resources available, the assessments' impact on training schedules and structures, and the methods' ease of application can all affect the feasibility and sustainability of AMS[10,14]. Thus, besides striving for clarity, scope, and meaningfulness, monitoring strategies in real-world settings should also account for practicality and applicability[18].

Considering the criteria mentioned above, this study explored the operationalisation of an Athlete Monitoring System that could be practical, while still providing reliable information on individual athlete fatigue. For this, we selected five field-based tests that could be employed without interference to training, followed up by analyses of reliability, correlation, and True

Change. The tests were: the Session Rating of Perceived Exertion; the Acute:Chronic Workload Ratio; the Orthostatic Stress Test; the Brunel Mood Scale; and finally, the Repeated Jumps Test. These methods were selected based on the available technology, aiming to create an integrated picture of training load and associated stress that is related to autonomic function, mood, and neuromuscular performance in adolescent diving athletes[14].

1.1 Session Rating of Perceived Exertion

Rating of Perceived Exertion (RPE) methods have been commonly employed to measure training loads in several sports modalities[10]. The workload is assessed by a group of scales developed to evaluate the intensity of physical tasks as they are perceived by the individuals performing them. Subjects select a score based on how hard they consider that activity – the range of scores varying with the scale used – employing an internal self-evaluation process mediated by the task characteristics, afferent feedback, proprioception, memory, and efferent feed-forward[19,20].

The method selected for this work is based on the use of the Borg CR-10 adapted scale multiplied by training duration in minutes (termed, then, session-RPE or s-RPE), resulting in a critical determinant of the magnitude of load[21]. It has been tested in Diving settings, presenting with excellent validity and reliability when compared to Heart Rate methods of assessing training intensity[22].

In other sports, significant correlations between session-RPE and load markers have been observed, such as distance, speed, blood lactate, and $\dot{V}O_2max$[20]. Although higher and lower intra-subject s-RPE scores are expected to reflect harder and easier training sessions, values can also be influenced by training duration and accumulated fatigue[10,23]. Nevertheless, due to its proven utility in a variety of contexts, the adoption of this method is widely recommended, particularly alongside other subjective and objective variables[19,20].

1.2 Acute:Chronic Workload Ratio

Borrowing from the concepts of the Fitness-Fatigue model, Blanch & Gabbett popularized the mathematical formula to calculate changes in training load, as they relate to training history, termed the Acute:Chronic Workload Ratio (ACWR)[24]. The calculation includes a measure of Acute load, using the averaged values for the most recent days of training, divided by the Chronic Load, using averaged values from the most recent weeks of training. The former, signifies the "Fatigue", the amount of work an athlete has done most recently, which has provoked a negative stress response; the later symbolises the "Fitness", the amount of work an athlete is prepared to do, based on medium to long-term application of training load that provoked a positive training adaptation[9]. When these values are divided, it results in a ratio that expresses the magnitude and direction of training load changes, in relation to loads that the athlete has previously completed[25].

The ratio can be calculated using measures of external load, such as running distance, total weight lifted, number of sprints, and also internal load, such as s-RPE scores[13]. Traditionally, the last 7 days of load data make up the Acute load, while the last 28 days make up the Chronic, but there have been different configurations proposed based on characteristics specific to certain sports modalities[26]. Notwithstanding, due to the associations found between high ACWR values and injury risk[27,28], there have been recommendations of safer ranges of load change, where adverse effects from training are possibly minimised[13].

Most recently, methodological issues have been raised that could affect the ratio's applicability. Firstly, there is uncertainty regarding what calculation model can best represent the Fitness-Fatigue phenomenon, as there are arguments for an Exponentially Weighted Moving Average approach over a simpler Rolling Average model[29]. Secondly, mathematical coupling (*i.e.* including the most recent load values as part of both the Acute and Chronic averages) could affect the measure's scaling characteristics[30]. Thirdly, Impellizzeri *et al.*[31] have investigated in detail the statistical properties of the variable, bringing to light issues such as spurious correlations and poor mathematical basis of ratio variables. Lastly, we are uncertain of the utility of ACWR on return-to-training scenarios; in such cases, Chronic Workload can be unusually low due to weeks where no training took place, resulting in disproportionally inflated ACWR values.

To what extent these issues affect the future applications of this measure is yet to be seen. In this investigation, based on common use in the literature, we opted for a 28-days Rolling Average Uncoupled ACWR calculation model.

1.3 Orthostatic Stress Test

Orthostatic Stress (OS) refers to the cardiovascular challenges to maintain blood pressure when actively standing up in healthy humans. Coming out of a resting supine (or sitting) position into an orthostatic position provokes an immediate decrease in R-R intervals, a condition of tachycardia caused by a simultaneous decrease in vagal output and increase in sympathetic activity. This prevents a drop in blood pressure, due to the sudden venous pooling on the lower limbs associated the influence of gravity[32]. As the R-R intervals shorten, blood pressure increases, activating a baroreceptor reflex, which provokes a vagal-mediated response to increase R-R intervals, causing a condition of relative bradycardia[33]. The entire phenomenon usually happens within 30 seconds of standing up, resulting in two peaks in R-R intervals (a

Minimum OS RRi value, and a Maximum OS RRi value) that can be visualised on ECG and Heart Rate monitors[34,35]

The Orthostatic Stress Test has been employed in clinical settings for evaluation of the abovementioned response for over half a century[34]. It has also been employed in sports settings, along with other cardiac markers such as HRV, as an accessible method to monitor athletes[36,37]. Intra-individual acute changes in heart rate measures are related to states of heightened training load stress, as well as periods of adaptation; for example, compared to baseline, a decrease in values of resting RRi and Minimum OS RRi were found to be associated with fatigue, overreaching, and even overtraining in athletes[36,38].

Such effects occur due to the Autonomic Nervous System's (ANS) mediating role in the adaptation responses to stress stimuli, which can influence its Resting, Reactivity, and Recovery capabilities[39]. In effect, the more reactive the ANS, the quicker the autonomic response to a specific demand – be it a change in posture, or the start of physical activity –, enabling fast physiological and self-regulatory adaptations to occur[40]. Stress related to sports training and performance has been shown to interfere with cardiac autonomic function in several different patterns, possibly also influencing the adaptation response to the workload[41–44]. For such reasons, employing an assessment method that can evaluate both Resting and Reactivity autonomic capabilities, such as the Orthostatic Stress Test, can broaden the scope of AMS in the identification of fatigue[45].

1.4 Brunel Mood Scale

Another fundamental aspect of athlete monitoring practices, is measuring the impact of workloads on subjective variables[2]. Mood is one of these measures, consisting of a psychological construct that evaluates affective states, assessed with tests such as the Profile of

Mood States, originally developed for use in psychiatric patients[46]. The Brunel Mood Scale (BRUMS) is a simplified version of this scale, one that can evaluate six facets of mood in adolescents and adults: Anger, Confusion, Depression, Fatigue, Tension, and Vigour[47].

The association between Mood states and sports performance has been thoroughly studied; although previous research indicates Mood cannot differentiate levels of achievement between athletes, it can moderately predict performance outcomes – especially Vigour, which is positively associated with elite sports performance[48,49]. Of even more importance to our work, classic and modern studies have pointed out that training load changes can correlate to disturbances in mood: acute increases of workload are associated with increases in negative Mood states, namely Anger, Depression and Fatigue[50–53].

Considering the correlations between subjective and objective variables, the potential to positively impact AMS' sensitivity and consistency, and the ease of use associated with scales like BRUMS, its adoption on this work is more than justified[51].

1.5 Repeated Jumps Test

Neuromuscular function is traditionally evaluated by maximal or submaximal performance tests in laboratory settings[54]. In sports modalities that lack a valid and reliable gold-standard assessment – one that could evaluate physical capacities using specific techniques, for instance –, it is recommended that monitoring methods replicate the most common motor skills and metabolic demands required for a successful performance[10]. Tests that employ Jump-related tasks are commonly used to derive measures of power and evaluate fatigue, especially in modalities that involve jumping[11]. Such is the case of Diving.

Since the eighties, Repeated Jumps Tests have been developed to evaluate lower-limb neuromuscular power, emulating established methods like the Wingate Test[55]. One of such methods is Bosco's protocol, which involves continuous jumping for 15 to 60 seconds on a timing device, deriving measures like Peak Height and the Fatigue Index, presenting with high correlations against gold-standard tests[56].

The usefulness of such tests in AMS is explained by the drop in power production associated with periods of increased fatigue[57], an effect frequently observed post-match in team sports[58]. In reality, this effect might not be as clearcut; there have been observations of periods of increased training load stress – as detected by other physiological measures –, that have not resulted in decreases in physical performance output[59]. Regardless of these differences, vertical jumping is a widespread marker of neuromuscular status, having been employed in modalities similar to Diving, such as gymnastics[56], and its adoption on this study is more than justified.

2. OBJECTIVES

Considering the topics discussed, the objectives of this study are threefold:

1) To evaluate the baseline test-retest reliability of variables derived from the Orthostatic Stress Test, Repeated Jumps Test and Brunel Mood Scale.

2) To verify the correlations between Session Rating of Perceived Exertion, Acute:Chronic Workload Ratio, and variables from the Orthostatic Stress Test, Repeated Jumps Test, and Brunel Mood Scale.

3) Based on the group reliability results, to determine individualized ranges for each variable, outside of which a test result could be considered truly different than Baseline values.

Ultimately, we aim to account for measurement error and understand variable association to facilitate the identification of fatigue in junior Diving athletes, impacting training load decision-making and multidisciplinary interventions.

3. METHODS

3.1 Study group and protocols

This study was conducted on junior Diving athletes, assessed in January and February 2020. They were eligible for inclusion if meeting the following criteria: a) ages between 12 and 17 years; b) at least five years of training history; and c) national medallists. Exclusion criteria were as follows: a) poor adherence to the study protocol; b) injury or illness that could hinder performance during testing or training; c) use of substances that could interfere with physiological responses, like energy drinks or special medication. Ethical approval was obtained from the Health Sciences College Ethical Review Board of the University of Brasília, and both athletes and parents signed a consent form prior to taking part in the study.

At first, Pre-Season (PS) baseline measures were collected for reliability analysis. Pre-Season was considered the immediate week before the start of the training season, following a 3-weeks holiday break. Athlete data were collected twice, at least 24 hours apart (PS1 and PS2), following the study design and testing order described in Figure 1. The assessment schedule and time of day varied according to athlete availability. Anthropometric and training history measures were collected immediately before the start of the PS1 assessment and assumed constant throughout the study.

For In-Season (IS) testing, athletes were randomly assigned a day of the week for assessments, and the measures were repeated every seven days, for six concurrent weeks (IS1 to IS6), following the test order as also described in Figure 1. On the few occasions when athletes would not be available on their assigned day, testing was performed on the following training day. The evaluations were done 20 minutes before the start of the first training session of the day, on mornings or afternoons (depending on what period an athlete would train).

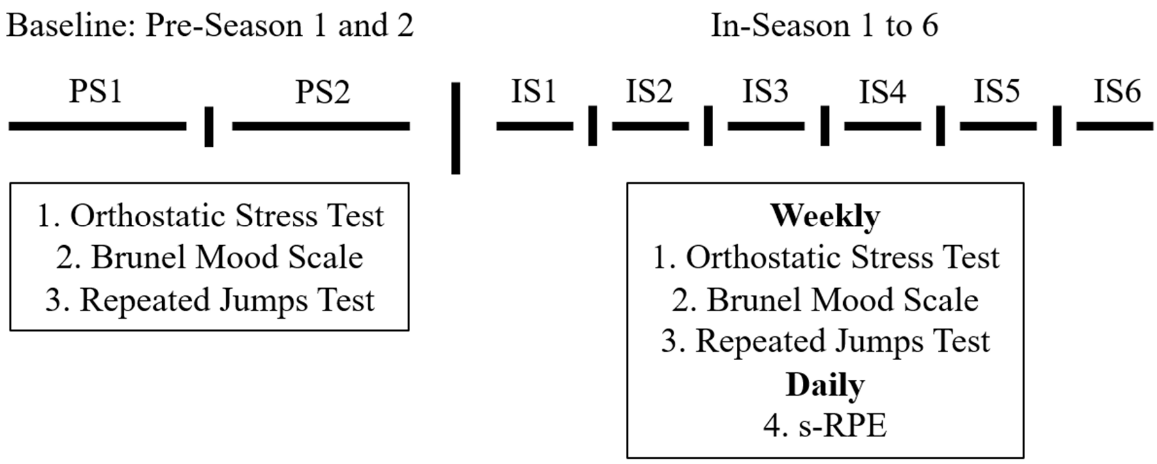

Figure 1 – Study design and testing order. PS stands for Pre-Season. IS stands for In-Season.

All data were collected in a private room next to the pool, with no distractions, keeping similar temperature (from 21 to 24 °C) and light conditions throughout the study[60]. Athletes were instructed to keep their usual routine on testing days regarding sleep quantity, diet, and overall day-to-day physical activity levels, in order to mimic real-world conditions.

3.2 Orthostatic Stress Test

The previously validated Polar® RS-800CX™ (Polar Electro, Kempele, Finland) heart rate monitor was used to record the R-R intervals at a sampling frequency of 1000 Hz[61]. At the start, the chest strap was positioned on the sternum, using ultrasound gel to facilitate signal conduction. For the entire test duration, subjects were instructed to breathe spontaneously, relax, and not move or speak. After laying down for two minutes to stabilise heart rate, there was a five-second count-down for the start of the test. Resting supine heart rate was collected for 5 minutes, and subjects were then given a warning at the end to stand up on the count of 3 seconds. Change of posture started at 300 seconds for all subjects, and they were instructed to do so within 5 seconds at most and remain standing, totalling 8 minutes of test duration[60]. Unless feeling dizzy, subjects were asked not to support themselves while standing. In cases of evident loss of communication between the chest strap and the watch, testing was redone from the start.

The recorded data were transferred to the Polar® ProTrainer 5 software version 5.40.170 (Polar Electro, Kempele, Finland) using an infra-red USB device. From that software, the total 8-minutes of recorded RRi of each test were exported to Microsoft Excel. Each curve was visually inspected for artifacts or spurious intervals (*i.e.*, those that result in sharp transient changes, around 20 or 25% different than the previous one); when present, they were removed from the calculation of the derived measures[37].

Five measures were derived from the raw RRi data: a) Average Supine RRi (in milliseconds): the average of all RRis for the first 5 minutes of the test. b) Minimum Orthostatic Stress (OS) RRi (ms): the single lowest RRi value measured in the first 30 seconds after standing up. c) Maximum OS RRi (ms): the single highest RRi value observed after the Minimum OS RRi, within 30 seconds after standing up. d) Average Orthostatic RRi (ms): the average of all RRi after the Maximum OS RRi until the end of the test. e) 30:15 Ratio: the ratio between the Maximum OS RRi and the Minimum OS RRi[62].

3.3 Brunel Mood Scale

Subjects were given a virtual Portuguese version of the Brunel Mood Scale on Google Forms and were instructed to fill the 24 mood descriptions on the questionnaire on a Likert scale ranging from 0 (*not at all*) to 4 (*extremely*)[63]. The timeframe used for the responses was "*How do you feel right now?*". Data were transferred automatically to a spreadsheet and copied to Microsoft Excel. To calculate the Vigour (a.u.) and Fatigue (a.u.) Mood subscales, the values associated with each of the following items on the scale were summed, respectively: *lively*, *energetic*, *active*, and *alert; worn out*, *exhausted*, *sleepy*, and *tired*[47]. For simplicity, the remaining subscales were not used in the analysis (*i.e.*, Anger, Confusion, Depression, and Tension).

3.4 Repeated Jumps Test

Athletes were instructed to keep shoes on for the execution of the test. A 5-minute time for a self-selected warm-up was provided, and subjects were instructed to repeat the same warm-up throughout all measuring days. The test was done on the Cefise® Jump System Pro™ (Cefise Biotecnologia Esportiva, Nova Odessa, Brazil), a contact mat that collects time on and off the ground. The data collection started after a 5-second count-down, after which subjects had to jump as high as possible, as fast as possible, for 20 seconds. The subject's hands were always to be kept on the hips, and squat depth was standardized as thighs parallel to the floor[55]. The athletes were verbally encouraged throughout the execution. Data were collected on proprietary software (Jump System™, version 1.0), and flight times in milliseconds (ms) were converted to seconds after being exported to Microsoft Excel.

From each time measure, jump height in meters (m) was calculated according to the following formula:

$$h = \frac{g \times t_f^2}{8}$$

where h = jump height; g = acceleration of gravity (9,81 m/s^2); t_f = flight time[55].

The total number of jumps for a given test ranged from 15 to 19 per athlete. Peak Height (m) was defined as the highest mark achieved; Average Height (m) was calculated as the average from all jump heights from a testing bout; lastly, the Fatigue Index (%) was defined as the loss in jump height between the highest and lowest attempts, calculated using the formula[54]:

$$Fatigue\ Index = \left(\frac{Peak\ height - Lowest\ height}{Peak\ height}\right) 100$$

3.5 Session-RPE and ACWR

Perceived exertion scores were filled In-Season by athletes on Google Forms, using the modified CR-10 scale[64], around 30 minutes after the end of each training session. Subjects were instructed to avoid distractions while providing data and to account for the overall difficulty of the entire training session, not only focusing on the easier or harder parts. Training duration was standard for all sessions, lasting 4 hours long. Data were automatically collected on a spreadsheet, and transferred to Microsoft Excel, where s-RPE (a.u.) scores were calculated by multiplying RPE and training duration, in minutes[64]. Compliance with data collection was 100%.

From the daily s-RPE scores, the Weekly Average s-RPE (a.u.) was calculated as the average s-RPE values between assessment days, from the day of the last testing session until the previous day of the current testing session. If the IS1 and IS2 measures of a given athlete were scheduled for a Tuesday, for example, s-RPE values from the first Tuesday to the next Monday were used for calculation of the average. Non-training days (due to weekends, Pre-Season, or lack of attendance) were also included in the average, and for those days load values were standardized as zero.

The 28-days Acute:Chronic Workload Ratio was calculated according to the formula[25,30]:

$$ACWR = \frac{W1}{(W2 + W3 + W4)\frac{1}{3}}$$

where W1 = acute workload, the average s-RPE of the most recent 7 days; W2, W3 and W4 = chronic workload, the average s-RPE of the most recent 8 to 14 days, 15 to 21 days, 22 to 28 days, respectively.

3.6 Statistical Analyses

Due to the small sample size, non-parametric tests were employed. GraphPad® Prism™ version 8.0.2 (GraphPad, San Diego, USA) was used to plot graphs and conduct Friedman's ANOVA to examine variation across measurements, with Dunn's Post Hoc Tests used for multiple comparisons. Weekly Average s-RPE values for PS1 and PS2 were not included in this test, as there was no training during the Pre-Season. Only IS5 and IS6 ACWR values are presented (as explained further below).

IBM® SPSS Statistics™ version 24 (IBM, Armonk, USA) was used for all other analyses. The Mann-Whitney test was used to compare sample characteristics according to sex, and the Wilcoxon matched-pairs signed rank test was performed to compare IS5 and IS6 ACWR measures. Correlation and reliability analyses were also performed using the same software, as described below.

P values < 0.05 were deemed statistically significant. Data are presented graphically and described as median and 95% confidence intervals (CI), unless stated otherwise. For reporting, s-RPE, RRi, Fatigue Index and Mood values were rounded to a whole number, while the subject characteristics, ACWR, 30:15 Ratio and Jump Heights were rounded to two decimals. Correlation, reliability, and p values were rounded to three decimals.

3.6.1 Reliability

PS1 and PS2 values are presented graphically, along with Bland-Altman and Scatter plots to assess agreement[65,66]. For test-retest reliability analysis, baseline data were log-transformed to account for the variables' different levels of measurement and non-normal distribution[67], and Intraclass Correlation Coefficients (ICC) were calculated employing a 2-way random-effects, absolute agreement model (2,1)[17].

3.6.2 Correlation

Correlation was assessed with Spearman's Correlation Coefficient, followed by Bootstrapping to calculate Bias corrected and accelerated (BCa) 95% CIs with one thousand samples.

For correlations between all variables, except ACWR, values from all eight assessments (PS1 and PS2, IS1 to IS6) were included, totalling eighty measures for each variable. s-RPE measures were assumed zero for the Pre-Season, as no official training was conducted then.

As for correlations with 28-days ACWR, only values from IS5 and IS6 were included, totalling twenty measures for each variable. Due to the low 21-days chronic workload values influenced by the off-season weeks (*i.e.*, when s-RPE equals 0), 7-day acute workload can be around fifteen times higher than chronic as measuring starts. As training days accumulate, values fall, approaching one, and then fluctuating around that number.

ACWR values starting from the twenty-nineth day (first day of IS5) represent the first measures where all subjects had accumulated 28 days of chronic training load, and the ratio is not influenced by off-season zero-value load data. For this reason, only measure from IS5 and IS6 were included in the corresponding analysis, since understanding the extent to which low chronic values influence ACWR calculation, and how well the measure can represent the return-to-training stress adaptation phenomenon, is not the scope of this work.

3.6.3 True Change

Two subjects were randomly selected to undergo individual True Change assessment, and results are presented graphically. For this analysis, predicted Baseline True Scores and corresponding confidence intervals were established for each subject. Any retest measures that fell outside of these ranges were considered truly different than Baseline.

PS1 and PS2 measures and the derived ICC were used to calculate the subject's baseline True Score (T) for each dependent variable, using the formula:

$$T = \bar{X} + ICC(S - \bar{X})$$

where $\bar{X}$ = mean of PS1 and PS2 scores; S = subject's observed PS1 score[17].

From the same data, the Standard Error of Prediction (SEP) for each variable is calculated according to the following formula:

$$SEP = SD\sqrt{1 - ICC^2}$$

where SD = standard deviation of PS1 and PS2 scores[17].

From the SEP, a 90% CI was established around each True Score (T), using the following formula[17]:

$$90\%\ CI = \pm 1.68 \times SEP$$

4. RESULTS

The final sample (n = 10) anthropometric characteristics and training history are shown in Table 1. There were no statistical differences between males and females (Age: U = 12.000, z = 0.000, p = 1.000; Training History: U = 4.000, z = -1.807, p = 0.114; Weight: U = 11.000, z = -0.213, p = 0.914; BMI: U = 6.000, z = -1.279, p = 0.257).

Table 1 – Median and [95% CI] characteristics of study participants (n=10) at the first Pre-Season (PS1) measure.

	n	Age (years)	Training History (years)	Weight (kg)	BMI (kg/m^2)
Female	4	15,00 [12,74 17,26]	6,50 [5,93 7,07]	60,80 [55,47 66,13]	24,57 [21,23 27,91]
Male	6	14,00 [13,59 14,41]	5,00 [4,33 5,67]	61,05 [53,60 68,50]	22,43 [20,64 24,22]
Total	10	14,00 [13,11 14,89]	6,00 [5,46 6,54]	60,80 [55,99 65,61]	23,38 [21,53 25,23]

Variable behaviour from PS1 and PS2, and IS1 to IS6 are presented on Figure 2. For ACWR, data for IS5 and IS6 are presented on Figure 3.

Significant effects were found for Weekly Average s-RPE (x_5^2 = 19.3, p = 0.002), Average Supine RRi (x_7^2 = 17.4, p = 0.015), Minimum OS RRi (x_7^2 = 16.3, p = 0.022), Peak Height (x_7^2 = 23.7, p = 0.001), Fatigue Index (x_7^2 = 14.5, p = 0.043), Vigour (x_7^2 = 25.8, p < 0.001) and Fatigue (x_7^2 = 21.2, p = 0.004).

Multiple comparison s-RPE results from IS2 and IS3 were greater than IS1 (p = 0.008 and p = 0.019, respectively). Average Supine RRi results from IS2 were greater than IS1 (p = 0.029).

Minimum OS RRi values from IS2 were also above IS1 ($p = 0.033$). Peak Height scores from PS2 and IS6 were higher than PS1 ($p = 0.002$ and $p = 0.012$). Vigour scores from IS1, IS2 and IS3 were below PS1 values ($p = 0.039$, $p = 0.002$ and $p = 0.039$). Finally, IS2 values were above PS2 for Fatigue ($p = 0.010$).

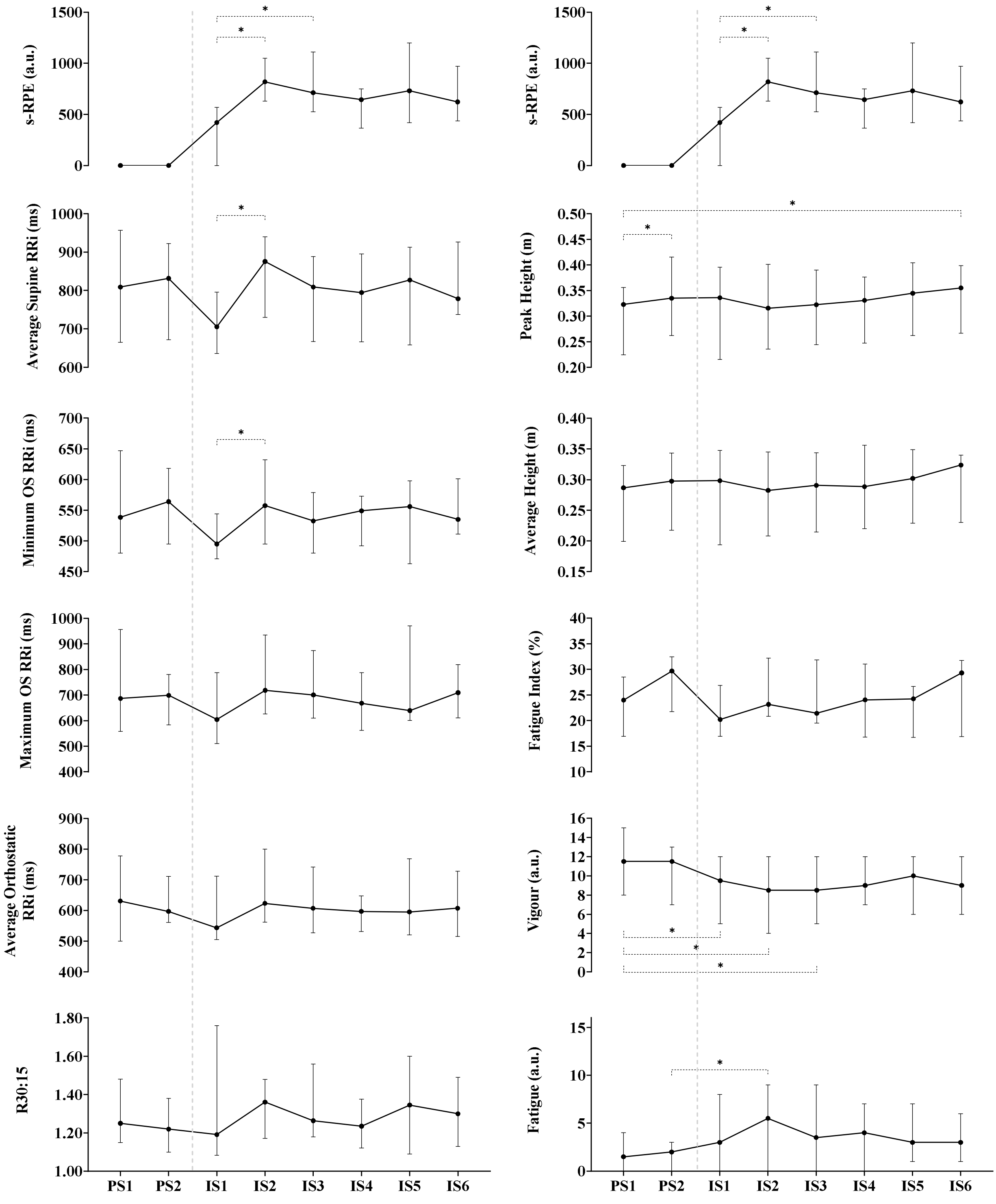

Figure 2 – Median and 95% CI of Weekly Average session-RPE and measures derived from the Orthostatic Stress Test (left), the Repeated Jumps Test and the Brunel Mood Scale (right) of junior Diving athletes (n=10) throughout eight measurements. s-RPE results repeated to facilitate comparison. Vertical grey dashed line separates Pre-Season and In-Season tests. RRi stands for R-R interval. PS stands for Pre-Season. IS stands for In-Season. * $p < 0.05$

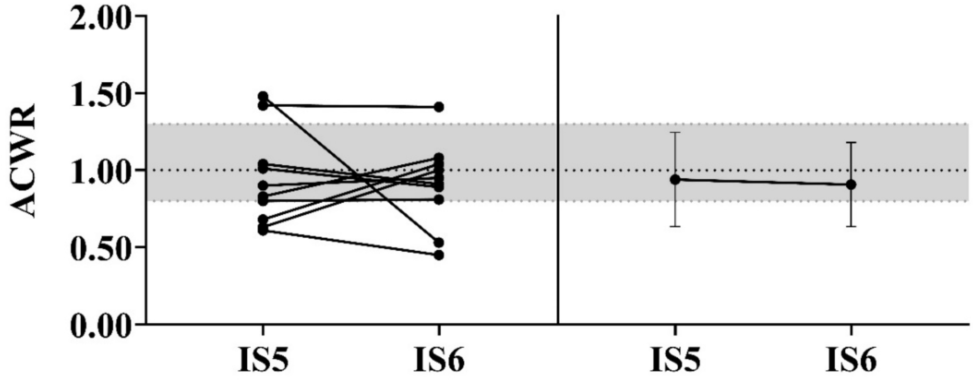

Figure 3 – Individual before-and-after (left) and median with 95% CI (right) values of Acute:Chronic Workload Ratio for IS5 and IS6 of junior Diving athletes (n=10). Grey ranges based on literature recommendations[68]. IS stands for In-Season.

There were no significant differences found in the ACWR scores between IS5 and IS6 ($T = 29$, $p = 0.878$).

4.1 Reliability

Median and 95% CI baseline values, Bland-Altman plots with Bias and 95% Limits of Agreement (LoA), and Scatter plots with perfect equality line for each measure are shown in Figures 4 to 6. Bias was negative for Average Supine RRi (-25, 95% LoA from -111 to 61), Minimum OS RRi (-2, 95% LoA from -89 to 84), Peak Height (-0.03, 95% LoA from -0.07 to 0.01), Average Height (-0.01, 95% LoA from -0.04 to 0.01), and Fatigue Index (-5, 95% LoA from -20 to 9). Bias was positive for Maximum OS RRi (51, 95% LoA from -221 to 323), Average Orthostatic RRi (15, 95% LoA from -106 to 137), 30:15 Ratio (0.09, 95% LoA from -0.29 to 0.47), and Vigour (1, 95% LoA from -2 to 4). Fatigue showed perfect agreement (0, 95% LoA from -1 to 2).

Intraclass Correlation Coefficient (2,1) results for each variable are presented on Table 2. Significant effects were found for all but two measures (30:15 Ratio and Fatigue Index), and confidence intervals crossed zero for another two (Maximum OS RRi, Peak Height). Average Height had the highest degree of reliability (ICC = 0.971, 95% CI from 0.695 to 0.994, $F_{9,9}$ = 64.870, $p < 0.001$), followed by Average Supine RRi (ICC = 0.955, 95% CI from 0.791 to 0.989, $F_{9,9}$ = 29.066, $p < 0.001$), Fatigue (ICC = 0.915, 95% CI from 0.713 to 0.978, $F_{9,9}$ = 23.181, $p < 0.001$), Average Orthostatic RRi (ICC = 0.900, 95% CI from 0.609 to 0.975, $F_{9,9}$ = 9.533, $p = 0.001$), Minimum OS RRi (ICC = 0.820, 95% CI from 0.421 to 0.952, $F_{9,9}$ = 9.248, $p = 0.001$), and, lastly, Vigour (ICC = 0.813, 95% CI from 0.442 to 0.949, $F_{9,9}$ = 10.090, $p = 0.001$).

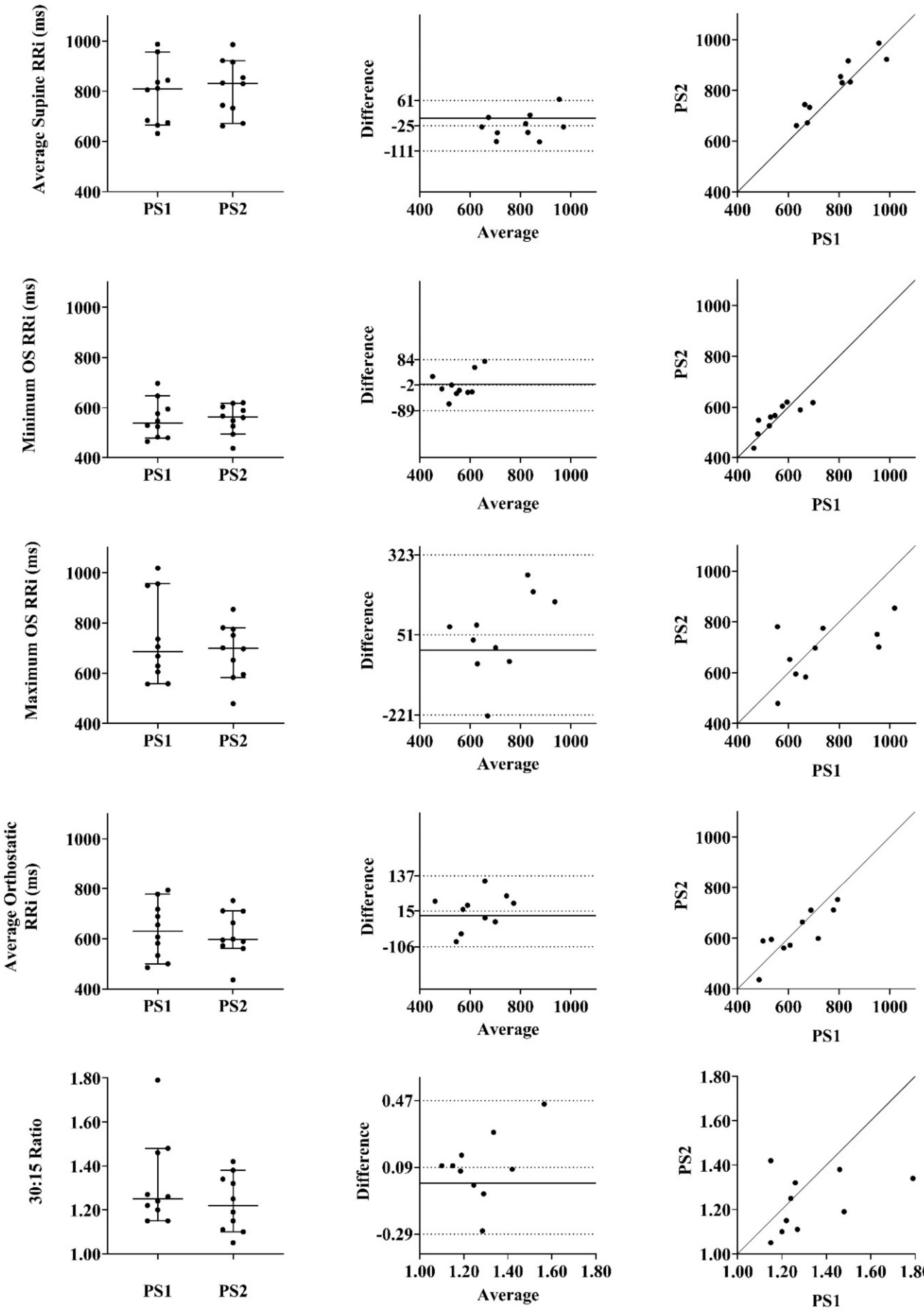

Figure 4 – Median and 95% CI (left), Bland-Altman plots with zero, bias and 95% limits of agreement lines (centre), and Scatter plots with perfect equality line (right) of Pre-Season 1 and 2 (PS1 and PS2) variables from the Orthostatic Stress Test of junior Diving athletes (n=10). OS indicates Orthostatic Stress. RRi stands for R-R interval.

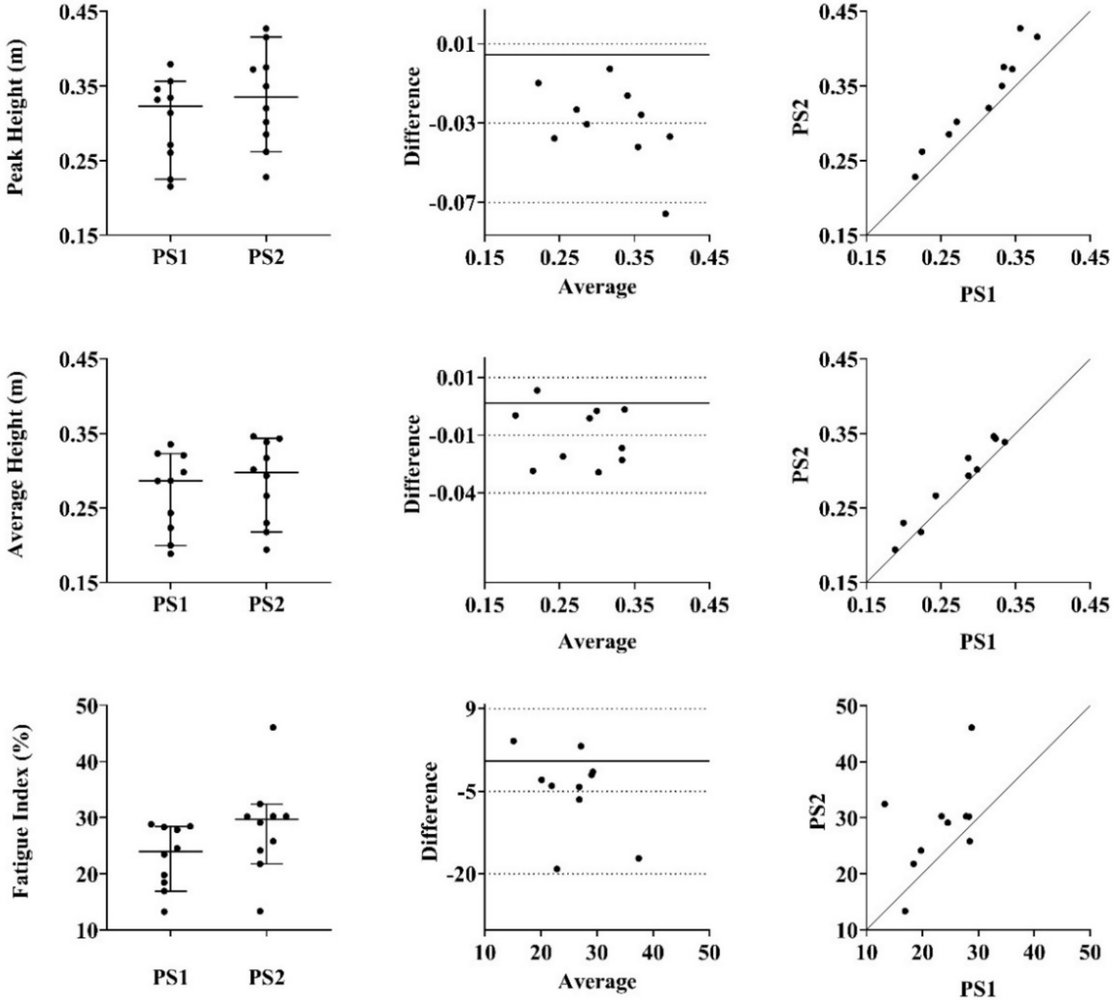

Figure 5 – Median and 95% CI (left), Bland-Altman plots with zero, bias and 95% limits of agreement lines (centre), and Scatter plots with perfect equality line (right) of Pre-Season 1 and 2 (PS1 and PS2) variables from the Repeated Jumps Test of junior Diving athletes (n=10).

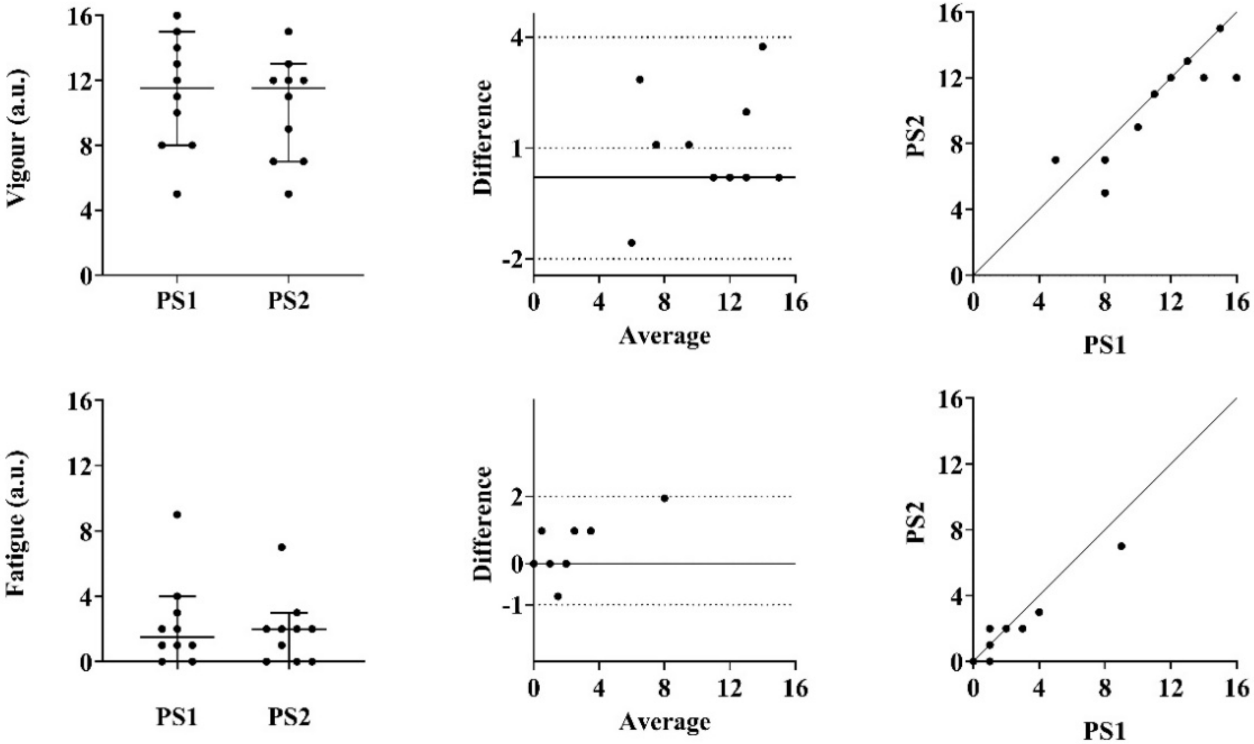

Figure 6 – Median and 95% CI (left), Bland-Altman plots with zero, bias and 95% limits of agreement lines (centre), and Scatter plots with perfect equality line (right) of Pre-Season 1 and 2 (PS1 and PS2) variables from the Brunel Mood Scale of junior Diving athletes (n=10).

Table 2 – Baseline test-retest ICC (2,1), 95% CI, and corresponding F Test results for variables derived from the Orthostatic Stress Test, Repeated Jumps Test, and Brunel Mood Scale of junior Diving athletes (n=10).

	ICC (2,1) [95% CI]	F Test with True Value 0			
		Value	*df*1	*df2*	Sig
Average Supine RRi	0.955 [0.791 0.989]	29.066	9	9	0.001*
Minimum OS RRi	0.820 [0.421 0.952]	9.248	9	9	0.001
Maximum OS RRi	0.569 [-0.017 0.870]	3.666	9	9	0.033
Average Orthostatic RRi	0.900 [0.609 0.975]	9.533	9	9	0.001
30:15 Ratio	0.340 [-0.230 0.770]	2.175	9	9	0.131
Peak Height	0.878 [-0.030 0.978]	69.224	9	9	0.001*
Average Height	0.971 [0.695 0.994]	64.870	9	9	0.001*
Fatigue Index	0.378 [-0.156 0.782]	2.577	9	9	0.087
Vigour	0.813 [0.442 0.949]	10.090	9	9	0.001
Fatigue	0.915 [0.713 0.978]	23.181	9	9	0.001*

RRi stands for R-R interval. OS indicates Orthostatic Stress. * $p < 0.001$

4.2 Correlation

Correlation results between variables for all eight assessments are shown in Figure 7. There were significant correlations between: Average Weekly s-RPE and Fatigue (r = 0.368 [0.174 0.541], p = 0.001); Peak Height and Maximum OS RRi (r = -0.258 [-0.433 -0.071], p = 0.021); Peak Height and Average Orthostatic RRi (r = -0.311 [-0.480 -0.106], p = 0.005); Peak Height and 30:15 Ratio (r = -0.283 [-0.470 -0.061], p = 0.011); Average Height and Average Orthostatic RRi (r = -0.223 [-0.438 -0.005], p = 0.047); Average Height and Vigour (r = 0.302

[0.114 0.472], p = 0.006); Fatigue Index and Average Supine RRi (r = -0.283 [-0.464 -0.083], p = 0.011); Fatigue Index and Minimum OS RRi (r = -0.325 [-0.515 -0.094], p = 0.003); Fatigue Index and Maximum OS RRi (r = -0.252 [-0.466 -0.008], p = 0.024); Fatigue Index and Average Orthostatic RRi (r = -0.309 [-0.500 -0.104], p = 0.005); Fatigue Index and Vigour (r = -0.374 [-0.582 -0.147], p = 0.001); Fatigue Index and Fatigue (r = 0.482 [0.288 0.646], p < 0.001); Fatigue and Minimum OS RRi (r = -0.413 [-0.606 -0.197], p < 0.001); Fatigue and Average Orthostatic RRi (r = -0.359 [-0.523 -0.179], p = 0.001).

Correlation between Peak Height and Vigour (r = 0.207 [0.005 0.387], p = 0.065) was not significant, but the CI did not cross zero. Correlation between Fatigue and Average Supine RRi (r = -0.233 [-0.444 0.011], p = 0.038) was significant, but the CI crossed zero.

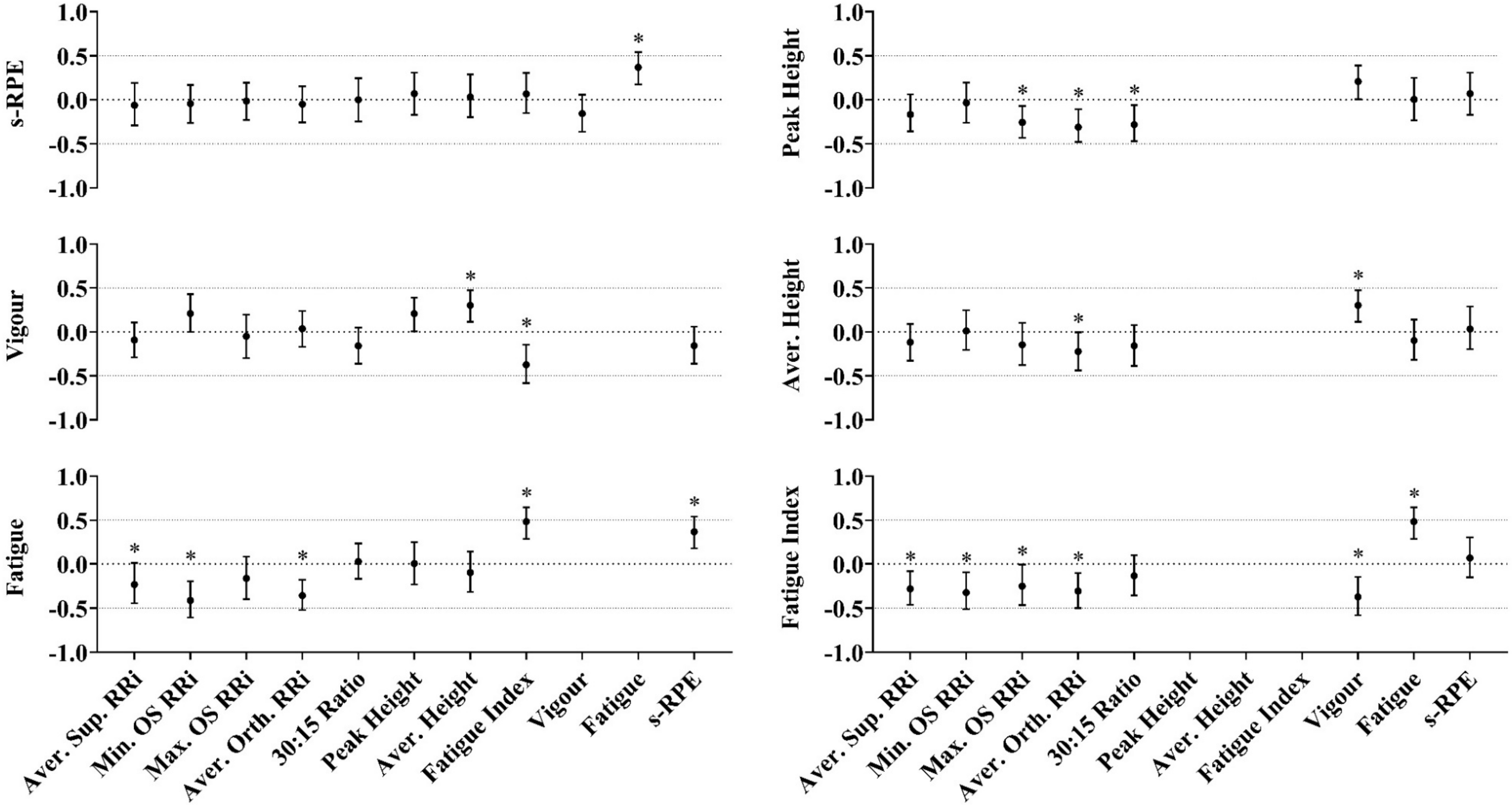

Figure 7 – Spearman's r correlation matrix and BCa 95% CI between Weekly Average session-RPE and all the derived variables from the Orthostatic Stress Test, Repeated Jumps Test, and Profile of Mood States throughout all assessments (n=80) in junior Diving athletes. Aver stands for Average. Sup stands for Supine. Min stands for Minimum. Max stands for Maximum. Orth stands for Orthostatic. * $p < 0.05$.

Correlations with IS5 and IS6 ACWR values are shown on Figure 8. Correlation was significant with Average Supine RRi (r = -0.493 [-0.832 -0.039], p = 0.027). Correlations were significant with Minimum OS RRi (r = -0.526 [-0.924 0.093], p = 0.017), and Average Orthostatic RRi (r = -0.493 [-0.878 0.139], p = 0.027), but the confidence intervals crossed zero.

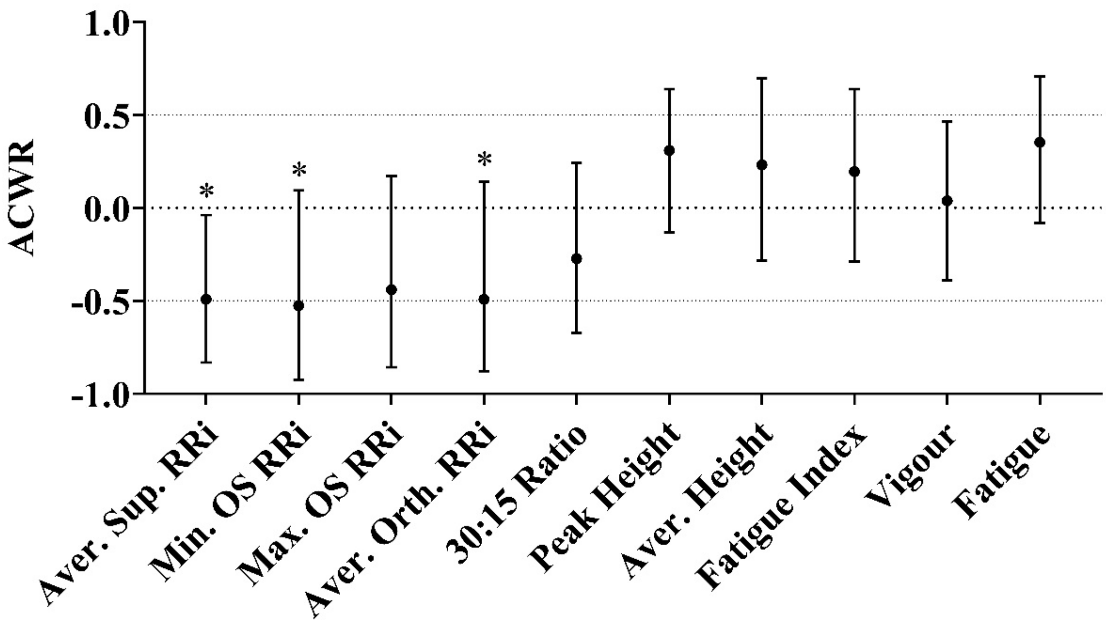

Figure 8 – Spearman's r correlation matrix and BCa 95% CI between 28-days uncoupled Acute:Chronic Workload Ratio and all the derived variables from the Orthostatic Stress Test, Repeated Jumps Test, and Profile of Mood States on IS5 and IS6 (n=20) of junior Diving athletes. Aver stands for Average. Sup stands for Supine. Min stands for Minimum. Max stands for Maximum. Orth stands for Orthostatic. * $p < 0.05$.

4.3 True Change

Standard Error of Prediction results are shown in Table 3.

Table 3 – ICC-derived Baseline SEP values for assessing variable probable change.

	Baseline Average	Baseline SD	SEP
Average Supine RRi	803 ms	115 ms	34 ms
Minimum OS RRi	556 ms	66 ms	38 ms
Maximum OS RRi	712 ms	145 ms	119 ms
Average Orthostatic RRi	626 ms	100 ms	43 ms
30:15 Ratio	1.28	0.17	0.16
Peak height	0.32 m	0.06 m	0.03 m
Average height	0.28 m	0.05 m	0.01 m
Fatigue Index	26%	7%	7%
Vigour	11 a.u.	3 a.u.	2 a.u.
Fatigue	2 a.u.	2 a.u.	1 a.u.

Lastly, assessment of True Change for two randomly selected individuals are shown on Figure 9. For subject nine, the Average Supine RRi and Minimum OS RRi scores on IS3, and Fatigue score on IS4 were lower than the baseline True Score. The 30:15 Ratio on IS1, Average Height on IS1, 3, 4, 5 and 6, and Fatigue scores on IS1, 2 and 3 were all above the baseline True Score.

Results for subject four indicate lower than baseline True Score for Average Supine RRi and Average Height on IS1, and Vigour on IS1, 2 and 3. Average Supine RRi on PS2 and IS4, Average Orthostatic RRi on IS3 and IS4, 30:15 Ratio on IS1 and IS2, as well as Fatigue on IS1 and IS2 were above the baseline True Score.

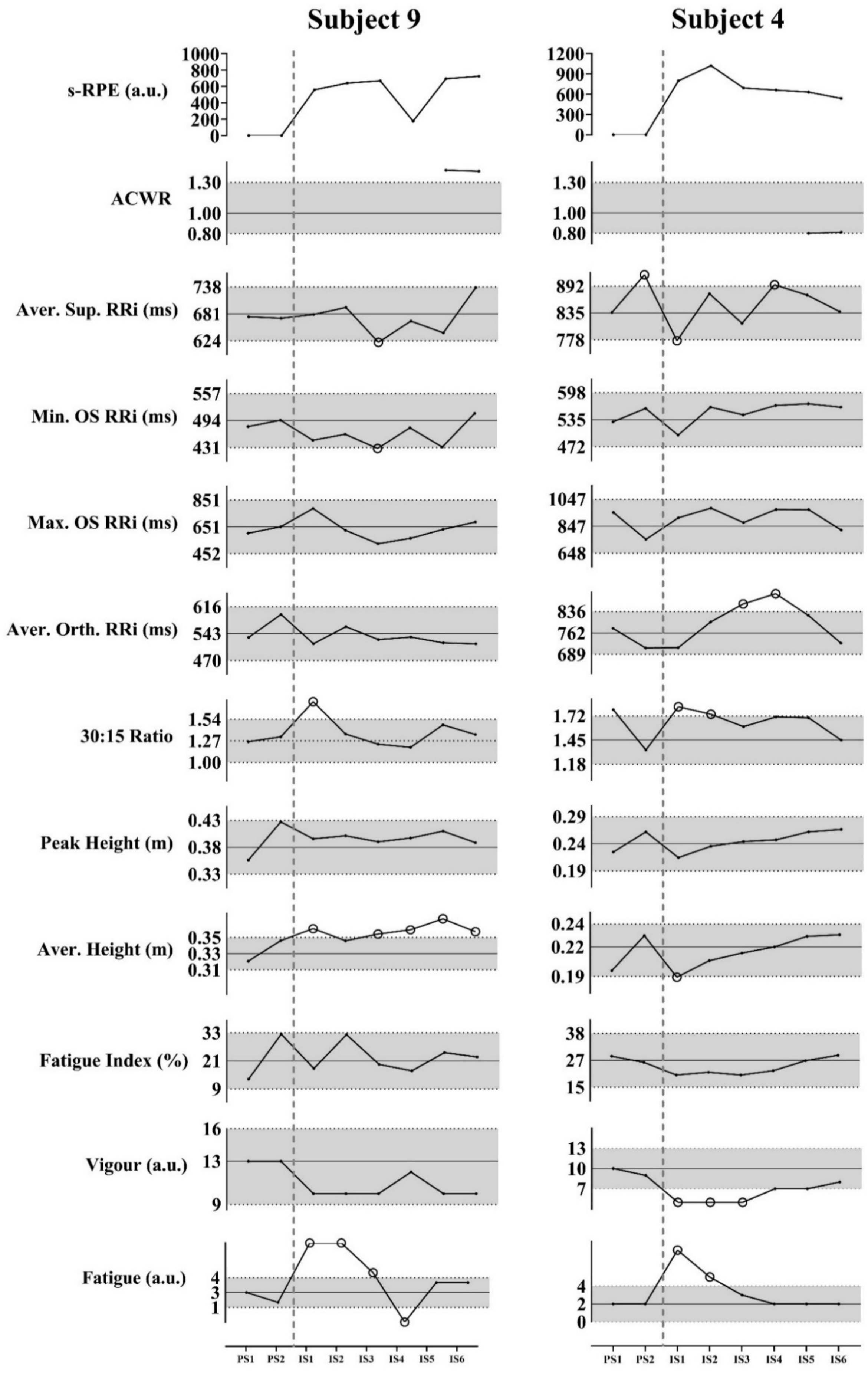

Figure 9 – Individual behaviour matrix for Weekly Average session-RPE, Acute:Chronic Workload Ratio, and all the derived variables from the Orthostatic Stress Test, Repeated Jumps

Test, and Profile of Mood States of two randomly selected junior Diving athletes throughout eight assessments. Only ACWR values for IS5 and IS6 are shown. Horizontal grey ranges on each graph represent the subject's baseline True Score predicted from the PS1 measurement (centre line) and 90% SEP-derived CI (top and bottom lines). Circled-out measures represent points that fall outside of CI, indicating change in relation to the baseline True Score. ACWR ranges are based on literature recommendations. Vertical grey dashed lines separate Pre-Season and In-Season measurements. Aver stands for Average. Sup stands for Supine. RRi stands for R-R interval. Min stands for Minimum. OS stands for Orthostatic Stress. Max stands for Maximum. Orth stands for Orthostatic. PS stands for Pre-Season. IS stands for In-Season.

5. DISCUSSION

In this study, we proposed a practical athlete monitoring system framework using reliability and correlation analyses of key indicators to facilitate integrated fatigue and training load stress detection in junior Diving athletes.

Although assessing gender differences was not the aim of this work, males and females had similar anthropometric, age, and training history characteristics. This in-and-of-itself does not justify a monitoring approach that ignores gender, especially knowing that past research has identified differences in not only performance[69], but also autonomic[70], and psychological[71] variables between male and female athletes. Creating individual normality ranges to assess change in each variable, as proposed in Figure 9, is a possible course of action, as it can account for variation from other sources besides gender, using group reliability and correlation values to form the statistical foundation through which tailored approaches can be developed[15].

As for changes in variables along the weeks, it is important to note that intra-subject conditions were kept as constant as possible – testing was done on the same days of the week and period of the day for the same athlete. As for inter-subject conditions, assessments were performed on different days of the week, under different workload patterns. For example, a subject measured on a Saturday (*i.e.*, after 5 concurrent training days) could be under a different stress response compared to a subject measured on the Monday of the same week (*i.e.*, after one day of total rest), even if presenting similar Average Weekly s-RPE values. For this reason, statistical analyses cannot point out the source of inter-subject variation along the weeks.

This testing configuration was chosen to accommodate the available resources, as there was only one tester, one room, and one piece of each equipment used. Additionally, only one athlete was assessed before each training session, to avoid affecting training schedules and duration. If the appropriate resources were available, and preserving non-interference, same-weekday or daily monitoring could certainly be better strategies to measure differences in stress response, with similar inter-individual conditions[72].

Nevertheless, Average Weekly s-RPE variation indicates an overall change in In-Season load, with IS2 (819 a.u.) and IS3 (713 a.u.) standing out against IS1 (421 a.u.) median values. Transition and return-to-training periods require a controlled approach to gradually increase training load and minimize risks[73]. IS2 median values were the highest recorded for the entire study, maybe due to an intentional planned increase in load, or possibly due to the dissociation between external load and perceived exertion scores exacerbated by fatigue[10]. As there was no access to training plans, transition strategies could not be evaluated, and such effects could not be differentiated.

Dependent variables derived from all tests also suffered changes throughout the eight assessments. All Heart Rate measures point to a marked decrease in RRi values on IS1, and to a recovery to median baseline values in the following week, with the Average Supine RRi (706 vs. 876 ms) and the Minimum OS RRi (495 vs. 558 ms) significantly affected. Increased sympathetic predominance and resting tachycardia are known effects of high-intensity training and over-reaching periods[36,42,43]. As our results show, abrupt training load changes, such as those experienced during a transition from Off- to In-Season, can elicit a similar stress response.

Mood states presented with prolonged patterns of negative effects, with Vigour possibly affected by changes in s-RPE, falling on IS1 (10), 2 (9), and 3 (9), compared to PS1 (12), and Fatigue increased on IS2 (6), compared to PS2 (2). The observed changes are in line with other studies, that have demonstrated mood suppression according to increases in training load[50,52].

Neuromuscular variables presented with a different response to training load stress. There were no clear decrements in performance for the first assessment of the season compared to baseline – median Fatigue Index even decreases to its lowest value (20%), although non-significantly –, and changes in the acute training load were possibly felt only on IS2. IS2 values for both Peak and Average Jump Height do suffer a slight non-significant decrease, possibly caused by the increase in s-RPE[57], but the overall six-week tendency points to a gain in vertical jumping ability of 0.04 m for Peak Height, and 0.03 m for Average Height, possibly due to training-resulted adaptations.

The source of the increase in median Peak Jump Height on PS2 (0.33 m) compared to PS1 (0.32 m) is unclear, as all subjects achieved higher scores on the second assessment. A similar 6-week testing bout happened in January 2019, and athletes underwent pilot assessments in December of that same year, prior to the Off-Season. Nevertheless, it is still likely that familiarization effects are present, even though vertical jump height has been shown to have good levels of inter-day reliability[74,75]. Any potentiation effects – *i.e.* performance gains due to prior execution of the same exercise – are also unlikely, as the time-course for improved muscle activity is usually much shorter[76].

Changes to the Fatigue Index do point to a non-significant tendency to rise until IS6. Due to its ratio nature, increases in this measure can usually be caused by a) a decrease in Lowest Jump Height; b) a simultaneous increase in Peak Jump Height and decrease in Lowest Jump Height; or c) an increase in Peak Jump Height.

In our study, on PS2, median Peak Jump Height increased by 0.01 m compared to PS1, while median Lowest Height remains similar; this could explain the 6% increase in the Fatigue Index for that measurement, in comparison with PS1. On IS2, there is a 0.02 m loss in Peak Jump Height, while Lowest Height remained the same, causing the Fatigue Index to rise by 3% compared to the previous assessment. From IS3 to IS6, Peak Height increased by 0.01 m each week, while Lowest Height raised a total of 0.01 m from IS4 to IS6, causing the Fatigue Index on IS6 to increase to its second-highest median value, at 29%.

Although other variables show signs of an increase in overall stress on IS6, the Fatigue Index changes observed seem to be mainly caused by fluctuations in Peak Height. This does not necessarily represent a loss in capacity to maintain peak neuromuscular performance throughout the test – which would be the expected interpretation of this variable –, and certainly raises questions regarding the Index's usefulness, as seen in the literature[77].

Overall, Mood and Perceived Exertion variables appeared to more frequently and clearly distinguish deviation from baseline. This potentially illustrates subjective variables' increased sensitivity, comparing to objective ones, in response to variations in training load[51].

ACWR results for IS5 and IS6 are statistically similar, but individual before-and-after results show contrasting inter-subject behaviour: while some athletes kept their position constant, others crossed the 1.00 threshold, upwards or downwards. For individuals that went from below 1.00 to above 1.00 (*i.e.*, subject 5, who moved from 0.83 to 1.08), this means the acute 7-days load is higher than the chronic 21-days load, a condition of increased training stress; for individuals that went from above 1.00 to below 1.00 (*i.e.*, subject 10, who moved from 1.48 to 0.53), a lower acute than chronic load condition is associated with lower stress or even recovery phases. Such variations could be caused by the different schedules for assessing each athlete, but it is important to emphasize the potential of central tendency measures to mask contrasting variable behaviour, as seen in Figure 3. Considering the impact of training load fluctuation on overall athlete performance and health[7], the argument for the individualization of analyses only gets stronger.

5.1 Reliability

As for reliability, starting with the Orthostatic Stress Test measures, Average Supine and Orthostatic RRi showed excellent results, with ICC equal to or above 0.900 and no visual signs of systematic bias on the Bland-Altman analysis[66]. LoA in relation to median values ranged from around 20% for the former, and 30% for the later, indicating excellent agreement between PS1 and PS2 conditions. The same can be said about Minimum OS RRi, which also showed small bias and 30% LoA in relation to median values – even though the ICC score was not as high.

LoA for Maximum OS RRi were around 75% of median scores, and, although significant, ICC 95% CIs crossed zero. This reflects methodological difficulties found in determining Maximum OS RRi scores: unlike Minimum OS RRi, Maximum values did not present with an expected clear Peak in several instances, or Peak values happened after 30 seconds of posture change. This indicates possible inconsistencies regarding the classic time ranges for the Orthostatic reflex phenomenon[34], which most likely impacted its reliability.

Lastly, the 30:15 Ratio presented with non-significant and low ICC results, and LoA around 60% of median scores. Low reliability results could have been caused by the same methodological issues that influenced results for the Maximum OS RRi (it forms the 30:15 Ratio's numerator). It is also worth noting that ratio measures in which the relationship between numerator and denominator is not linear could present with statistical abnormalities[78,79]; since the physiological mechanisms that cause and influence the Minimum and Maximum OS RRi responses are not the same[35], this could certainly be the case with the 30:15 Ratio.

Jump Height variables presented with a clear negative bias, indicating an increase in value for all measures on PS2. Nevertheless, LoA were low, compared to median PS1 values (around 20% for Peak Height, and around 17% for Average Height), and ICC results for Average Height were the highest of all measures. Averaged measures have been shown in the literature to be highly reliable in identifying fatigue[80], and our results confirm those findings. Although significant and above 0.850, Peak Height ICC 95% CIs crossed zero, adding evidence to the possible learning effect discussed before. Although previously deemed unnecessary[75], pre-

Season re-familiarization procedures in performance tests could be useful to maximise reliability, even when the sample is experienced in the exercise measured.

The Fatigue Index also showed the same tendency to increase on PS2, possibly caused by the increase in Peak Height, as discussed before. In addition, compared to PS1 median values, LoA were the highest of all measures (around 120%), and ICC results were non-significantly low. This reinforces the need to assess the utility of ratio variables in AMS, as they could add unnecessary measurement error and misrepresent physiological phenomena[79].

As for Mood variables, Fatigue stood out as having a perfect agreement, LoA around 19% of median PS1 values, and above 0.900 ICC results. Vigour presented with a slight positive bias, which possibly affected its LoA (around 38% of median PS1 scores) and ICC results (although still above 0.800). Nonetheless, such results reinforce the high reliability of subjective measures in assessing athletes' response to training[51].

5.2 Correlation

In this study, we also evaluated the correlation between measures of training response for all eight assessments, and the results were not as expected. Fatigue correlated positively with Average Weekly s-RPE, and Average Supine RRi correlated negatively with ACWR, indicating Mood and Heart Rate measures' response to the changes in acute load, and changes in acute load in relation to the chronic load, respectively. Increased resting Heart Rate is a classic sign of fatigue symptoms in athletes[36,38], and increased Fatigue-related emotions have been associated with fluctuations in training intensity[53], so our results are in tandem with what has been observed in the literature. However, no other variable correlated significantly with independent measures. This could be explained by the variability of the psycho-physiological response to training load[81], demonstrating the importance of multidisciplinary approaches for comprehensive fatigue detection in athletes. Another limitation that needs pointing out is that, although training duration was a standard 4-hour for all In-Season weeks, individual session times were not reported, and could have varied slightly. s-RPE has been found to have high measurement error[82], and a more precise time collection could have impacted correlation results.

Considering the correlation between dependent variables, lower RRis were associated with higher Fatigue-related emotions, and an increased Fatigue Index. Unexpectedly, the same negative relationship was found between RRi and Jump Height, indicating that states of relative resting tachycardia and sympathetic predominance could facilitate higher jump performances. Such results have been observed in the literature[42], with peak performance happening in periods of decreased cardiac vagal modulation.

Higher Peak and Average Height were also related to higher emotions of Vigour, but not to lower Fatigue scores. Research into mood associations with performance has shown that higher Vigour is a moderate facilitator of performance, while lower Fatigue is a very small one[48].

Finally, even though the Fatigue Index presented with poor reliability and with methodological inaccuracies, as discussed before, it correlated with six out of seven dependent variables, impacting the variable's usefulness. The same cannot be said about the 30:15 Ratio, which only correlated with Peak Height, besides presenting with poor reliability.

5.3 True Change

The reliability and correlation analyses discussed above form two strong foundations for the AMS we explored in this study. The former assists decision-making by quantifying measurement error and facilitating the creation of individual ranges for assessing True Change[17]. The later helps establish usual patterns of joint variable behaviour, which could increase the understanding of variability in individual stress responses and broaden the scope of fatigue identification[14].

The first randomly selected individual (Subject 9) presented with stable training load behaviour for the first three measurements, a sudden decrease on IS4 due to low attendance, and a return to the initial values for IS5 and IS6. Heart Rate measures indicate an increasing fatigue response towards IS3, with Average Supine and Minimum OS RRi falling outside of the True Change intervals. This response is corroborated by Fatigue measures, which were elevated for the first three assessments. As stated before, no access to training plans creates difficulties in understanding planned intensity and in assessing the intentionality of the relative load monotony observed from IS1 to IS3. Nonetheless, the results could justify a planned decrease in training intensity and duration for IS4 – which eventually happened due to the low attendance – enabling measures to return to baseline and facilitating performance improvements.

A sudden spike in Maximum OS RRi, combined with a decrease in Minimum OS RRi on IS1, caused an increase in the 30:15 Ratio outside of intervals. Low reliability of Maximum OS RRi could be affecting the results, as the IS1 value for this measure still falls inside the confidence intervals, and we cannot be sure that they are different from baseline. Another explanation lies in a particular pattern of autonomic fatigue response, characterized by increased parasympathetic predominance and exacerbated baroreflex response in Overreaching states: this could also result in lower Minimum OS RRi values, higher Maximum OS RRi, and thus a spike in 30:15 Ratio[41,44]. The same effect happens to Subject 4 on IS1 and IS2.

The sudden decrease in training load for IS4 was felt throughout, with most measures returning to baseline levels, and Fatigue decreasing past baseline. It could have also facilitated performance on IS5, when the athlete achieved their highest Average Jump Height of the period. For IS5 and IS6, s-RPE returns to the same levels as the first three assessments. Due to this sudden decrease in load and the subsequent abrupt recovery, ACWR scores are above the recommended ranges on the last two assessments, but there were no clear stress effects, with most measures remaining within confidence intervals.

Lastly, except for IS2, all Average Jump Height measures are above baseline. It is unlikely that performance could be increased in such a brief period, reinforcing the impact of the negative bias encountered in PS1 and PS2 measures. True Values could be calculated using PS2 measures or the average of PS1 and PS2 values, to reduce the influence of a possible learning effect. Peak Height presented with the same phenomenon, possibly due to larger confidence intervals resulted from lower reliability levels.

The next individual's (Subject 4) load behaviour is not the same. IS2 and IS1 values were the highest reported, in that order, followed by a slight tendency to decrease on the final four assessments. ACWR values remained, for this reason, on the lower end of the recommended range for IS5 and IS6. Signs of stress were concentrated around IS1 and IS2, impacting Average Supine RRi, Average Jump Height, Vigour, and Fatigue. Starting at IS3, all measures presented with a recovery tendency, with values rising above baseline – sometimes outside of confidence intervals, like with Average Supine and Orthostatic RRi.

Heart Rate measures on IS6 showed possible signs of fatigue, although still not outside of baseline levels. The same tendency is not seen in other variables, with Jump Height achieving some of its highest values, and Mood remaining within baseline, which could justify maintenance of training load.

In summary, based on the individual data presented, multidisciplinary teams can visualise varied patterns of stress behaviour in athletes – sometimes not affecting neuromuscular performance – guiding training load manipulation to ensure proper recovery and lowered risks. Central tendency and grouped measures, like those presented on Figure 2, do not provide with the same information or flexibility.

6. CONCLUSION

Considering the objectives of this work, we conclude:

1) Averaged and subjective variables presented with high degrees of reliability. Single-value variables presented with varying results, ranging from good to moderate reliability – although non-significant, in some cases. Ratio variables presented with low and non-significant reliability, putting to question their use in AMS.

2) Fatigue and Average Supine RRi were the only measures to significantly correlate with the independent variables (s-RPE and ACWR), possibly evidencing the variability of the psycho-physiological response to fatigue. Nonetheless, several associations between dependent variables were found, with an overall tendency of Heart Rate and Mood measures to react negatively to increases in training load, while Jump Height decrements were hardly observed.

3) Establishing individualized ranges to assess variable True Change in comparison to baseline is a possible solution to identify integrated fatigued states in adolescent diving athletes.

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8. ANEXOS

ANEXO A: Versão online da Escala de Humor de Brunel

Como você se sente AGORA?

0 = nada 1 = um pouco 2 = moderadamente
3 = bastante 4 = extremamente

Apavorado(a) *

0	1	2	3	4
○	○	○	○	○

Animado(a) *

0	1	2	3	4
○	○	○	○	○

Confuso(a) *

0	1	2	3	4
○	○	○	○	○

Esgotado(a) *

0	1	2	3	4
○	○	○	○	○

Deprimido(a) *

0	1	2	3	4
○	○	○	○	○

Desanimado(a) *

0	1	2	3	4
○	○	○	○	○

Irritado(a) *

0	1	2	3	4
○	○	○	○	○

Exausto(a) *

0	1	2	3	4
○	○	○	○	○

Inseguro(a) *

0	1	2	3	4
○	○	○	○	○

Sonolento(a) *

0	1	2	3	4
○	○	○	○	○

Zangado(a) *

0	1	2	3	4
○	○	○	○	○

Triste *

0	1	2	3	4
○	○	○	○	○

Ansioso(a) *

0	1	2	3	4
○	○	○	○	○

Preocupado(a) *

0	1	2	3	4
○	○	○	○	○

Com disposição *

0	1	2	3	4
○	○	○	○	○

Infeliz *

0	1	2	3	4
○	○	○	○	○

Desorientado(a) *

0	1	2	3	4
○	○	○	○	○

Tenso(a) *

0	1	2	3	4
○	○	○	○	○

Com raiva *

0	1	2	3	4
○	○	○	○	○

Com energia *

0	1	2	3	4
○	○	○	○	○

Cansado(a) *

0	1	2	3	4
○	○	○	○	○

Mal-humorado(a) *

0	1	2	3	4
○	○	○	○	○

Alerta *

0	1	2	3	4
○	○	○	○	○

Indeciso(a) *

0	1	2	3	4
○	○	○	○	○

ANEXO B: Versão online da Escala de Percepção de Esforço CR-10

Data *

Date

dd/mm/aaaa

Como foi o treino para você?

Classificação	Descritor
0	Repouso
1	Muito, Muito Fácil
2	Fácil
3	Moderado
4	Um Pouco Difícil
5	Difícil
6	-
7	Muito Difícil
8	-
9	-
10	Máximo

*

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

ANEXO C: Parecer consubstanciado do CEP, número 3.971.287

UNB - FACULDADE DE CIÊNCIAS DA SAÚDE DA UNIVERSIDADE DE BRASÍLIA

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Monitoramento anual de atletas de Saltos Ornamentais
Pesquisador: Roque Bernardes Neto
Área Temática:
Versão: 2
CAAE: 26303219.7.0000.0030
Instituição Proponente: Faculdade de Educação Física - UnB
Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.971.287

Apresentação do Projeto:
Resumo: "Introdução: O seguinte projeto pretende explorar a relação entre medidas de monitoramento de carga externa e de carga interna em atletas de Saltos Ornamentais. A relação entre a carga externa e o estresse fisiológico, psicológico e metabólico provocados explica o incremento progressivo de performance nos esportes de competição, e a medida e o controle de tais variáveis é fundamental para diminuição dos riscos do acúmulo de fadiga, de sub-recuperaçãoe de inadequação da carga. Uma abordagem multivariada permite uma visão fisiológica e psicológica integral do atleta, e, para tal, os métodos de acompanhamento propostos se mostram adequados para fornecer respostas da adaptação ao treino nos Saltos Ornamentais. Objetivo:Medir, comparar e correlacionar as medidas de carga externa – capacidade de produção de potência muscular, número de séries e repetições, Grau de Dificuldade médio da sessão, s-RPE planejado – e carga interna – medidas antropométricas, medidas de qualidade da dieta, sono e imunidade, medidas de função autonômica cardíaca, marcadores bioquímicos, s-RPE do atleta,e variáveis psicológicas – em atletas de Saltos Ornamentais, conforme progressão da aplicação de carga na temporada de treinamento para competições de 2020. Materiais e Métodos: a amostra será composta por cerca de 80 atletas de Saltos Ornamentais, com idade entre 7 e 22anos, matriculados no Centro de Excelência em Saltos Ornamentais da UnB em 2019 e 2020.A coleta de dados acontecerá de acordo com o método e a periodicidade específica de cada teste,iniciando se em janeiro e com duração de 12 meses. As variáveis serão testadas quanto à normalidade, e

Endereço: Faculdade de Ciências da Saúde - Campus Darcy Ribeiro
Bairro: Asa Norte **CEP:** 70.910-900
UF: DF **Município:** BRASILIA
Telefone: (61)3107-1947 **E-mail:** cepfsunb@gmail.com

descritas de acordo com a natureza da sua distribuição. Os testes estatísticos correspondentes à distribuição serão aplicados, com nível de significância igual ou menor que 0,05."

De acordo com a Introdução: "A Carga indica a principal variável de treino que, quando manipulada, pode transformar a performance esportiva (Bompa e Buzzichelli, 2015, p. 87). Classicamente descrita pelas variáveis Volume e Intensidade, a carga é atualmente melhor representada pela medida que expressa o trabalho realizado por um indivíduo em treinamento – denominada carga externa –, e pela medida do estresse fisiológico e psicológico imposto por esse trabalho – chamada de carga interna (Halson, 2014; Kellmann et al., 2018). A relação entre a aplicação de carga externa e o estresse fisiológico relativo provocado é fundamental para o incremento progressivo de performance nos esportes de competição (Hynynen et al., 2008; Pind e Mäestu, 2017). De fato, faz-se necessária que a sobrecarga de treino seja suficiente para induzir perturbação na homeostase, e gerar fadiga, que por sua vez permitirá o desenvolvimento de overreaching funcional (i.e., um decréscimo temporário da performance de treino); se seguido de recuperação, haverá Supercompensação, isto é, a adaptação dos sistemas fisiológicos e aumento da performance (Halson, 2014; Kellmann et al., 2018). A importância da distinção entre Cargas externa e interna é também evidenciada pelos conceitos de especificidade e individualidade: cargas externas de natureza diferente provocam, num mesmo atleta, alterações fisiológicas e psicológicas diferentes; ademais, o estresse provocado pela aplicação de uma mesma carga externa pode não ser igual em dois atletas diferentes (Cardinale et al., 2017; Halson, 2014; Kellmann et al., 2018; Pind e Mäestu, 2017). Na criação de um plano de treinamento, portanto, espera-se uma relação proporcional e específica entre a magnitude e natureza da Carga externa aplicada, e a magnitude e natureza da Carga interna sentida; espera-se sincronia entre a carga planejada pelo treinador e aquela percebida pelo atleta (Foster, Rodriguez -Marroyo e Koning, De, 2017; Halson, 2014; Minganti et al., 2011). Uma desigualdade nessa relação pode revelar estados de fadiga, ou que os estímulos de treino são insuficientes ou inadequados para provocar as adaptações fisiológicas desejadas (Foster, Rodriguez-Marroyo e Koning, De, 2017; Halson, 2014)."

E ainda "[...]Os Saltos Ornamentais (SO) é um esporte de coordenação motora complexa, de execução de elementos técnicos que prezam pela estética e a destreza, e que exige capacidades de força, flexibilidade e velocidade de seus praticantes (Huber, 2016, p. 182; Stambulova, Stambulov e Johnson, 2012). descritas de acordo com a natureza da sua distribuição. Os testes estatísticos correspondentes à distribuição serão aplicados, com nível de significância igual ou menor que 0,05."

De acordo com a Introdução: "A Carga indica a principal variável de treino que, quando manipulada, pode transformar a performance esportiva (Bompa e Buzzichelli, 2015, p. 87). Classicamente descrita pelas variáveis Volume e Intensidade, a carga é atualmente melhor representada pela medida que expressa o trabalho realizado por um indivíduo em treinamento – denominada carga externa –, e pela medida do estresse fisiológico e psicológico imposto por esse trabalho – chamada de carga interna (Halson, 2014; Kellmann et al., 2018). A relação entre a aplicação de carga externa e o estresse fisiológico relativo provocado é fundamental para o incremento progressivo de performance nos esportes de competição (Hynynen et al., 2008; Pind e Mäestu, 2017). De fato, faz-se necessária que a sobrecarga de treino seja suficiente para induzir perturbação na homeostase, e gerar fadiga, que por sua vez permitirá o desenvolvimento de over reaching funcional (i.e., um decréscimo temporário da performance de treino); se seguido de recuperação, haverá Supercompensação, isto é, a adaptação dos sistemas fisiológicos e aumento da performance (Halson, 2014; Kellmann et al., 2018). A importância da distinção entre Cargas externa e interna é também evidenciada pelos conceitos de especificidade e individualidade: cargas externas de natureza diferente provocam, num mesmo atleta, alterações fisiológicas e psicológicas diferentes; ademais, o estresse provocado pela aplicação de uma mesma carga externa pode não ser igual em dois atletas diferentes (Cardinale et al., 2017; Halson, 2014; Kellmann et al., 2018; Pind e Mäestu, 2017). Na criação de um plano de treinamento, portanto, espera-se uma relação proporcional e específica entre a magnitude e natureza da Carga externa aplicada, e a magnitude e natureza da Carga interna sentida; espera-se sincronia entre a carga planejada pelo treinador e aquela percebida pelo atleta (Foster, Rodriguez -Marroyo e Koning, De, 2017; Halson, 2014; Minganti et al., 2011). Uma desigualdade nessa relação pode revelar estados de fadiga, ou que os estímulos de treino são insuficientes ou inadequados para provocar as adaptações fisiológicas desejadas (Foster, Rodriguez-Marroyo e Koning, De, 2017; Halson, 2014)."

E ainda "[...]Os Saltos Ornamentais (SO) é um esporte de coordenação motora complexa, de execução de elementos técnicos que prezam pela estética e a destreza, e que exige capacidades de força, flexibilidade e velocidade de seus praticantes (Huber, 2016, p. 182; Stambulova, Stambulov e Johnson, 2012). Uma sessão de treino técnico típica dos SO inclui a repetição de diversos exercícios de complexidade variada, que compõem e auxiliam o desenvolvimento do conjunto de saltos exigidos para as rotinas de competição. Além disso, atletas da modalidade seguem uma agenda rígida de treinos que podem incluir preparação física, coreografia, prevenção de lesão, etc (Huber, 2016, p. 199). Consequentemente, a incidência de lesões e overtraining nesse esporte também é alta (Stambulova, Stambulov e Johnson, 2012). Tendo em vista os benefícios do controle das variáveis de treino no desenvolvimento de atletas de alto rendimento, o presente trabalho procura explorar estratégias de monitoramento de atletas, estabelecendo relações entre diversas medidas de carga externa e interna, medidas psicológicas, bioquímicas, antropométricas, alimentares, de lesão e recuperação, e revelando também possíveis indicadores de acúmulo de fadiga e reestabelecimento de performance em atletas de Saltos Ornamentais."

Hipóteses: "O ajuste de carga externa refletirá no comportamento da carga interna; haverá correlação significativa entre a carga planejada pelo técnico e a percebida pelos atletas; as variações de percepção de esforço terão reflexo nas medidas de função do sistema nervoso autônomo, e de performance neuromuscular; a percepção de carga do técnico e dos atletas se correlacionará à média de dificuldade dos elementos realizados em uma sessão de treino; a fadiga neuromuscular e as alterações na função autonômica estarão relacionadas; e, será possível prever significativamente períodos de fadiga e subrecuperação, e períodos de reestabelecimento da performance e prontidão para ajuste de carga."

Descrição da Amostra: "A amostra será composta por cerca de 80 atletas de Saltos Ornamentais, todos matriculados no Centro de Excelência em Saltos Ornamentais da UnB em 2020, com idades variando entre 7 e 22 anos de idade, competidores do time brasileiro nas categorias infantil, juvenil e adulta."

Atletas infantis Observações, testes, entrevistas, e preenchimento de formulários: 40 Atletas Juvenis Observações, testes, entrevistas, e preenchimento de formulários: 35 Atletas adultos Observações, testes, entrevistas, e preenchimento de formulários: 05

Critérios de inclusão e exclusão: "Serão incluídos no estudo todos os atletas que compõem a equipe do Centro de Excelência em Saltos Ornamentais da Universidade de Brasília, que seguem treinamento diário, incluindo os já matriculados em 2019, e os que serão matriculados em 2020, após processo de seleção. Serão excluídos do estudo aqueles atletas que interromperem o treinamento e se desmatricularem do Centro."

Local de coleta: "Os dados serão coletados primariamente no ambiente de treinamento, localizado no Centro Olímpico da Universidade de Brasília, no Distrito Federal. Há dados que poderão ser coletados durante a participação dos atletas em competições, que podem acontecer em todo o território nacional, conforme planejamento anual da modalidade."

Procedimentos de coleta: "A coleta de dados acontecerá ao longo do ano, quando acontecerão treinos preparatórios para competições. Os treinos são diários, de segunda à sábado, pelas manhãs e tardes, e possuem duração de 4 a 8 horas por dia, divididos em até 3 sessões, dependendo do grupo de atletas."

Objetivo da Pesquisa:

"O objetivo do estudo é, portanto, correlacionar as medidas de carga externa – sendo elas, a capacidade de produção de trabalho muscular, o número de séries e repetições, a média de dificuldade dos elementos executados nas sessões de treino, e a session-RPE planejada –, com as medidas de carga interna – sendo elas, medidas antropométricas, de comportamento alimentar, sono, imunidade, bioquímicas, índices de função autonômica, a session-RPE do atleta e medidas psicométricas – em atletas de Saltos Ornamentais, conforme progressão da aplicação de carga em período de 12 meses de treinamento."

Objetivos secundários: "Visualizar o comportamento temporal das medidas de carga externa de treino; visualizar o comportamento temporal das medidas de carga interna de treino; comparar a carga programada pelo técnico e a percebida pelos atletas; correlacionar a função autonômica e a session-RPE dos atletas; correlacionar a session-RPE dos atletas e os índices de potência e fadiga neuromuscular; correlacionar a session-RPE planejada, e a dos atletas, com a média da soma dos elementos de dificuldade de uma sessão de treino; correlacionar os índices de fadiga neuromuscular e os índices de função autonômica; correlacionar medidas antropométricas com a carga externa; correlacionar medidas da qualidade do sono, da dieta e imunidade com a carga externa; correlacionar medidas psicométricas com a carga externa e outras medidas de carga interna; por meio da observação de todas as medidas de carga interna, prever momentos de prontidão fisiológica para o ajuste de carga de treino e momentos de acúmulo de estresse que justifiquem estratégias de recuperação; comparar o desenvolvimento dos atletas em relação aos dados dos anos 2017, 2018 e 2019; analisar o efeito de possíveis variáveis confundidoras, como assiduidade e perfil psicológico, nas variáveis principais; medir a incidência de lesões e outros acometimentos que impeçam a continuidade dos treinos por mais do que 24 horas."

Avaliação dos Riscos e Benefícios:

"Riscos: Os testes de performance física apresentam os mesmos riscos associados à prática de atividade física, como dor muscular e fadiga, que reduzirão em torno de 48 horas após a coleta. A fim de minimizar os riscos, toda a coleta será feita por pessoal treinado, utilizando equipamentos adequados, e os riscos serão esclarecidos previamente a todos os sujeitos. Os formulários, questionários, testes psicológicos, medidas antropométricas, observações e a consulta ao banco de dados apresentam como risco o constrangimento, mas para minimizá-lo, os participantes serão entrevistados individualmente e sem exposição, e seus dados não serão identificados, e terão assegurados o direito de recusar a responder qualquer questão e/ou desistência de participação em qualquer testes, em qualquer momento, sem nenhum prejuízo para os mesmos."

Benefícios: O estudo é justificado pela dificuldade apresentada no controle da carga interna e externa em esportes de coordenação complexa, e o relativo ineditismo de abordagens similares nos Saltos Ornamentais (Minganti et al., 2011). O controle de carga também é estratégia principal para conferir adaptações ao treino, minimizar fadiga e risco de lesões e doenças, evitar."

Comentários e Considerações sobre a Pesquisa:

Trata-se de um projeto de pesquisa de Pós-graduação Nível de Mestrado de Roque Bernardes Neto, sob orientação do Prof. Guilherme Eckhardt Molina, a ser desenvolvido na Faculdade de Educação Física da UnB, nas dependências do Centro de Excelência em Saltos Ornamentais da UnB.

É estudo descritivo/analítico, observacional e longitudinal.

Período de Execução: após aprovação - até 31/12/2020.

Considerações sobre os Termos de apresentação obrigatória:

Documentos acrescentados ao processo e analisados para emissão deste parecer:

1) Informações Básicas do Projeto em "PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1469357.pdf", postado em 24/03/2020;

2) Carta de respostas às pendências apontadas no Parecer Consubstanciado No. 3.930.463 em "14_Pendencias.pdf", postado em 24/03/2020;

3) Modelos de TCLE e TCLE para Pais em "5_TCLE.doc" e "05_TCLE_PAIS.doc", ambos postados em 24/03/2020, com adequações realizadas.

Recomendações:

Não se aplicam.

Conclusões ou Pendências e Lista de Inadequações:
Análise das respostas às pendências apontadas no Parecer Consubstanciado No 3.930.463

1. De acordo com os documentos "11_Projeto.docx", páginas 17 e 18 de 34, itens 2.4.3 e 2.4.3.1, "09_Compromisso_Dados.pdf" e "10_Autorizacao_Dados.pdf", postados em 22/11/2019), é previsto acesso ao Banco de Dados de Acompanhamento do Centro de Excelência em Saltos Ornamentais da UnB, no qual constam dados de análise bioquímicas, laudos e resultados de exames de sangue, incluindo ainda inventários e testes psicológicos, formulários de acompanhamento de treino, resultados de testes físicos, resultados de exames de sangue, resultados de competições, acompanhamento de lesões, formulários de planejamento de treino, e resultados de avaliações antropométricas. A informação de que o banco de dados será acessado deverá constar no TCLE para responsáveis e TCLE para participantes maiores de idade. Solicita-se adequação.
RESPOSTA: "Também consultaremos o Banco de Dados de Acompanhamento de Atletas, no qual constam dados de análise bioquímicas, laudos e resultados de exames de sangue, testes e inventários psicológicos, formulários de acompanhamento de treino, resultados de testes físicos e de competições, formulários de planejamento, acompanhamento de lesões e resultados de avaliações antropométricas."
ANÁLISE: Ajustes foram realizados e os arquivos foram ajustados, respectivamente: "05_TCLE.doc" e "05_TCLE_PAIS.doc".

Todas as pendências foram atendidas.
Não há óbices éticos para a realização do presente protocolo de pesquisa.

Considerações Finais a critério do CEP:
Conforme Resolução CNS 466/2012, itens X.1.- 3.b. e XI.2.d, e Resolução CNS 510/2016, Art. 28, inc. V, os pesquisadores responsáveis deverão apresentar relatórios parcial semestral e final do projeto de pesquisa, contados a partir da data de aprovação do protocolo de pesquisa.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1469357.pdf	24/03/2020 15:22:23		Aceito

Declaração de Pesquisadores	14_Pendencias.pdf	24/03/2020 15:21:24	Roque Bernardes Neto	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	05_TCLE_PAIS.doc	24/03/2020 15:18:21	Roque Bernardes Neto	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	05_TCLE.doc	24/03/2020 15:17:56	Roque Bernardes Neto	Aceito
Outros	08_CV_Gabriela.pdf	25/11/2019 19:23:41	Roque Bernardes Neto	Aceito
Outros	08_CV_Narayana.pdf	25/11/2019 19:23:19	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	04_Compromisso.pdf	25/11/2019 19:22:24	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	04_Compromisso.doc	25/11/2019 19:22:08	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	13_Pendencias.pdf	25/11/2019 19:21:55	Roque Bernardes Neto	Aceito
Projeto Detalhado / Brochura Investigador	11_Projeto.pdf	22/11/2019 18:36:30	Roque Bernardes Neto	Aceito
Projeto Detalhado / Brochura Investigador	11_Projeto.docx	22/11/2019 18:36:11	Roque Bernardes Neto	Aceito
Declaração de Instituição e Infraestrutura	10_Autorizacao_Dados.pdf	22/11/2019 18:35:51	Roque Bernardes Neto	Aceito
Declaração de Instituição e Infraestrutura	10_Autorizacao_Dados.doc	22/11/2019 18:35:29	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	09_Compromisso_Dados.pdf	22/11/2019 18:34:31	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	09_Compromisso_Dados.doc	22/11/2019 18:34:16	Roque Bernardes Neto	Aceito
Outros	08_CV_Roque.pdf	22/11/2019 18:34:05	Roque Bernardes Neto	Aceito
Outros	08_CV_Paloma.pdf	22/11/2019 18:33:50	Roque Bernardes Neto	Aceito
Outros	08_CV_Molina.pdf	22/11/2019 18:32:07	Roque Bernardes Neto	Aceito
Outros	08_CV_Alexandre.pdf	22/11/2019 18:31:56	Roque Bernardes Neto	Aceito
Orçamento	07_Orcamento.doc	22/11/2019 18:31:23	Roque Bernardes Neto	Aceito
Cronograma	06_Cronograma.doc	22/11/2019	Roque Bernardes	Aceito

Cronograma	06_Cronograma.doc	18:31:10	Neto	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	05_TALE.doc	22/11/2019 18:30:29	Roque Bernardes Neto	Aceito
Declaração de Instituição e Infraestrutura	03_Coparticipante.pdf	22/11/2019 18:29:32	Roque Bernardes Neto	Aceito
Declaração de Instituição e Infraestrutura	03_Coparticipante.doc	22/11/2019 18:29:20	Roque Bernardes Neto	Aceito
Declaração de Instituição e Infraestrutura	02_Proponente.pdf	22/11/2019 18:28:17	Roque Bernardes Neto	Aceito
Declaração de Instituição e Infraestrutura	02_Proponente.doc	22/11/2019 18:28:08	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	01_Encaminhamento.pdf	22/11/2019 18:26:53	Roque Bernardes Neto	Aceito
Declaração de Pesquisadores	01_Encaminhamento.docx	22/11/2019 18:26:40	Roque Bernardes Neto	Aceito
Folha de Rosto	00_Folha_de_Rosto.pdf	22/11/2019 18:25:07	Roque Bernardes Neto	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BRASILIA, 14 de Abril de 2020

Assinado por:
Marie Togashi
(Coordenador(a))

ANEXO D: Termo de assentimento livre e esclarecido (atletas)

Universidade de Brasília - Faculdade de Educação Física
Laboratório de Aptidão Física e Movimento – AFiM
Centro de Excelência Esportiva – CENESP-UnB

UnB

TERMO DE ASSENTIMENTO LIVRE E ESCLARECIDO

Gostaríamos de convidar você a participar da pesquisa "Monitoramento anual de atletas de Saltos Ornamentais". Estamos realizando essa pesquisa para entender o cansaço e como melhor descansar após os treinos, e também para descobrir como o corpo de quem pratica Saltos Ornamentais muda de acordo com o treino. A pesquisa vai acontecer durante o ano de 2020.

Caso você concorde em participar, vamos fazer as seguintes atividades com você: medir o tamanho de algumas partes do seu corpo, fazer algumas perguntas sobre o que você come e como você descansa, pedir para você preencher alguns formulários e testes sobre o treino e sobre como você está se sentindo, medir os batimentos do seu coração, fazer testes físicos, e observar o seu treino. Cada teste vai ter sua duração explicada antes da aplicação, e serão realizados no local de treinamento e/ou competição

Essa pesquisa tem alguns desconfortos: no caso dos testes físicos, são os mesmos que você sente quando treina, como dor muscular e cansaço; no caso dos outros testes, você pode se sentir envergonhado em alguns momentos. Mas garantimos que você fará os testes sozinho(a) e que seu nome não será revelado. Todos os testes serão realizados por profissionais treinados para minimizar as sensações ruins e a vergonha.

Para participar desta pesquisa, o seu responsável deve autorizar e assinar um Termo de Consentimento, em duas cópias. Todas as despesas extras que você tiver relacionadas diretamente à pesquisa (como passagem para o local da pesquisa, alimentação ou exames) serão pagas pelo pesquisador responsável. Você também não receberá qualquer vantagem em dinheiro. Apesar disso, se você tiver algum dano por causa das atividades que fizermos nesta pesquisa, você tem direito a indenização.

Você pode perguntar o que quiser sobre a pesquisa, e estará livre para participar ou se recusar a participar. Mesmo que você queira participar agora, você pode desistir quando quiser. A sua participação é voluntária e se não quiser participar você não vai ter nenhum problema. Os resultados da pesquisa serão divulgados quando ela terminar, mas o pesquisador não vai divulgar o seu nome, e o material que indica sua participação não será liberado sem a permissão do seu responsável. O responsável por você também pode desistir de participar a qualquer momento.

Em caso de dúvida, favor falar com o pesquisador Roque Bernardes Neto pelo e-mail roquebneto@gmail.com, ou na Universidade de Brasília, pelo telefone (61) 3107-2519. Para ligações a cobrar, ligar no número (61) 99805-1799.

Este Termo de Assentimento está impresso em duas cópias, sendo que uma será arquivada pelo pesquisador responsável e a outra será dada para você. Os dados da pesquisa ficarão guardados pelo pesquisador durante 5 (cinco) anos. Depois desse tempo, ele poderá continuar guardando ou jogar fora os documentos.

Este projeto foi aprovado pelo Comitê de Ética em Pesquisa da Faculdade de Ciências da Saúde (CEP/FS) da Universidade de Brasília. O CEP é composto por profissionais de diferentes áreas cuja função é defender os interesses dos participantes da pesquisa em sua integridade e dignidade e contribuir no desenvolvimento da pesquisa dentro de padrões éticos. As dúvidas sobre a assinatura do TALE ou os direitos do participante da pesquisa podem ser esclarecidos pelo telefone (61) 3107-1947 ou do e-mail cepfs@unb.br ou cepfsunb@gmail.com, horário de atendimento de 10:00hs às 12:00hs e de 13:30hs às 15:30hs, de segunda a sexta-feira. O CEP/FS se localiza na Faculdade de Ciências da Saúde, Campus Universitário Darcy Ribeiro, Universidade de Brasília, Asa Norte.

"Sei que a qualquer momento poderei pedir novas informações, e o meu responsável poderá mudar de ideia sobre minha participação, se quiser. Já tendo sido autorizado pelo meu responsável, declaro que concordo em participar da pesquisa e que pude ler e esclarecer as minhas dúvidas."

Brasília, ____ de _______________ de 20___.

____
Assinatura do (a) menor

____
Assinatura do (a) pesquisador (a)

ANEXO E: Termo de consentimento livre e esclarecido (responsáveis)

Universidade de Brasília - Faculdade de Educação Física
Laboratório de Aptidão Física e Movimento – AFiM
Centro de Excelência Esportiva – CENESP-UnB

Termo de Consentimento Livre e Esclarecido aos Responsáveis

O menor de idade pelo qual o(a) senhor(a) é responsável está sendo convidado(a) a participar da pesquisa "Monitoramento anual de atletas de Saltos Ornamentais", sob a responsabilidade do pesquisador Roque Bernardes Neto.

O projeto pretende analisar ao longo do ano o comportamento de variáveis fisiológicas e psicológicas para o melhor entendimento da relação estímulo-fadiga-recuperação de performance no treinamento esportivo. O objetivo dessa pesquisa é desenvolver estratégias de monitoramento que garantirão uma melhor recuperação dos atletas e a diminuição dos riscos associados ao treinamento de alto-rendimento, como lesão e queda imune. Caso você autorize, seu filho irá realizar testes de observação do comportamento da Frequência Cardíaca, testes de esforço, preenchimento de formulários de acompanhamento de treino, testes psicológicos, entrevistas, e será observado durante o treino. Cada teste tem duração específica, que será esclarecida sempre antes da coleta. Os testes serão realizados nos espaços de treinamento e competição. Também consultaremos o Banco de Dados de Acompanhamento de Atletas, no qual constam dados de análise bioquímicas, laudos e resultados de exames de sangue, testes e inventários psicológicos, formulários de acompanhamento de treino, resultados de testes físicos e de competições, formulários de planejamento, acompanhamento de lesões e resultados de avaliações antropométricas.

A participação dele(a) não é obrigatória e, a qualquer momento, poderá desistir. Tal recusa não trará prejuízos em sua relação com o pesquisador ou com a instituição em que ele treina. Tudo foi planejado para minimizar os riscos da participação dele(a), que, no caso dos testes de esforço, são os mesmos experimentados durante a prática de atividade física, como dor muscular e fadiga, que reduzirão em torno de 48 horas após os testes; no caso dos formulários, questionários, testes psicológicos, e demais testes, há o risco de constrangimento, mas, para minimizá-lo, o atleta será entrevistado individualmente e sem exposição, e seus dados não serão identificados. Toda a coleta, será realizada por profissionais treinados visando minimizar os riscos e desconfortos. Ele(a) poderá a qualquer momento interromper a participação e, se houver interesse, conversar com o pesquisador sobre o assunto.

O(A) senhor(a) e o menor de idade pelo qual é responsável não receberão remuneração pela participação, e as suas respostas não serão divulgadas de forma a possibilitar sua identificação. Todas as despesas extras que o(a) senhor(a) tiver relacionadas diretamente ao projeto de pesquisa (tais como, passagem para o local da pesquisa, alimentação no local da pesquisa ou exames para realização da pesquisa) serão cobertas pelo pesquisador responsável. Caso haja algum dano direto ou indireto decorrente da participação na pesquisa, o(a) senhor(a) deverá buscar indenização, obedecendo-se as disposições legais vigentes no Brasil. Em caso de dúvida em relação aos procedimentos realizados, favor contatar o pesquisador Roque Bernardes Neto roquebneto@gmail.com, ou na Universidade de Brasília, pelo telefone (61) 3107-2519. Para ligações a cobrar, ligar no número (61) 99805-1799.

Este projeto foi aprovado pelo Comitê de Ética em Pesquisa da Faculdade de Ciências da Saúde (CEP/FS) da Universidade de Brasília. O CEP é composto por profissionais de diferentes áreas cuja função é defender os interesses dos participantes da pesquisa em sua integridade e dignidade e contribuir no desenvolvimento da pesquisa dentro de padrões éticos. As dúvidas com relação à assinatura do TCLE ou os direitos do participante da pesquisa podem ser esclarecidos pelo telefone (61) 3107-1947 ou do e-mail cepfs@unb.br ou cepfsunb@gmail.com, horário de atendimento de 10:00hs às 12:00hs e de 13:30hs às 15:30hs, de segunda a sexta-feira. O CEP/FS se localiza na Faculdade de Ciências da Saúde, Campus Universitário Darcy Ribeiro, Universidade de Brasília, Asa Norte.

Brasília, ___ de __________de _________.

____

Assinatura do(a) responsável

____

Assinatura do Pesquisador Responsável

Universidade de Brasília - Faculdade de Educação Física
Laboratório de Aptidão Física e Movimento – AFiM
Centro de Excelência Esportiva – CENESP-UnB

CONSENTIMENTO

Eu,____(colocar o nome legível do pai/mãe/responsável/cuidador) declaro que entendi os objetivos, riscos e benefícios da participação do menor de idade pelo qual sou responsável, ____ (colocar o nome do menor), sendo que:

(   ) aceito que ele(a) participe   (   ) não aceito que ele(a) participe

Brasília, ___________________ de ____________ de 20__

____

Assinatura