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Original Article

Investigation into the dynamics of internal and external intensities during a tourist canyoning season

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Abstract:
This study aimed to achieve its objectives by: (i) detailing and analyzing fluctuations in internal and external intensities and assessing well-being of canyoning guides; (ii) investigating the connections between required intensities, well-being measures, and the subjective perception of effort throughout the entire season and its distinct periods. The methodology involved a daily monitoring process for 18 professional canyoning guides (aged 35.28±4.56 years; BMI 24.31±2.94) over an 11-week period, utilizing Polar V800 watch equipment. The Hooper Index (HI) questionnaire and perceived subjective effort (RPE) were administered, and body mass and handgrip strength were measured at two specific points during the season. The findings revealed significant associations between internal intensity variables (VII) and measures of well-being during the overall season, excluding maximum heart rate (HR max), which displayed no correlation with any of the mentioned variables. Significant associations between internal and external intensities were evident, except for RPE, which did not show any association with external intensity variables (VIE). Similarly, well-being vs. VIE did not show significant associations. The first period of the season revealed a lower number of significant associations, while the second period had the highest number of significant associations between variables. Conclusions: Overall, VII is significantly related to measures of well-being. It is noticeable that the perceived effort ratings of the routes show fewer fluctuations in the middle of the season, while well-being ratings increase. The obtained results can help in controlling the psychophysiological needs of the guides and thus achieve better organization and scheduling of activities with greater professionalism and psychophysiological disposition for the tourist.
Keywords: Canyoning, monitoring, internal variables, external variables, Hooper Index, Subjective Perception of Effort.

Introduction

Canyoning is one of the outdoor sports associated with dangers and risks, practiced in a mountainous environment. It involves the progressive exploration of a river or stream bed, overcoming varying levels of difficulty using a variety of techniques with or without ropes and various equipment (Brandão, 2016; M. Costa, 2019).

R. J. E. S. de Melo & Gomes (2016) states that it has low competitive potential but high tourism potential. Canyoning has gained greater visibility and a larger number of enthusiasts, thus changing the perspective of many people towards it. Today, it is possible to find followers who engage in canyoning purely for leisure, seeking relaxation and enjoyment of nature. This can contribute to restoring cognitive abilities and promoting feelings of rejuvenation (Willis, 2015).

In the sports aspect, participants are expected to be capable of engaging in this activity independently, without the presence of guides. However, in the leisure (commercial, touristic) aspect, participants are not required to have knowledge of the locations for the practice, techniques, and equipment. In other words, it is anticipated that they do not have the autonomy to progress in this environment without a guide (M. Costa, 2019).

Guides, in particular, must possess extensive technical, physiological, emotional, and operational knowledge, as they are involved in a sport with unique and challenging characteristics (Hardiman & Burgin, 2011) considered risky (Ayora, 2011; Brandão, 2016). They must have various skills to ensure the well-being of tourists and clients (M. Costa, 2019).

As previously mentioned, canyoning is associated with risk factors, particularly the exposure time that individuals are exposed to existing dangers, which cannot be modified or minimized (Ayora, 2011; Brandão et al., 2018). This is the scenario where and when skills and knowledge must be applied for the well-being of all (M. Costa, 2019). Brandão et al. (2018) revealed that, when quantifying the perception of perceived risk by experienced canyonists, human factors (originating from human behavior) are mentioned more frequently than environmental factors (originating from nature).

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To act appropriately in each canyoning situation, physical fitness must be taken into account. This is essential to predict an athlete's performance in the sport and can indicate success criteria (Trivic et al., 2020; Jeon & Eom, 2021). Guides must also maintain these physical conditions.

Under such conditions, anthropometry, which studies anthropometric variables (measures of size and proportions of the human body), can be considered. This can help study individuals involved in this activity by obtaining measurement information (such as weight and height, for example). Such information is crucial for understanding whether they possess a healthy body composition. Additionally, comprehending daily physical activity (PA) habits would be the perfect complement for a health assessment (Reid et al., 2020) Therefore, this is a reality that can lead to situations of fatigue, resulting in effects on physical and mental response capacity in the activity (Ferreira et al., 2021). However, through monitoring and evaluation, a guide's understanding of their responses and recovery can be improved, potentially reducing the incidence of injuries and fatigue while enhancing their performance (Bourdon et al., 2017).

The intensity during practice can be understood at two levels: (i) physical demands (i.e., locomotor and mechanical), also known as external intensity variables (VIE); and (ii) psychophysiological demands (i.e., organic and biological responses to external demands), also referred to as internal intensity variables (VII).

Considering and monitoring these intensity demands (both internal and external) (Bourdon et al., 2017) allows for a comprehensive assessment, even though it is challenging to precisely determine (Impellizzeri, Marcora, & Coutts, 2019) the guide's overall state (felt internal intensity) caused by the activity (required external intensity) (Bourdon et al., 2017). VII depends on specific VIE, meaning that physiological capabilities and physical demands are imposed by a particular sport, and it becomes crucial to interpret them (Gabbett et al., 2017). To accurately estimate internal and external demands, sensitive monitoring tools (objective/perceptive) are required (Rabbani, Clemente, Kargarfard, & Chamari, 2019a). Various methods have been used to assess VII, including the evaluation of perceived subjective effort (RPE) (Bourdon et al., 2017), heart rate (HR), blood lactate concentration, and oxygen consumption (Bourdon et al., 2017; S. M. Marcora, Staiano, & Manning, 2009). Heart rate monitors, in addition to recording VII, also capture VIE and have been an easily applicable and manageable tool used in various studies (Roos, Taube, Beeler, & Wyss, 2017; de Müllenheim et al., 2018; Dobbs et al., 2019; Matos et al., 2019). In the systematic review by Dobbs et al. (2019), it was concluded that the margin of error is acceptable. Although there is extensive research in the field of monitoring (Bourdon et al., 2017), its applicability in canyoning remains unknown.

Similarly, through questionnaires, the impact of VII and VIE on overall well-being can be assessed. The Hooper Index (HI) questionnaire (assessing sleep quality, stress, fatigue, and muscle pain), when applied to football players, has proven to be a reliable tool for monitoring fatigue (Rabbani et al., 2019a). It provides valuable information on the subjective well-being of athletes in team sports (Nobari, Alves, et al., 2021; Nobari, Fani, et al., 2021) and individual sports (Matos et al., 2019). Through well-being measures, the RPE rate, and monitoring with GPS devices in canyoning activities, evidence can be obtained to help guides manage their psychophysiological availability and maintain physical fitness at their best performance before, during, and after the canyoning season. Given that in canyoning there are various scientific approaches on various topics, but limited or lacking information regarding the psychophysiology of guides. It can be noted that there is literature on injuries and their incidence in canyoning practitioners (Ströhle et al., 2019; Ernstbrunner et al., 2018; Stephanides & Vohra, 2007), patterns of rescue operations and injury severity in Spain (Soteras, Subirats, & Strapazzon, 2015; Strapazzon, Reisten, Argenone, & Zafren, 2017), risks and risk perception in experienced canyonists in the Iberian Peninsula (Brandão, Monteiro, Pereira, Coelho, & Quaresma, 2018; Brandão, Pereira, Gonçalves, Coelho, & Quaresma, 2018), profiles and perceptions of canyoning tourists in Madeira (Soares & Nunes, 2020), evaluation of canyoning spots in the Northern region of Portugal (Correia, Silva, & Rachão, 2022), the geotourism potential of canyoning in Serbia (Tomic, Antić, Tešić, Tijana, & Momčilović, 2022). However, observing and evaluating the psychophysiological behaviors of canyoning guides remains an understudied topic.

Therefore, considering the limited literature in this area, especially regarding canyoning, this article analyzes the associations between VIE and VII, effort, and well-being perceived by canyoning guides during activities over a season. This analysis can enable guides to prioritize more careful training tailored to their needs.

Materials & Methods

Study design

The study has a cohort design and was conducted in a tourist animation company located in the Peneda-Gerês National Park (PNPG), over 11 weeks, covering the months of July, August, and September. It is primarily during this time of the year that canyoning activities take place in this area.

The experimental approach took place with the canyoning guides at Ribeira de Carcerelha, a canyoning location characterized by granite rock, a 150 m drop, and low water flow (typical for this time of the year). It is classified as II/VIII/AIII (corresponding to the level of commitment, vertical component, and aquatic component). The average ambient temperature recorded by the Polar V800 instrument was 28.5°C.

Daily monitoring of the guides was conducted using the Polar V800 watch equipment, which they wore during the activities. Prior to and following the activity, they responded to the Hooper Index and RPE questionnaires, focusing on the night/morning before the activity and the activity performed on that day. They were also accompanied during the first week of the study to ensure better interaction with the instruments. The internal and external variables provided by the Polar watch and RPE were analyzed for their associations.

The assessment of physical fitness - strength and body composition - was conducted at two time points (initial: July 10th and 11th; and final: September 25th and 26th) using the Handgrip Dynamometer - Saehan SH5001 and the Tanita- BC-418. These instruments were used in the same location, in a controlled indoor environment with ample natural light, in the morning (between 9 and 10 a.m.) after approximately two hours of breakfast ingestion. In a pre-study meeting held prior to the start date, all guides were informed about the study's procedures.

Participants

A convenience sampling strategy was employed for participant recruitment. Participants were recruited through email invitations. From the guides recruited and available to participate in the study, a selection was made based on the following eligibility criteria: (i) a minimum of three years of experience as a guide; (ii) possessing a minimum of 200 hours of training in canyoning; (iii) signing informed consent with a description of the study protocol, following the guidelines of the Declaration of Helsinki for human research (World Medical Association, 2013).

As a result of the selection process, 18 male Portuguese canyoning guides were included in the study, with a mean age of 35.28±4.56 years, height of 177.22±6.67 cm, body mass of 76.43±10.08 kg, and a body mass index of 24.31±2.94 kg/m². Their fat mass averaged 13.78±5.67 kg, while their fat-free mass was 62.67±5.93 kg. Participants were informed about the study's design, potential benefits, and risks of participation. After their agreement, they provided informed and voluntary consent. The study adhered to the ethical guidelines for research involving human subjects outlined in the Declaration of Helsinki (World Medical Association, 2013).

Methodological procedures

1) *Body composition assessment and handgrip strength test*

Body composition analyzer

To assess body composition, the Tanita BC-418 electronic personal scale from Tokyo, Japan, was employed. This equipment provides precise measurements with an accuracy of 0.1 kg. It is a validated instrument known for its non-invasive nature and high reliability, making it suitable for body composition evaluation (Kelly & Metcalfe, 2012). Guides, dressed in swimwear or swim shorts and barefoot, were weighed in a single attempt, repeating the process at the beginning and end of the study. Measurements included variables such as body mass, fat mass, visceral fat, and body mass index.

Grip force

Manual grip strength (MGS) was estimated using the Saehan SH5001 hydraulic dynamometer. This instrument is reliable, validated, and comparable when set in the 2nd position (Reis & Arantes, 2011) to measure maximal isometric strength recruited by hand and forearm muscles. The grip was adjusted to the recommended 2nd position (4.8 cm reach) (Elaine & Chrisyine, 1981), and readings were recorded in kilograms (Kg) or pounds (Ib) (Vasava, Sorani, & Rathod, 2021).

Each participant performed three attempts with each hand, alternating between right and left (Jordre & Schweinle, 2020). They were instructed to exert a maximal isometric contraction for three seconds during each attempt, with a 30-second passive rest between attempts (Mahoney et al., 2020).

The procedure was conducted in a recommended seated position (Fernandes & Marins, 2011), which involved sitting in a chair with a backrest and no arms, feet in contact with the ground, lower limbs flexed at 90°, neutral shoulders, and elbows flexed at 45° (Elaine & Chrisyine, 1981). Verbal feedback was provided during repetitions (Shiratori, Iop, Júnior, Domenech, & Gevaerd, 2014). The best result achieved for each segment was collected and subsequently processed for statistical comparisons (Jordre & Schweinle, 2020; Mahoney et al., 2020).

2) *Monitoring effort intensities during routes*

Heart rate and locomotor demands

The Polar V800 wrist heart rate monitor with GPS technology was used in this study (dimensions: 37 mm x 56 mm x 12.7 mm; weight = 79 g; Polar, Finland). Previous studies have tested and validated the Polar V800 HR in mountain sports and running (Roos, Taube, Beeler, & Wyss, 2017; Caminal et al., 2018). Its water resistance has also been tested and complies with the International Standard ISO 22810 or IEC 60529 (Polar Electro Oy, 2015). Guides wore this equipment on their left wrists, and heart rate sensors were placed around the torso immediately below the chest (upper abdomen), properly adjusted and paired with the corresponding watch. When possible, the same sensor was used by the same individual. Heart rate data were recorded at a sampling rate of 1 Hertz (1 Hz).

For each participant, the following variables were collected: maximum heart rate (HR max), minimum heart rate (HR min), and average heart rate (HR avg) (bpm), duration (h/min/s), distance covered (km), average and maximum speed (km/h), average and maximum pace (min/km). These variables were recorded by the equipment and used for analysis.

Perceived Subjective Effort (RPE) In the RPE, the Borg CR-10 scale was applied (0 - no intensity and 10 - extreme effort intensity) (G. Borg, 1990). It is an excellent tool for monitoring and estimating activity intensity

(IA) (Brãndão, 1989) and is validated, reliable, simple, and non-invasive (Haddad, Stylianides, Djaoui, Dellal, & Chamari, 2017).

All guides rated the following statement: "Rate the intensity of today's activity from 0 to 10. Relate the subjective intensity of effort, tension, discomfort, and/or fatigue experienced in today's canyoning activity. Rate this intensity on a scale from 0 to 10, where: 0 - no intensity; 1 - very light; 2 - light; 3 - moderately light; 4 - somewhat light; 5 - moderately intense; 6 - with some intensity; 7 - intense; 8 - very intense; 9 - extremely intense; and 10 - excessively intense."

The RPE questionnaire was filled out individually using an online form, within 30 minutes after the end of each activity. IA was determined using RPE data and activity duration, applying the formula: session RPE (sRPE) (arbitrary unit (AU)) = RPE x activity duration in minutes, as proposed by Foster et al., (2001). This system is a simple way to monitor IA across various sports and has been applied and validated in team sports (Clemente et al., 2017), individual sports, intermittent activities (Haddad et al., 2011; Padulo et al., 2014), and water sports (Della Valle & Haas, 2013).

3) Well-being assessment

The Hooper questionnaire was individually administered online using a provided link, 30 minutes before each activity, as previously done in other studies (Nobari, Alves, et al., 2021a; Nobari, Fani, et al., 2021). It reflects each guide's self-reported well-being in terms of their perception of stress, fatigue, muscle soreness, and sleep quality, based on a seven-point scale (1 - very, very low to 7 - very, very good). The Hooper Index (HI) score was calculated by summing the four parameters that were subjectively rated (Clemente et al., 2017; Ferreira et al., 2021). The Hooper Index was calculated based on the sum of different scores for each route taken by the guides.

Statistical analysis

Descriptive statistics, including mean and standard deviation, were used to summarize the data. Preliminary analyses of normality and homogeneity of the sample were conducted using the Kolmogorov-Smirnov and Levene tests, respectively. Since normality was not confirmed, the Spearman's Rho test was employed to analyze the relationships between variables. Statistical analyses were conducted using IBM SPSS (version 27.0.0.0., IBM, Chicago, USA) with a significance level set at $p < 0.05$.

Results

During a canyoning season, 18 guides were monitored during a total of 213 activities (11.83±6.51 activities per guide). There was a significant disparity in the number of routes per guide, with a minimum of 3 and a maximum of 26 routes completed. About 77.78% of the guides completed between 3 and 15 routes, while only 22.22% of them were guides on 18 to 26 occasions.

Changes in physical fitness and anthropometry after the season

In **Table 1** presents data characterizing the participants at two assessment points (initial/final) using the provided instruments: Tanita and Handgrip. The guides had an average age of 35.28±4.56 years and an average height of 177.22±6.67 cm.

There was a decrease in body mass (0.57 kg), body mass index (BMI) (0.21 kg/m2), visceral fat classification (0.39 UA), and a 1.62% decrease in fat mass (1.37 kg). Lean mass and total body water increased by 0.79 kg and 0.94 kg, respectively. Grip strength also increased in both the right and left hands (1.55 kg and 0.94 kg, respectively).

Table 1. *Description of values for body composition and grip strength tests for canyoning guides.*

Variables	M ± DP Initial	M ± DP Final	Difference initial- final
Age (years)	35,28±4,56	-	-
Height (cm)	177,22±6,67	-	-
Body mass (kg)	76,43±10,08	75,86±9,98	0,57
Body mass index (kg/m2)	24,31±2,94	24,10±2,78	0,21
Fat mass (%)	17,56±4,99	15,94±4,93	1,62
Fat mass (kg)	13,78±5,67	12,41±5,27	1,37
Fat free mass (kg)	62,67±5,93	63,46±6,28	0,79
Total body water (TBW) (kg)	44,04±4,68	44,98±4,86	0,94
Classification of visceral fat (AU)	8,56±2,96	8,17±2,90	0,39
Handgrip, right hand (kg)	38,78±2,79	40,33±2,85	1,55
Handgrip, left hand (kg)	37,78±2,60	38,72±2,33	0,94

Descriptive Values of Monitored Intensities in the Courses

In **Table 2** provides the descriptive statistics of the data obtained through the instrument used during canyoning courses. On average, the courses covered a distance of 2.17 ± 0.29 km in 185.23 ± 30.37 minutes, with a mean maximum heart rate (HR) of 144.56 ± 17.67 beats per minute (bpm), a mean minimum HR of 62.38 ± 13.45 bpm, and a mean HR of 94 ± 13.22 bpm.

The minimum and maximum values of internal intensity variables (biological/objective), obtained from the Polar V800 device, such as maximum HR, minimum HR, and mean HR, can be observed in the same table. The minimum recorded maximum HR was 107 bpm, and the maximum was 191 bpm. Regarding the minimum HR, the range was from 43 bpm to a maximum of 179 bpm. As for the mean HR, the minimum recorded was 70 bpm, and the maximum was 155 bpm.

***Table 2**. Description of data obtained through the Polar V800 Watch instrument used during canyoning courses.*

Polar Watch	M±DP	Median	Minimum	Maximum
Start time (h:min:sec)	11:31:01±0:46:43	11:23:45	10:09:07	15:16:21
Duration (h:min:sec)	3:05:31±0:30:22	3:03:17	1:42:04	4:39:19
Duration (min)	2.17±0,29	2.15	1.14	3.22
Total distance (km)	0,72±0,16	0,70	0,40	1,80
Average speed (km/h)	144,56 ± 17,67	142	107	191
Max HR (bpm)	62,38±13,45	62	43	179
HR min (bpm)	94±13,22	92	70	155

HR: heart rate.

Measures of perceived well-being and effort obtained from the Hooper questionnaire and the RPE can be observed in **Table 3.** Among the well-being variables, stress has the highest average value, although it is still considered low stress. On the other hand, the lowest average value is found in "muscular pain" (1.94 U.A.), which is considered very little pain.

***Table 3.** Description of well-being data and classification of external intensity in canyoning courses.*

Variable	M±DP	Median	Minimum	Maximum
sRPE (UA)	580,49±365,61	489,00	0	1720
RPE	3,14±1,87	3,00	0	9 (extremely intense)
HI	8,67±3,65	8,00	4 (medium)	20
Muscle pain (DM)	1,94±0,98	2,00 (very low)	1 (very very low)	5 (high)
Fatigue (F)	2,31±1,02	2,00	1	5
Stress (S)	3,04±1,12	3,00 (low)	2	5
Quality of sleep (QS)	2,42±1,08	2,00 (very good)	1 (very very good)	3 (good)
Customers (n)	6,92±3,14	6	2	22
Groups (n)	1,86±0,89	2	1	5

sRPE: subjective perception of effort session (RPE*session time), UA: arbitrary units; HI: Hooper Index (sum of 4 subgroups).

Significant Relationships Between Intensity Variables

In **Table 4,** you can observe the descriptive statistics of significant associations between internal and external variables during the canyoning season (Appendix A contains all associations between variables). According to the Spearman association, it was found that distance and maximum heart rate (HR máx) are significantly positively associated (Rho=0.296*; p<0.001). On the other hand, the minimum heart rate (HR mín) is also significantly, but with a small magnitude, positively associated with average speed (Rho=0.215; p=0.002). The average heart rate (HR méd) is positively associated, but with small magnitudes, with both distance (Rho=0.220; p=0.001) and average speed (Rho=0.165; p=0.016). Average speed negatively significantly associates with sRPE (Rho=-0.226** p=0.001).

***Table 4**. Spearman Association between Internal and External Variables during the Canyoning Season.*

	HR max.	HR min.	HR méd.	sRPE
Distance	Rho=0,296**; p<0,001		Rho=0,220**; p=0,001	
Medium Speed		Rho=,215**; p=0,002	Rho=0,165*; p=0,016	Rho=-,226** p=0,001

HR: art rate; sRPE: exercise subjective perception session (RPE*session time).

Relationships between intensity variables and well-being

In **Table 5**, you can observe the descriptive statistics of significant associations between internal variables and well-being during the canyoning season (Appendix A contains all associations between variables). These relationships include internal intensities and well-being, except for maximum heart rate (HR máx), which has no relationship with well-being.

The minimum heart rate (HR mín) is significantly, albeit slightly, related to all well-being variables (QS: Rho=0.348*; p<0.001; Fatigue: Rho=0.203; p=0.003; Stress: Rho=0.193; p=0.005; Muscle pain: Rho=0.160; p=0.019). The average heart rate (HR méd) is significantly, albeit slightly, related to QS (Rho=0.256*; p<0.001), Fatigue (Rho=0.148; p=0.031), and HI (Rho=0.191**; p=0.005).

RPE is positively associated, albeit slightly, with QS (Rho=0.157*; p=0.022), stress (Rho=0.163*; p=0.017), fatigue (Rho=0.193*; p=0.005), and HI (Rho=0.156; p=0.023).

Conversely, sRPE is positively, albeit slightly, associated with QS (Rho=0.141*; p=0.040), fatigue (Rho=0.184*; p=0.007), and HI (Rho=0.142; p=0.038).

Table 5. *Spearman Correlation Between Internal Variables and Well-being Variables During the Canyoning Season.*

	HR mín	HR méd	RPE	sRPE
Quality sleep	Rho=0,348**; p<0,001	Rho=0,256**; p<0,001	Rho=0,157*; p=0,022	Rho=0,141*; p=0,040
Fatigue	Rho=0,203**; p=0,003	Rho=0,148*; p=0,031	Rho=0,193**; p=0,005	Rho=0,184**; p=0,007
Stress	Rho=0,193**; p=0,005		Rho=0,163*; p=0,017	
Muscle pain	Rho=0,160*; p=0,019			
HI	Rho=0,270**; p<0,001	Rho=0,191**; p=0,005	Rho=0,156*; p=0,023	Rho=0,142*; p=0,038

HR: Heart rate; sRPE: Session of Subjective Perceived Exertion (sRPE*time of the session); HI: Hooper Index (sum of subgroups).
*Significant association for p < 0.05
** Significant association for p < 0.01.

Relationships between intensity and well-being variables by periods

In **tables 6, 7,** and **8**, the descriptive statistics of the associations between internal, external, and well-being variables during different periods of the canyoning season can be observed. Appendices B, C, and D provide detailed information on all associations between intensity and well-being variables in each period of the season.

During all three periods of the canyoning season, positive significant correlations were found between maximum heart rate (HR max) and the distance covered. In the first period (P1), the correlation was rho=0.368*; in the second period (P2), it was rho=0.237; and in the third period (P3), it was rho=0.283*.

In the first two periods of the season, similar significant correlations were found between internal intensity variables and well-being. This included positive correlations between minimum heart rate (HR min) and sleep quality (QS) (P1: rho=0.353*; P2: rho=0.384) and between HR min and the Hooper Index (HI) (P1: rho=0.278; P2: rho=0.374*). Additionally, there was a positive correlation between the Rating of Perceived Exertion (RPE) and fatigue in the first and second periods (P1: rho=0.285; P2: rho=0.214*).

The second period (P2) stood out for having more significant correlations between internal intensity variables and well-being compared to the other periods. Positive significant correlations were observed between HR max and sleep quality (QS) (rho=0.236*) and between HR min and fatigue, stress, and muscle pain (rho=0.307*; rho=0.311; rho=0.258), respectively. Furthermore, there were positive significant correlations between average heart rate (HR avg) and sleep quality (QS), fatigue, stress, and the Hooper Index (HI) (rho=0.325; rho=0.264; rho=0.244; rho=0.315*), respectively. RPE also positively correlated with fatigue, stress, and HI (rho=0.204; rho=0.215*), respectively, and there was a significant correlation between session-RPE (sRPE) and fatigue (rho=0.209*). Average speed showed a positive correlation with HR min (rho=0.221*), and the distance was positively correlated with HR avg (rho=0.204*).

In the third period (P3), new significant positive correlations were observed, including a negative correlation between RPE and distance (rho=-0.326*) and average speed (rho=-0.327*). Furthermore, average speed showed a moderately negative correlation with sRPE (rho=-0.412*), and there was a positive correlation between mean pace and sleep quality (QS) (rho=0.300).

Table 6*. Spearman's Association in Period 1 of the Canyoning Season (internal variables vs. well-being variables).*

	HR máx	HR mín	RPE
Quality of sleep		Rho=0,353**; p=0.008	
Fatigue			Rho=0,285*; p=0,033
HI		Rho=0,278*; p=0,038	
Distance	Rho=0,368**; p=0,005		

HR: heart rate; RPE: subjective perception of effort; HI; Hooper Index.

Table 7. *Spearman's Association in Period 2 of the Canyoning Season (internal variables vs. external variables; internal variables vs. well-being variables).*

	HR máx	HR mín	HR méd	RPE	sRPE
Quality sleep	Rho=0,236*; p=0,018	Rho=0,384**; p<0,001	Rho=0,325**; p=0,001		
Fatigue		Rho=0,307**; p=0,002	Rho=0,264**; p=0,008	Rho=0,214*; p=0,032	Rho=0,209*; p=0,036
Stress		Rho=0,311**; p=0,002	Rho=0,244*; p=0,014	Rho=0,204*; p=0,041	
Muscle pain		Rho=0,258**; p=0,009			
HI		Rho=0,374**; p<0,001	Rho=0,315**; p=0,001	Rho=0,215*; p=0,031	
Distance	Rho=0,237*; p=0,017		Rho=0,204*; p=0,041		
Average speed		Rho=0,221*; p=0,026			

HR: heart rate; RPE: subjective perception of effort; sRPE: subjective perception of effort session (RPE*session time); HI: Hooper Index (sum of subgroups).

Table 8. *Spearman's Association in Period 3 of the Canyoning Season (internal variables vs. external variables; external variables vs. well-being variables).*

	HR máx	PSE	sPSE	QS
Distance	Rho=0,283*; p=0,034	Rho=-0,326*; p=0,014		
Average speed		Rho=-0,327*; p=0,014	Rho=-0,412**; p=0,002	
Average pace				Rho=0,300*; p=0,025

HR: heart rate; PSE: subjective perception of effort; sPSE: subjective perception of effort session (PSE*session time); QS: sleep quality.

Discussion

The present study aimed to analyze the associations between internal and external intensity variables and measures of well-being throughout a canyoning season. The main results revealed that the median of RPE and well-being categories varied between two and three UA, indicating good levels.

Overall, throughout the season, there were significant associations of small magnitude between internal intensity variables (VII) and measures of well-being. With less frequency, there were also significant relationships between external intensity variables (VIE) and well-being. The weaker relationships between these intensities are likely due to the nature of canyoning as a tourist activity where the goal is not to rush through the riverbed but to ensure customer satisfaction and provide a safe and professional experience.

The second period, coinciding with the period of the season with the highest daily workload and the most clients, showed a greater number of relationships between internal intensity variables and well-being. When the workload increases (as seen with more daily tours), the guides' perception of well-being increases.

Variations in Physical Fitness and Anthropometry After the Season

Comparing the initial and final assessments conducted using the Tanita body composition analyzer, a decrease in body mass (0.57 kg) and fat mass (1.37 kg) was observed. As a result of the decline in these body measurements, the BMI also decreased. In compensation, there was an increase in lean body mass (0.79 kg). These values are in line with expectations due to the increased intensity imposed during the season. Physical

exercise can have a positive impact on anthropometric parameters, such as reducing fat mass and increasing lean mass (Leite, D´Arce, Silva, & Garcia Júnior, 2009; Vannuchi, Carreira, Pegoraro, & Gvozd, 2016).
Handgrip strength also increased in both hands: the right hand (1.55 kg) and the left hand (0.94 kg). Similar results were observed in a Pilates study conducted during the same time period (Carlos Loura Santos, Luiz Vancini, & Jacon Sarro, 2017). However, it's worth noting that the strength gains, when comparing the initial and final assessments, are lower than the reference values mentioned by Nascimento, Benassi, Cabocio, Salvador, & Gonçalves (2010) (50.9 kg for the dominant hand and 41.2 kg for the non-dominant hand).
It's important to consider that handgrip strength data can vary depending on factors like different sports, gender, body weight, age, and training type (Fernandes & Marins, 2011). To the best of our knowledge, there are no existing studies that associate sports involving the use of ropes (canyoning) with handgrip strength.
Relationships between intensity variables
During canyoning excursions, the mean RPE was 3.14±1.87, and the sRPE was 580.49±365.61 (median=489). A study on training intensity and its relationship with well-being in trail athletes reported an average RPE of 6.15±2.24 (Matos et al., 2019). The difference between these values can be attributed to the distinct nature of the activities and their internal and external intensity requirements. Moreover, this study falls within the reference range for RPE (RPE=2.3-6.3 AU) and surpasses the values for sRPE (sRPE=156-394 AU) reported in a systematic review of young male football players (Oliveira et al., 2022).
Regarding associations over the season, distance showed a small significant association with both HR máx and HR méd. The relationship between these variables seems logical and is discussed in the meta-analysis titled "Relationships between internal and external load measures in team sports: A meta-analysis" (Shaun et al., 2017). To generate muscle contractions necessary for locomotion, increased oxygen consumption and cardiac output are required (Vanrenterghem, Nedergaard, Robinson, & Drust, 2017). Consequently, it can be understood that distance and heart rate are interrelated.
Similarly, average velocity (AV) had a small but significant association with HR méd and HR mín. It's believed that activities with intermittent bursts are more energetically demanding than running at a continuous pace (Zamparo, Zadro, Lazzer, Beato, & Sepulcri, 2014; Gao et al., 2022). Therefore, considering the characteristics of canyoning, the association between heart rate and velocity is justified.
AV was also significantly associated with sRPE. Despite its subjective nature, sRPE serves as a good indicator of internal intensity. It has shown associations with both internal and external intensities in a meta-analysis of team sport athletes (Mclaren et al., 2017).
Controlling and monitoring activity intensity using RPE is effective in optimizing performance and reducing the risk of injuries caused by excessive external intensity (Fort-Vanmeerhaeghe, Romero-Rodriguez, Lloyd, Kushner, & Myer, 2016).
Relationships between intensity variables and well-being
The internal intensity variables (VIE) did not show significant associations with well-being measures. In contrast, Matos et al. (2019) found a small but significant relationship between the well-being variable "QS" and all internal intensity variables, such as distance and duration.
However, the internal intensity variables (VII), such as minimum heart rate (HR mín), were significantly associated with all well-being measures. Average heart rate (HR méd) was related to "QS," "fatigue," and "HI." Recent studies have highlighted the relationship between physiological needs and well-being, which can vary depending on the type of training, duration, and intensity (Rossi et al., 2022). Researchers like Selmi et al. (2022) in the context of soccer have suggested monitoring athletes before each activity or training session with psychometric tests to enhance performance and detect early signs of fatigue.
Perceived exertion (RPE) was related to all well-being measures and the Health Index (HI), except for muscle soreness. A recent study on variations in intensity variables and well-being during a professional basketball season found relationships between work intensities, muscle soreness, and fatigue at different periods of the season (Ferreira et al., 2021). Matos et al. (2019), while studying training intensity and its relationship with well-being in recreational mountain trail runners, also identified associations between QS and training intensities (distance, duration, sRPE, and RPE).
Additionally, session perceived exertion (sRPE) correlated significantly with "QS," "fatigue," and "HI," resembling the findings of Silva et al. (2022), who found moderate associations between sRPE and fatigue and small associations with sleep and muscle soreness during the game week, as well as small associations with fatigue in the week following the game. Filipe M. Clemente et al. (2020) showed very strong associations between acute weekly load (wAL) and muscle soreness, QS and fatigue when studying 13 players from the Portuguese 1st Division volleyball. J. A. Costa et al. (2022) reported similar associations between well-being measures and sRPE, consistent with the findings in the present study.
Perceived exertion is commonly significantly related to well-being measures. This suggests that reliable data can be obtained through cost-effective and relevant methods, which can be considered for the evaluation of guides in this sport (Oliveira et al., 2022).
Relationships between intensity variables and well-being by period
Analyzing the same variables across different periods of the season revealed a significant but small association between distance and maximum heart rate (HR máx) in all three periods. The results of this study

align with Abdullahi, Coetzee, & Berg (2019), who examined 21 badminton players and found associations between workload intensity and Health Index (HI) (80% of HR máx) and moderate intensity (MI) (60 to 80% of HR máx).

Minimum heart rate (HR mín) was significantly associated with "QS" and "HI" with small magnitude. Recent studies have highlighted the importance, applicability, and effectiveness of the Hooper Index questionnaire. Being non-invasive, it is a simple and practical tool for perceptual monitoring (J. A. Costa et al., 2022; Nobari, Gholizadeh, Martins, Badicu, & Oliveira, 2022), as applied to the guides in this study.

Perceived exertion (RPE) was related to fatigue in the first two periods. Filipe M. Clemente et al. (2019) found moderate to large associations between weekly training intensity and perceived fatigue, muscle soreness, and stress in different months of the season. In line with our findings, there are associations between workload intensity parameters (Waw and wACWR) with fatigue, HI, stress, and sleep during the preseason in young fighters, as described by Nobari, Badicu, Akyildiz, & Clemente (2023).

In P2, the average heart rate (HR méd.) correlated with distance, and the minimum heart rate (HR mín) with average velocity (AV). To meet the demands of the activity, more motor units might be recruited, increasing energy expenditure (Flynn, Connery, Smutok, Zeballos, & Weisman, 1993; Schwane, Johnson, Vandenakker, & Armstrong, 1983). Furthermore, different running modes and speeds can lead to varying physiological responses (Gao et al., 2022).

New and small but significant associations were found in P2 between internal intensities and well-being, such as maximum heart rate (HR máx) with "QS," minimum heart rate (HR mín) with "QS," fatigue, stress, muscle soreness, and HI, and average heart rate (HR méd.) with "QS," fatigue, stress, and HI. These results characterized the phase of the season where a higher number of routes are performed, resulting in a greater perception of fatigue, stress, and muscle soreness, which can negatively affect the "QS." Additionally, personal and environmental factors are dynamic and can influence outcomes, increasing susceptibility to sports injuries (Pol, Hristovski, Medina, & Balague, 2019).

Pethick, Winter, & Burnley (2015) concluded that fatigue, along with strength and neuromuscular control, is a risk factor with a strong relationship. Fatigue leads to decreased strength, subsequently affecting motor coordination, altering biomechanical variables (Pol et al., 2019; Wojtys, Beaulieu, & Ashton-Miller, 2016), and potentially placing the guide in an unsafe condition (Zago et al., 2021). Similarly, muscle soreness can weaken technical performance, nerve conduction, and muscle coordination (Selmi, Ouerghi, et al., 2018).

The perceived exertion (RPE) significantly correlated with fatigue, as well as stress and HI. Similar reports were found in mountain running athletes in a recent study by Matos et al. (2019). Filipe M. Clemente et al. (2019) revealed strong associations between RPE, fatigue, muscle soreness, and stress.

As for the session perceived exertion (sRPE), it was associated with fatigue. Mid-season, Filipe M. Clemente et al. (2020) reported almost perfect relationships between weekly acute load (wAL) and muscle soreness, "QS," fatigue, stress, and HI. sRPE should be used in conjunction with other tools capable of indicating the health status of guides (in the case of the present study). HI is one of the best self-reported well-being questionnaires in other sports such as football (Nobari et al., 2020), and it was thus applied in canyoning.

The internal intensity variable corresponding to the mean pace was significantly related to "QS" only in P3. Sleep quality is an excellent and essential indicator for physical and psychological recovery and relates to athlete performance (Kellmann et al., 2018).

In P3, new small but significant associations were found between RPE and distance and average velocity. There were reasons for the relationship between internal intensities and distance as they result from psychophysiological mechanisms. Additionally, it is believed that neural processes guide the subjective perception of effort (S. Marcora, 2009).

Finally, in the last period, average velocity (AV) and sRPE were also related. Shaun et al. (2017) stated that it makes sense for there to be significant associations between these variables because they result from similar processes to those of distance and RPE. These small significant associations can be justified by accelerations vs. decelerations (intermittent exercise) and frequent changes in movement, leading to physiological variability to meet muscle needs (Vanrenterghem et al., 2017).

It is important to control individual measures for assessing performance in sports sciences since psychophysiological responses should be associated with the capacity, volume, and intensity of activities (Robertson, Kremer, Aisbett, Tran, & Cerin, 2017).

Saw, Main, & Gastin (2016) recommend that well-being reports should be used and accompanied by other assessment tools. The classification of perceived exertion (RPE) has been commonly used to quantify the perceived effort imposed by the required intensities (Saw et al., 2016). These questionnaires, applied before and after activities, provide reliable (although subjective) information about each individual and each route completed (Malone et al., 2018). Similarly, sRPE is a simple and cost-effective tool that allows for quantifying internal intensities of activities (Slimani, Davis, Franchini, & Moalla, 2017).

The GPS watch is also a valid and relevant tool for assessing external intensity (Ravé, Granacher, Boullosa, Hackney, & Zouhal, 2020). The information collected through a set of assessment tools contributes to better control and mastery of the intensities that affect those being evaluated (Ravé et al., 2020).

Future directions and practical implications

The present study had some limitations, primarily regarding the sample size, as only one team of canyoning guides from a single company was studied and analyzed.

Therefore, some limitations to mention should be considered for future studies, including:

1) Different companies in locations with different geographical and morphological characteristics.
2) It would be relevant to include less experienced guides on the field and consider additional lifestyle factors (volume of external physical exercise and nutrition).
3) Understanding the different roles of canyoning guides during the routes would be interesting to consider, as they were not included in this study.

Despite the limitations presented, considering the overall state of the present study, it was found that measures of well-being (HI, QS, Stress, and Fatigue) were significantly associated with the RPE throughout the season. Similarly, sRPE was associated with QS, fatigue, and HI. The perception of well-being and RPE seem to be good indicators that reflect well-being and the internal intensities imposed by external intensities.

The minimum and average heart rate (HR mín and HR méd) were also significantly associated with all subgroups of HI, except for HR méd and muscle pain, which showed no association. Once again, internal intensities, but this time objective ones, appeared as good indicators of the perceived well-being and heart rate variability caused by external intensities.

Regarding VIE, these had a small magnitude association between maximum and average heart rate (HR máx and HR méd) vs. distance and minimum and average heart rate (HR mín and HR méd) vs. average speed.

A higher number of associations between variables occurred in P2, which is the period with the highest intensity demands on guides with a higher volume of activities.

Conclusion

The objective of this study was to determine the existing relationships between intensity variables (internal and external) and well-being. Although there is literature on canyoning, this is the first study that analyzes guides in terms of intensity and well-being over an 11-week canyoning season.

More relationships were found between internal intensities and well-being in the middle of the season, and more associations between internal and external variables in the last period of the season compared to the first. This is due to the increased perception of demands; the higher the required intensity, the greater the perception of it. Therefore, the period of the season with the highest volume of activities (mid-season) requires greater vigilance and attention. It is crucial to monitor the well-being of canyoning guides.

The Polar watch can be an alternative method considered by researchers to provide objective data on the correspondence between internal and external intensity. Even though these individuals are not athletes, and this practice (in this context) is carried out for tourism, they are responsible for the activities. Therefore, they should be able to identify significant variations in psychophysiological and motor responses during canyoning routes, thus avoiding increased stress and fatigue and, consequently, possible incidents.

Conflicts of interest

The authors declare no conflicts of interest.

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