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RESEARCH

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Comparative analysis of physical fitness and body composition in first-year bachelor sports sciences students from France and Portugal

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Abstract

Background Physical fitness and body composition are foundational to the training and academic success of sports sciences students. However, baseline physical profiles may vary across institutions and countries, reflecting differences in cultural, educational, and physical activity environments. This study aimed to compare physical fitness levels and anthropometric characteristics of first-year sports sciences students from three European institutions in France and Portugal.

Methods A cross-sectional study was conducted with 172 first-year university students (121 males, 51 females) enrolled in sports sciences programs at one French (UMLP) and two Portuguese institutions (IPB and IPG). Participants completed a standardized physical fitness test battery assessing aerobic capacity (estimated VO_{2max}), upper- and lower-body strength (handgrip, isometric mid-thigh pull), explosive power (standing long jump), flexibility (sit-and-reach), and balance (standing stork test). Anthropometric measures included body mass, fat mass, and lean mass. Group and gender differences were analyzed using ANOVA and effect sizes.

Results Students from UMLP displayed significantly higher performance in estimated VO_2max (IPB vs UMLP d = 1.08; IPG vs UMLP d = 0.81), strength (isometric mid-thigh pull [IPB vs UMLP d = 0.65; IPG vs UMLP d = 0.73]), flexibility (IPB vs UMLP d = 0.61; IPG vs UMLP d = 0.69), balance (IPG vs UMLP d = 0.91), and body composition (higher lean mass [IPB vs UMLP d = 0.19; IPG vs UMLP d = 0.28], lower fat mass [IPB vs UMLP d = 0.22; IPG vs UMLP d = 0.31]) compared to their Portuguese peers. IPG students outperformed the other groups in the standing long jump test (IPB vs IPG d = 0.51; IPG vs UMLP d = 1.38). Males consistently outperformed females across all fitness domains except flexibility. Significant group-by-gender interactions were observed for flexibility and strength measures.

Conclusions This study highlights substantial differences in physical fitness and body composition among first-year sports sciences students across institutions in France and Portugal. These findings underline the importance of assessing students' physical readiness at university entry and suggest that institutional and cultural factors may influence

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physical health trajectories. Targeted interventions may be warranted to ensure baseline fitness equity and promote academic and athletic success.

Keywords Physical fitness, University students, Sports sciences, Cross-cultural comparison, Gender differences

Introduction

While not universal (e.g., [1]), it is generally believed that the physical capacities of students play a pivotal role in their academic success [2–4]. This also applies to students pursuing degrees in sports sciences, even if only few specific information is available [5]. Moreover, and specifically, sports sciences academic programs often integrate components that require not only theoretical knowledge but also substantial physical fitness, motor skills, and physiological resilience. Hence, evaluating physical capacities is essential to ensure that students meet the demands of their curriculum and are prepared for careers in sports coaching, physical education, rehabilitation, and athletic performance.

Evidences suggest a general decline in the physical fitness levels of the youth, attributed to lifestyle factors such as increased screen time, poor nutrition, and reduced physical activity [6, 7]. This decline would be particularly concerning in the context of sports sciences, where students are expected to model healthy behaviors and maintain high fitness levels. A decrease in physical activity and physical fitness has been reported in the youth in both Portugal [8, 9] and France [10–12]. Cultural and educational differences may influence physical fitness levels. Indeed, despite traditions in sports and physical education, distinct approaches to physical activity, sports training, and university curricula (e.g., early exposure to structured sports programs vs. physical practice based on traditional sports vs. more informal physical activity) can lead to different fitness levels, training habits, and overall preparedness for sport science careers [13, 14]. Such cultural differences have been highlighted in students from Portugal, Italy and Spain [15]. It has been reported that Spanish adolescents are more active than both French [16] and Portuguese [17] ones, but to the best of our knowledge, no direct comparison between French and Portuguese students has been done, especially for sports sciences students. Although sports sciences students are expected to maintain high fitness levels, the trends mentioned above raises questions about whether incoming sports sciences students cohorts still meet the academic expectations.

Hence, this study aimed to assess and compare the physical capacities of bachelor students enrolled in sport sciences programs in Portugal and France, examining key fitness parameters, such as cardiorespiratory fitness, muscular strength, flexibility, and body composition [18]. By systematically evaluating these capacities, this research seeks to provide reference values and highlight potential differences between these two countries of Western Europe that could help to provide evidence-based recommendations for enhancing educational programs and promoting lifelong physical health among future professionals in the field of physical activity for health and sports performance. We hypothesized that, despite cultural differences, the sports sciences students from the two countries would not have marked physical fitness differences.

Methods

Participants

An a priori power analysis was performed using G*Power [19]. One hundred and fifty-eight participants were required to detect a medium effect size ($f^2=0.25$) with 80% power ($\alpha=0.05$) for an “ANOVA: fixed effects, specials, main effects and interactions” statistical test. The sample comprised 172 participants with an average age of 19.7 ± 2.5 years (males: $N=121$, with an average age of 19.8 ± 2.9 years; females: $N=51$, with an average age of 19.5 ± 1.3 years). As for the inclusion criteria, the participants needed to be students in the first year of each institution and free from injuries. As exclusion criteria, participants taking any medication that could affect physical performance or test results, and pregnant women. All procedures were in accordance with the Declaration of Helsinki regarding human research, and the Institutional Ethics Board approved the research design (N.º P533182-R654085-D1985073).

Research design

In each institution (Instituto Politécnico de Bragança – IPB; Instituto Politécnico da Guarda – IPG; University Marie et Louis Pasteur – UMLP), the data collection was conducted during the first week of classes on three different days. When conducting studies or experiments involving large sample sizes, selecting simple and quick variables for measurement is often critical. This approach ensures efficiency, reliability, and cost-effectiveness while maintaining the integrity of the research. In this sense, the set of variables chosen met these criteria. On the first day, a set of somatic features were collected. On the second day, their cardiorespiratory fitness (maximal oxygen uptake – VO_{2max}) was estimated using the StepTest4all [20]. On the third day, variables related to muscular strength (isometric mid-thigh pull – IMTP; handgrip strength – HG; standing long jump – SLJ), balance (standing stork test – SST) and flexibility (sit and reach – S&R) were collected. Figure 1 depicts the data collection process and the tests used.

Data collection

Anthropometrics

The participants' height was measured with a digital stadiometer (SECA 242, Hamburg, Germany). Afterward, their body mass (BM, in kg), body mass index (BMI, in kg/m^2), fat mass percentage (%FM, in %), and lean mass percentage (%LM, in %) were measured using a bioimpedance device (Tanita, MC 780-P MA, Tokyo, Japan), according to the manufacturer's software instructions.

Cardiorespiratory fitness

The participants' cardiorespiratory fitness was measured using a step test protocol – StepTest4all [20]. This protocol is a standardized physical fitness assessment designed to evaluate an individual's cardiovascular endurance and aerobic fitness based on a VO_{2max} estimation. It utilizes a progressive step test approach, where participants step on and off a platform at a specified pace for a predetermined duration. Before the test, the step height needs to be established. More information about this topic can be found elsewhere [20]. In the present study, a step height of 40 cm and a fast pace resulted in an intensity that reached 80% of the estimated maximum heart rate (HR_{max}) in 5 to 10 min. The criteria for ending the test are: (i) when the HR reached 80% of HR_{max}, (ii) when the participant felt uncomfortable with the exertion, or (iii) when the participant was unable to complete the exercise at the correct cadence. In the present study, all participants reached 80% of HR_{max}. During the test and the passive (standing) recovery period, the participants' HR was monitored using a Garmin strap (Garmin International Inc., Olathe, KS, USA). The test was done with the participants wearing fitness clothing and shoes. The HR_{max} was estimated as:

$$HR_{max} = 208 - 0{,}7 \bullet age \quad (1)$$

Where HR_{max} is the maximal heart rate (in bpm) and age is the chronological age (in years) [21]. As for the VO_{2max}, this was estimated as:

$$VO_{2max} = 17.105 + 0.260 \bullet HRR60 + 8.563 \bullet (sex) + 4.097 \bullet (PA_{level}) \quad (2)$$

where VO_{2max} is the maximum oxygen uptake (in $mL{\cdot}kg^{-1}{\cdot}min^{-1}$), HRR60 is the heart rate recovery during 60 s (in bpm) immediately after the end of the step test, gender is zero for women and 1 for men, and PA_{level} is the physical activity level (level 1 – low; level 2 – moderate; level 3 – high) [20].

Muscular strength, balance, and flexibility

Participants also wore fitness clothing and shoes for muscular strength, balance, and flexibility assessments. They perform a standardized warm-up of 5 to 10 min consisting of light jogging, jumping jacks, skipping, dynamic stretching, and mobility exercises. The participants were previously instructed about the protocol of each test and were allowed to test each one before data collection. Before the IMTP test (in kg) execution in a digital dynamometer (Takei, T.K.K. 5402, Takai, Japan), the bar's height was adjusted. For each participant, the handles were aligned with his/her mid-thigh level while standing to obtain the optimal knee (125°–145°) and hip (140°–150°) angles [22]. Afterward, they were instructed to adopt an upright torso, slight flexion in the knee resulting in some dorsiflexion, shoulder girdle retracted and depressed, shoulders above or slightly behind the vertical plane of the bar, and feet roughly centered under the handle approximately hip-width apart [23]. After stabilization, the participant was given a countdown

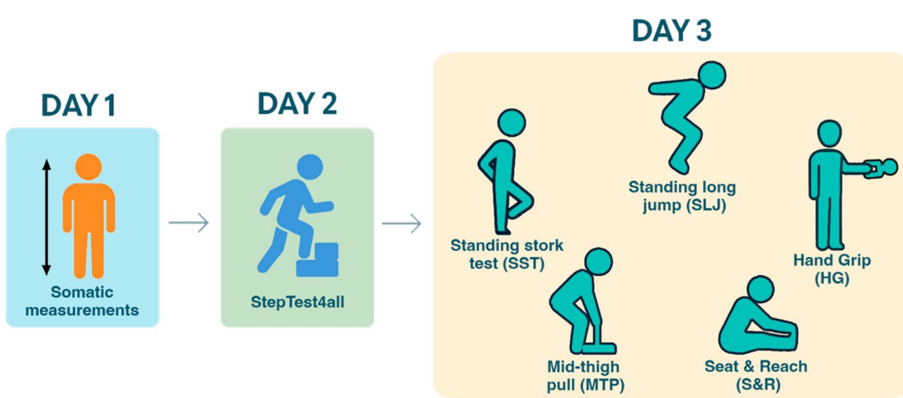

Fig. 1 Data collection process and tests underwent

and instructed to perform a maximal pull. Minimal pretension was allowed to ensure no slack in the subject's body before initiating the pull [24]. Each participant performed 3 maximal trials for five seconds with a two-minute rest to ensure a full recovery. They were advised to pull the handle with maximal effort as quickly as possible and simultaneously to push the feet down into the ground [24]. The best trial was used for further analysis.

The HG test was done in the dominant upper limb. Dominance was established by self-report. A digital hand dynamometer (JAMAR, Lafayette, LA, USA) was used to measure the isometric handgrip (in kg). The participants were instructed to stay in the orthostatic position, extending both upper limbs along the trunk. Afterward, they were asked to produce their maximal grip with the dominant upper limb [25]. Three trials were performed with a two-minute rest between each trial to ensure full recovery. The best trial was used for further analysis.

For the SLJ (in cm), the participants were instructed to stand behind a line that marks the starting point with both feet shoulder-width apart. Starting from the standing position, in continuous movement, the students were instructed to flex their knees, pull their arms back, and jump in length as far as possible, landing with both feet parallel [26]. An expert evaluator recorded the distance with a measuring tape (RossCraft, Canada). Distances were measured from the starting point to the heels. Three trials were performed, and the best value was used for further analysis.

A standard box was used for the S&R test (in cm). A sliding ruler was centered on the top of the box to obtain the S&R scores. The ruler was positioned so the 0 cm mark represented the toes' level. Therefore, negative values indicated that the participants couldn't reach the toes' level. On the other hand, positive values indicated that they could overreach the toes' level [27]. The reach scores were recorded to the nearest 0.5 cm using the rule on the box, and considered as: (i) excellent if reach > 14 cm for males and > 15 cm for females; (ii) above average if reach between 14.0 and 11.0 cm for males and 15.0 and 12.0 cm for females; (iii) average if reach between 10.9 and 7.0 cm for males and 11.9 and 7.0 for females; (iv) below average if reach between 6.9 and 4.0 cm for both males as females, and; (v) poor if reach < 4 cm for both males and females [28]. Three trials were performed, and the best value was used for further analysis.

For the SST, the participants were instructed to stand barefoot on a flat surface with their hands on their hips. Each participant chose the dominant foot on the ground and the non-dominant one lifted. Afterward, they lifted one foot off the ground and placed the toes of the lifted foot against the inside of the knee of the standing leg. When the participants were stable in the starting position, the timer started with a stopwatch. They were advised to maintain balance in such a position for as long as possible. The test ended when (i) the participants' foot lost contact with the inside of the knee, (ii) the standing foot's heel touched the ground, and (iii) the participants' hands left their hips, and; (iv) the participants' lost balance or falls [29]. Each participant performed three trials and the best one (more time) was used for further analysis. Normative values for males: excellent > 50 s; above average 37–50 s; average 15–36 s; below average 5–14 s; poor < 5 s. Normative values for females: excellent > 27 s; above average 23–27 s; average 8–22 s; below average 3–7 s; poor < 3 s [29].

Statistical analysis

Tests of data distribution (Kolmogorov–Smirnov) and homogeneity (Levene's test) were conducted before analysis. The data are shown in descriptive statistics for means and one standard deviation. A two-way ANOVA ("group" factor and "gender" factor) was used to test differences between groups and genders, and the respective interaction. The three different institutions were used as groups. The significance level was set at $\alpha < 0.05$. The eta square (η^2) was used as an effect size index and calculated and interpreted as: (i) without effect if $0 < \eta^2 \leq 0.04$; (ii) minimum if $0.04 < \eta^2 \leq 0.25$; (iii) moderate if $0.25 < \eta^2 \leq 0.64$ and; (iv) strong if $\eta^2 > 0.64$ [30]. Whenever suitable, the Bonferroni post-hoc correction was used (p-value was set at 0.017 and 0.025 for the "group" and "gender" effects, respectively). The mean difference (MD) and 95% confidence intervals (95%CI) were used. Cohen's d was used to estimate the standardized effect size between pairwise: (i) trivial if $0 \leq d < 0.20$; (ii) small if $0.20 \leq d < 0.60$; (iii) moderate if $0.60 \leq d < 1.20$; (iv) large if $1.20 \leq d < 2.00$; (v) very large if $2.00 \leq d < 4.00$, and; (vi) perfectly distinct if $d \geq 4.00$ [31]. Data were analyzed using SPSS, v.29.0 for Windows (SPSS Inc, Chicago, USA).

Results

Table 1 presents the descriptive data of all variables per group (i.e., institution) and gender. The participants from UMLP were older than the ones from the remaining two groups. Despite a significant "group" effect ($p = 0.020$), this had a minimum effect size ($\eta^2 = 0.05$), and the post-hoc correction did not detect significant differences. Non-significant "gender" effect and "group X gender" interaction was noted (Table 1). As for BM, a significant "gender" effect was noted with a moderate effect size ($p < 0.001$, $\eta^2 = 0.27$), where females presented smaller values than males (MD = −12.34, 95% = −15.46 to −9.23, $p < 0.001$, d = 1.43) (Table 2). Non-significant "group" effect and interaction were noted. A significant

Table 1 Demographics, anthropometrics, and participants' physical characteristics per group (i.e., different institutions). It also presents the "group" effect, "gender" effect, and respective interaction

	IPB		IPG		UMLP				
	Mean ± SD		Mean ± SD		Mean ± SD				
	Males	Females	Males	Females	Males	Females	Group effect	Gender effect	Interaction
Number of students									
Anthropometrics									
Age [years]	19.5 ± 1.9	18.6 ± 1.0	19.5 ± 4.4	18.9 ± 1.6	20.5 ± 0.7	20.2 ± 0.5	$F=3.987$; $p=0.020$ $\eta^2=0.05$	$F=1.847$; $p=0.176$ $\eta^2=0.01$	$F=0.219$; $p=0.804$ $\eta^2=0.00$
BM [kg]	71.4 ± 8.3	60.5 ± 7.2	72.5 ± 9.2	61.0 ± 11.2	72.7 ± 9.9	58.1 ± 7.2	$F=0.282$; $p=0.755$ $\eta^2=0.00$	$F=61.155$; $p<0.001$ $\eta^2=0.27$	$F=0.569$; $p=0.567$ $\eta^2=0.01$
Height [cm]	175.0 ± 5.7	161.8 ± 5.1	175.5 ± 5.1	160.5 ± 7.1	178.6 ± 5.9	164.8 ± 5.0	$F=6.496$; $p=0.002$ $\eta^2=0.07$	$F=199.806$; $p<0.001$ $\eta^2=0.55$	$F=0.299$; $p=0.742$ $\eta^2=0.00$
BMI [kg/m^2]	23.4 ± 2.9	23.1 ± 3.1	23.5 ± 3.0	23.6 ± 3.8	22.8 ± 2.5	21.5 ± 2.2	$F=3.725$; $p=0.026$ $\eta^2=0.04$	$F=0.864$; $p=0.354$ $\eta^2=0.01$	$F=0.797$; $p=0.452$ $\eta^2=0.01$
FM [%]	17.1 ± 4.9	27.2 ± 5.1	15.8 ± 6.6	31.0 ± 5.7	14.8 ± 4.2	21.7 ± 4.7	$F=13.212$; $p<0.001$ $\eta^2=0.14$	$F=131.963$; $p<0.001$ $\eta^2=0.45$	$F=7.869$; $p<0.001$ $\eta^2=0.09$
LM [%]	78.8 ± 4.7	69.1 ± 4.8	80.14 ± 6.6	65.0 ± 5.7	80.7 ± 4.4	74.3 ± 4.5	$F=12.296$; $p<0.001$ $\eta^2=0.13$	$F=125.744$; $p<0.001$ $\eta^2=0.44$	$F=9.088$; $p<0.001$ $\eta^2=0.10$
Physical fitness									
VO_{2max} [ml/kg/min]	40.8 ± 4.5	32.6 ± 6.0	43.4 ± 6.0	32.2 ± 3.9	48.9 ± 3.2	40.8 ± 5.2	$F=37.240$; $p<0.001$ $\eta^2=0.35$	$F=97.532$; $p<0.001$ $\eta^2=0.42$	$F=1.297$; $p=0.277$ $\eta^2=0.02$
IMTP [kg]	127.1 ± 25.7	82.1 ± 16.6	128.0 ± 26.7	69.9 ± 17.0	176.1 ± 42.3	102.2 ± 15.4	$F=29.553$; $p<0.001$ $\eta^2=0.27$	$F=136.499$; $p<0.001$ $\eta^2=0.46$	$F=2.866$; $p=0.060$ $\eta^2=0.03$
HG [kg]	44.4 ± 6.3	29.3 ± 4.9	44.9 ± 7.9	29.8 ± 4.6	49.4 ± 8.8	30.5 ± 5.3	$F=2.749$; $p=0.067$ $\eta^2=0.03$	$F=178.092$; $p<0.001$ $\eta^2=0.53$	$F=1.233$; $p=0.294$ $\eta^2=0.01$
SLJ [cm]	191.0 ± 20.2	143.0 ± 13.0	210.9 ± 31.8	160.9 ± 25.3	168.4 ± 19.8	134.4 ± 19.3	$F=25.914$; $p<0.001$ $\eta^2=0.25$	$F=108.128$; $p<0.001$ $\eta^2=0.40$	$F=1.675$; $p=0.191$ $\eta^2=0.02$
S&R [cm]	2.5 ± 6.9	0.72 ± 8.7	0.2 ± 8.2	3.3 ± 8.8	4.3 ± 9.1	12.2 ± 10.6	$F=9.090$; $p<0.001$ $\eta^2=0.10$	$F=3.819$; $p=0.052$ $\eta^2=0.02$	$F=3.183$; $p=0.044$ $\eta^2=0.04$
SST [s]	12.8 ± 13.1	11.5 ± 10.9	7.8 ± 5.9	9.0 ± 8.7	21.8 ± 17.4	16.2 ± 13.9	$F=8.160$; $p<0.001$ $\eta^2=0.10$	$F=0.662$; $p=0.417$ $\eta^2=0.01$	$F=0.809$; $p=0.447$ $\eta^2=0.01$

IPB Instituto Politécnico de Bragança, *IBG* Instituto Polytechnic of Guarda, *UMLP* Université Marie et Louis Pasteur, *BM* body mass, *BMI* body mass index, *FM* fat mass, *LM* lean mass, VO_{2max} maximal oxygen uptake, *IMTP* isometric mid-thigh pull, *HG* handgrip, *SLJ* standing long jump, *S&R* sit and reach, *SST* standing stork test *F* f-ratio, *p* significance value, η^2 eta square (effect size index)

"group" effect with minimum effect size ($p=0.002$, $\eta^2=0.07$) was noted for the participants' height. Pairwise differences were noted only between IPG and UMLP (MD = −3.65, 95% = −6.33 to −0.97, $p=0.004$, d = 0.16), where the UMLP participants were taller (Table 2). A significant "gender" effect was also noted with a moderate effect size ($p<0.001$, $\eta^2=0.55$) among the three institutions (Table 1). Pairwise differences between genders are presented in Table 2 (males were significantly taller than females). Notwithstanding, no significant interaction was noted for height. The BMI presented a significant "group" effect but without an effect size ($p=0.026$, $\eta^2=0.04$) (Table 1). The post-hoc correction did not yield significant differences. A non-significant "gender" effect and interaction were noted. FM presented a significant "group" effect with a minimum effect size ($p<0.001$, $\eta^2=0.14$) (Table 1). The pairwise comparison revealed significant differences between the UMLP participants

Table 2 Group and gender pairwise comparisons

	Group effect						**Gender effect**		
	IPB vs IPG		**IPB vs UMLP**		**IPG vs UMLP**				
	MD 95%CI	***p*-value effect size**	**MD 95%CI**	***p*-value effect size**	**MD 95%CI**	***p*-value effect size**	**MD 95%CI**		***p*-value effect size**
Anthropometrics									
Age [years]									
BM [kg]							−12.34 −15.46 to −9.23		$p<0.001$ d = 1.43
Height [cm]					−3.65 −6.33 to −0.97	$p=0.004$ d = 0.16	−13.99 −15.95 to −12.04		$p<0.001$ d = 2.31
BMI [kg/m^2]									
FM [%]			3.87 1.05 to 6.68	$p=0.003$ d = 0.22	5.16 2.63 to 7.70	$p<0.001$ d = 0.31	10.74 8.90 to 12.59	$p<0.001$ d = 1.69	
LM [%]			−3.58 −6.37 to −0.79	$p=0.007$ d = 0.19	−4.97 −7.48 to −2.46	$p<0.001$ d = 0.28	−10.39 −12.22 to −8.56	$p<0.001$ d = 1.65	
Physical fitness									
VO_{2max} [ml/kg/min]			−8.16 −10.89 to −5.43	$p<0.001$ d = 1.08	−7.09 −9.59 to −4.58	$p<0.001$ d = 0.81	−9.17 −11.01 to −7.34	$p<0.001$ d = 1.22	
IMTP [kg]			−34.61 −49.60 to −19.62	$p<0.001$ d = 0.65	−40.23 −54.07 to −26.39	$p<0.001$ d = 0.73	−58.97 −68.94 to −49.01	$p<0.001$ d = 1.54	
HG [kg]							−16.43 −18.86 to −14.00	$p<0.001$ d = 2.25	
SLJ [cm]	−18.88 −32.27 to −5.49	p = 0.002 d = 0.51	15.62 3.06 to 28.18	$p=0.009$ d = 1.05	34.50 22.90 to 46.10	$p<0.001$ d = 1.38	−44.00 −52.36 to −35.65	$p<0.001$ d = 1.70	
S&R [cm]			−6.60 −11.32 to −1.88	$p=0.003$ d = 0.61	−6.43 −10.66 to −2.20	$p<0.001$ d = 0.69			
SST [s]					−10.59 −17.18 to −4.00	$p<0.001$ d = 0.91			

IPB Instituto Politécnico de Bragança, *IBG* Instituto Polytechnic of Guarda, *UMLP* Université Marie et Louis Pasteur, *BM* body mass, *BMI* body mass index, *FM* fat mass, *LM* lean mass, VO_{2max} maximal oxygen uptake, *IMTP* isometric mid-thigh pull, *HG* handgrip, *SLJ* standing long jump, *S&R* sit and reach, *SST* standing stork test, *MD* mean difference, *95%CI* 95% confidence intervals, *d* Cohen's effect size

and the IPB and IPG (Table 2), with the former being the one presenting smaller FM. A "gender" effect was also noted where females presented greater FM than males (Tables 1 and 2). A significant "group X gender" interaction was noted ($p<0.001$, $\eta^2=0.09$) but with a minimum effect size. As for LM, this presented the same trend as FM. That is, significant "group" and "gender" effects, as well as a significant interaction ($p<0.001$, $\eta^2=0.10$), were noted (Tables 1 and 2). In this case, with males presenting greater LM than females.

As for the physical fitness variables, the estimated VO_{2max} presented a significant "group" ($p<0.001$, $\eta^2=0.35$) and "gender" effects ($p<0.001$, $\eta^2=0.42$), both with moderate effect sizes (Table 1, Figs. 1, 2 and 3). The pairwise comparison revealed significant differences between the UMLP participants' and the IPB and IPG (Table 2), with the former presenting greater estimated VO_{2max}. As for the pairwise comparison for gender, females presented smaller estimated VO_{2max} than males (MD = −9.17, 95% = −11.01 to −7.34, $p<0.001$, d = 1.22) (Table 2). The IMTP test presented the same trend as VO_{2max} (Tables and Figs. 1 and 2). The HG test only revealed a significant "gender" effect with a moderate effect size ($p<0.001$, $\eta^2=0.53$) (Table 1). Females presented smaller IMTP than males (MD = −16.43, 95% = −18.86 to −14.00, $p<0.001$, d = 2.25) (Table 2). The SLJ presented significant "group" ($p<0.001$, $\eta^2=0.25$) and "gender" ($p<0.001$, $\eta^2=0.40$) effects both with moderate

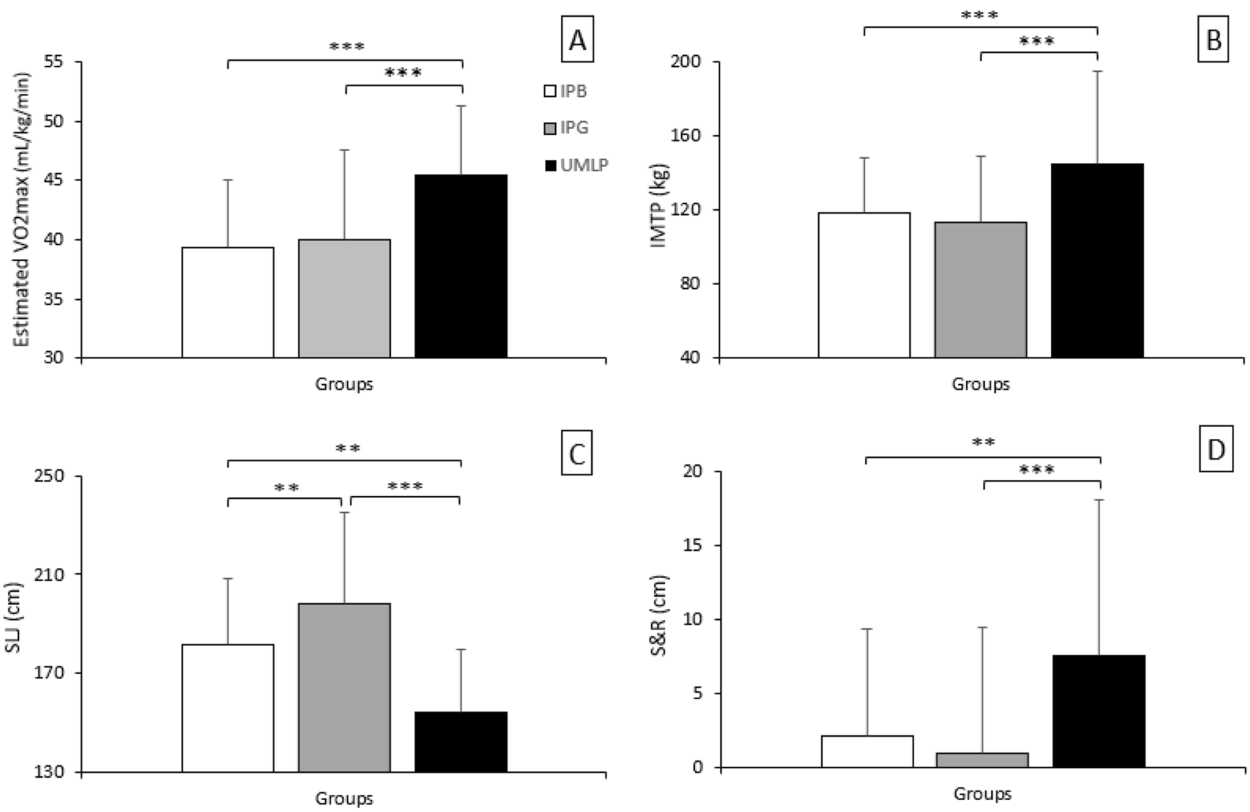

Fig. 2 Between-group comparisons. Panel **A** displays the estimated maximal oxygen uptake (VO_{2max} – mL/kg/min). Panels **B** shows the Isometric Mid-Thigh Pull (IMTP – kg). Panel **C** represents the Standing Long Jump (SLJ – cm). Panel D displays the Sit and Reach (S&R – cm). The white, gray, and black bars represent the Instituto Politécnico de Bragança (IPB), Instituto Polytechnic of Guarda (IPG) and Université Marie et Louis Pasteur (UMLP), respectively. Differences between-groups: ** means $p < 0.01$; *** means $p < 0.001$. Data are represented by mean and standard deviation

effect sizes (Table 1 and Fig. 1). The pairwise comparison for "group" denoted differences among the three groups. These are presented in Table 2. As for the "gender" effect, females presented smaller SLJ than males (MD = −44.00, 95% = −52.36 to −35.65, $p < 0.001$, d = 1.70) (Table 2, Fig. 2). The S&R denoted a significant "group" effect with a minimum effect size ($p < 0.001$, $\eta^2 = 0.10$). The pairwise comparison revealed significant differences between the UMLP and the IPB and IPG, where the former presented the best S&R scores (Table 2, Figs. 1 and 2). A non-significant "gender" effect was noted, but with a significant "group X gender" interaction (p = 0.044, $\eta^2 = 0.04$) (without effect size) (Table 1). Female participants from the UMLP presented better S&R scores than the IPB and IPG females and males. As for the SST, analysis revealed only a significant "group" effect with a minimum effect size ($p < 0.001$, $\eta^2 = 0.10$) (Table 1). The pairwise comparison revealed significant differences between IPG and UMLP, where the IPG participants presented smaller SST scores, i.e., poorer performances (MD = −10.59, 95% = −17.18 to −4.00, $p < 0.001$, d = 0.91) (Table 2).

Discussion

The present study aimed to assess and compare the physical fitness and anthropometric characteristics of students enrolled in sports sciences programs across three institutions in France and Portugal. Contrary to our initial hypothesis of minimal inter-group differences, our findings revealed significant disparities across most fitness domains, particularly between the French cohort (UMLP) and the two Portuguese institutions (IPB and IPG). These differences span cardiorespiratory fitness, muscular strength, flexibility, and body composition, and they suggest a potential divergence in baseline physical readiness for academic and professional sports science demands between the groups (Fig. 3).

The results of this study are in line with previous reports on the anthropometric and physical fitness indexes in students. On average, both genders fall within the normal BMI range (18.5–24.9 kg/m^2), with males showing slightly higher values than females. It is known that males are generally taller and heavier than females, with females exhibiting higher body fat percentages, reflecting typical sexual dimorphism

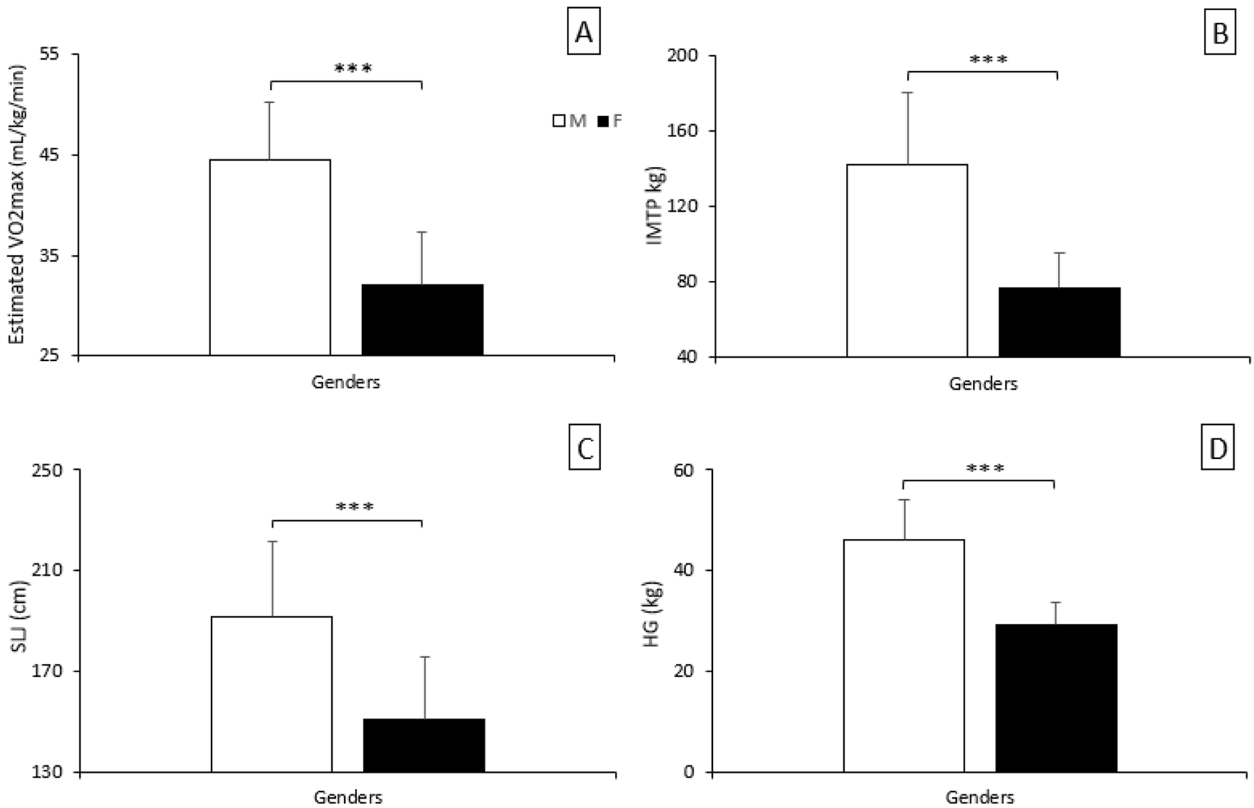

Fig. 3 Between-gender comparisons. Panel **A** displays the estimated maximal oxygen uptake (VO_{2max} – mL/kg/min). Panels **B** shows the Isometric Mid-Thigh Pull (IMTP – kg). Panel **C** represents the Standing Long Jump (SLJ – cm). Panel **D** displays the HandGrip (HG – kg). The white and black bars represent the Males (M) and Females (F), respectively. Differences between gender: *** means $p < 0.001$. Data are represented by mean and standard deviation

consistent with physiological differences [32–34]. This is in line with well-established biological differences in hormonal regulation, fat distribution, and muscle mass development. For example, females typically carry 10–12% more body fat than males of the same age due to estrogen-related fat deposition patterns and differences in lean tissue accretion during adolescence and early adulthood [35]. Both lean mass and fat mass percentages are in line with previous reporting [36–40]. Distinct patterns across institutions and between genders can be revealed. Specifically, students from UMLP exhibited significantly lower fat mass and higher lean mass percentages compared to their peers from IPB and IPG. These differences were more pronounced in male participants but present in both genders, suggesting institutional-level variation in physical conditioning and/or pre-university physical activity engagement. The higher fat mass observed among IPB and IPG students could reflect either lower training volumes, less structured athletic backgrounds, or differences in nutritional habits and physical activity norms prior to university entry.

Overall, our findings emphasize the value of early anthropometric screening to tailor training, nutrition, and health promotion strategies in university settings. Fat mass and lean mass profiles provide not only insight into performance potential but also serve as indicators of metabolic health and injury risk, especially in physically demanding academic pathways such as sports sciences.

The estimated VO_{2max} values observed in our cohorts are consistent with those reported in similar populations [11, 12]. Estimated VO_{2max} remains a robust indicator of not only cardiovascular health but also academic and athletic readiness in sports sciences education. Previous studies have shown positive associations between VO_{2max} and both academic performance and sport-specific success in physically demanding university programs [3, 41]. It is known that estimated $VO2_{max}$ among university students shows considerable variation influenced by gender, geographical location, lifestyle, and measurement methods. Accordingly, and in line with our results, males generally have higher VO_{2max} values than females, in accordance with the greater lean mass, and likely larger cardiac output and higher hemoglobin levels

[42]. These physiological and behavioral factors contribute to the persistent gender gap in aerobic performance, even among trained university cohorts. Importantly, it is crucial to consider methodological differences when comparing values across studies. Variations in testing protocols (e.g., treadmill vs. cycle ergometer vs step test) can influence VO_2 max results. However, VO_{2max} values can also vary significantly based on geographic location. For instance, the HUNT3 study from Norway reports higher average VO_{2max} values compared to studies from India and our results, potentially reflecting differences in physical activity habits and environmental factors [43–46].

The analysis of estimated VO_{2max} revealed that the UMLP cohort significantly outperformed both Portuguese groups (IPB and IPG), especially in males. This finding suggests that UMLP students enter university with a higher level of cardiorespiratory fitness, a core component of physical preparedness for sports sciences curricula and professional practice. This suggests that UMLP students may have had more consistent training backgrounds, potentially involving endurance-based sports or activities that develop aerobic capacity.

Our measured HG values align with established norms [40, 47–51]. As well, the IMTP values are comparable to those previously reported [24, 52–54], including those by Wang et al. (2016), who found significant correlations between isometric MTP strength and performance metrics in collegiate rugby players [55]. Gender-based differences in both HG and IMTP in our sample also followed established physiological patterns. Males consistently outperformed females, which aligns with the broader literature indicating that men possess greater absolute strength due to higher muscle mass, testosterone levels, and neuromuscular efficiency [42]. However, when normalized for body mass or fat-free mass, some gender differences may diminish, highlighting the importance of reporting relative as well as absolute strength.

The present results revealed marked inter-group differences in both HG and IMTP, with UMLP students demonstrating significantly greater performance than their counterparts from IPB and IPG. These disparities were particularly pronounced in male participants, although gender differences were consistently observed across all institutions. The magnitude of the between-group differences underscores the relevance of these force parameters in profiling physical readiness in sports sciences students.

The superior HG (a widely recognized surrogate marker of general upper-body strength and overall neuromuscular health) and IMTP (a robust indicator of lower-body strength and is increasingly used in both sports and clinical assessments) performance observed in UMLP students likely reflects a combination of biological, behavioral, and institutional influences. It is possible that differences in the academic program may attract or cultivate stronger candidates. Higher lean body mass may also contribute to these findings. Although less frequently assessed in general student populations, work such as Thomas et al. (2015) confirms that university-aged individuals with structured strength training backgrounds typically outperform recreationally active peers in IMTP performance [24]. In this context, higher values suggest a superior neuromuscular profile and are likely to reflect more systematic lower-body resistance training.

The SLJ distances recorded in our study are consistent with normative data presented by Mann et al. (2021), who examined the relationship between SLJ performance and anaerobic power in NCAA Division IA football players [56]. The SLJ test is widely recognized as a valid and reliable measure of lower-limb explosive strength, particularly of the hip and knee extensors. Across studies, males consistently exhibit higher SLJ distances than females, reflecting greater lower-body muscular strength and power [57–59]. Gender differences were also evident in our data, with males showing higher values than females across all groups, consistent with well-documented differences in muscle mass, fiber type distribution, and neuromuscular recruitment strategies.

Our results revealed that students from IPG outperformed their counterparts from UMLP and IPB. This was the only physical fitness domain where the French cohort (UMLP) did not dominate. This deviation suggests that indirect assessment of explosive leg power may be shaped by distinct training backgrounds or movement habits not captured in other domains like strength or cardiorespiratory fitness. Interestingly, this result contrasts with other force-based tests (IMTP and HG), where UMLP students performed best. One possible explanation lies in training specificity and/or physical activity habits. SLJ performance is sensitive to recent high-velocity training, plyometric exposure, and even sport types (e.g., volleyball, athletics, football). If IPG students engage more frequently in jumping-based or field sports, this could explain their advantage, despite having lower strength and VO_{2max} levels. This hypothesis aligns with previous studies demonstrating that SLJ performance does not necessarily correlate with maximal strength (e.g., IMTP), but rather with rate of force development and intermuscular coordination [24]. Furthermore, SLJ variability across institutions may also reflect sociocultural influences on sport preferences, as some programs or regions may emphasize agility and power sports more than others. Unlike IMTP and HG, which reflect more general neuromuscular strength, SLJ likely reflects a blend of technical skill, motor learning, and muscle–tendon unit stiffness, which could explain why performance varies independently of other strength metrics. Our findings on SLJ performance emphasize the need to consider both sport-specific neuromuscular adaptations and broader educational or regional trends when interpreting explosive power outcomes in sports sciences students. The results suggest that explosive capacity is less uniformly distributed across this population than other strength or endurance metrics, highlighting the importance of including power-based tests in physical profiling and curriculum development.

Finally, our participants' flexibility scores align with those reported for university-aged populations [60–62]. In our sample, SST performance was generally higher than that of a recent study with Romanian students [63], which may reflect the physically active profile and sports orientation of our participants. Gender-based analysis in our study replicated trends observed in adult-based data showing males outperforming females in SST time. Our results from SST revealed significant inter-group differences in balance performance. Notably, the UMLP cohort demonstrated superior balance abilities compared to the Portuguese groups (IPB and IPG). These inter-group disparities were particularly pronounced among male participants, although the trend was consistent across genders. As the SST is widely recognized as a reliable measure of static balance, primarily assessing postural stability and neuromuscular control in a single-limb stance, these findings suggest a more developed postural control and proprioceptive capacity in the UMLP students at university entry. If UMLP students had more diversified or specialized pre-university training backgrounds, this could explain their superior SST scores. Moreover, given the relatively simple nature of the SST, superior performance likely reflects not only physical ability but also greater familiarity with controlled motor tasks under static conditions. Since static balance is trainable and responsive to proprioceptive or core stabilization training, this group disparity may also reflect curricular or extracurricular training exposure prior to enrollment.

Across the entire sample, lower fat mass and higher lean body mass were consistently associated with superior performance in most fitness assessments. Students from UMLP, who demonstrated significantly lower fat mass and higher lean mass, also recorded the highest values in estimated VO_{2max}, isometric mid-thigh pull (IMTP), handgrip strength (HG), flexibility (Sit-and-Reach), and balance (Standing Stork Test). This alignment reinforces existing literature asserting that favorable body composition—particularly a higher proportion of fat-free mass—is a strong predictor of physical performance across multiple domains [3, 36, 41].

Explosive power, as measured by the Standing Long Jump (SLJ), performance appeared somewhat decoupled from general body composition trends. While lean mass provides the mechanical substrate for power production, SLJ performance also relies on neuromuscular coordination and plyometric efficiency, which may explain why IPG students excelled in this test despite having slightly less favorable body composition profiles than UMLP students. Balance performance (SST) and flexibility (Sit-and-Reach) were also moderately linked to anthropometry. Students with lower fat mass tended to show higher balance and flexibility scores, likely due to a lower center of mass and reduced mechanical restriction around joints. Murariu et al. (2022) similarly found that excess body weight negatively affected postural control in university students, particularly in single-leg balance tests like the SST [64]. Gender-based differences in these relationships were also apparent. Males, who had significantly greater lean mass and lower fat percentages, outperformed females in nearly all fitness metrics except flexibility, where females showed a relative advantage. These trends reflect established gender-specific physiological norms, including hormonal influences on muscle mass development and joint mobility [35].These findings not only support previous literature but also emphasize the importance of comprehensive anthropometric assessments in identifying strengths, weaknesses, and intervention needs in sports sciences students.

Prior studies noted higher physical activity levels in Spanish youth compared to Portuguese and French [15, 17], although they did not focus on sports science students. The lack of a direct comparison within a similar academic cohort underscores the originality of our work and emphasizes the need for more population-specific reference data. Existing literature shows no consensus on normative values in university populations across countries. Yet, this finding supports Gultom (2022), who highlighted physical fitness as a central component of academic performance in sports sciences, suggesting that fitness-oriented curricula may foster superior outcomes [5].

The performance advantage of UMLP students may be attributed to both institutional and cultural factors. The French cohort likely benefits from earlier engagement in structured physical activity and perhaps more selective admission criteria for sports sciences programs, in accordance with interpretation of international differences in physical activity patterns and structural determinants like urban planning, school policy, and recreational accessibility [13]. Moreover, UMLP students' higher lean mass and lower fat mass suggest differences in physical conditioning or lifestyle habits that precede university enrollment. These anthropometric advantages are particularly relevant as they directly affect physical fitness parameters such as strength and endurance [3]. The stronger performance in balance (SST) and flexibility also points to more comprehensive training backgrounds or diversified sports exposure. Another key observation is the minimal differences between IPB and IPG across most domains. This homogeneity supports the assumption that within-country factors such as similar curricular structures, regional lifestyles, and socioeconomic conditions contribute to uniformity in student fitness levels. This is consistent with findings by Kljajević et al. (2021), who emphasized the impact of university environments on fitness behaviors [14].

In line with previous findings [65, 66], significant gender differences were observed across all strength and endurance measures, with males consistently outperforming females. These differences reflect physiological norms in muscle mass distribution and hormonal profiles [35], but they also raise questions about whether current fitness benchmarks and curricular expectations adequately account for gender-specific capabilities and needs in sports sciences programs.

Practical implications

This study provides much-needed normative and comparative data on the physical fitness of sports sciences students in France and Portugal. The findings could inform curriculum development, especially regarding fitness prerequisites and support programs for underprepared students. Future studies should explore the underlying causes of these disparities, including pre-university training exposure, physical activity habits, and selection processes for sports sciences programs. Moreover, Institutions should implement targeted, evidence-based strategies such as preparatory physical activity courses, technology-enhanced interventions (e.g., mobile apps, social media campaigns), and instructor-led group classes to reduce disparities in physical fitness among first-year sports science students [67, 68]. Additionally, establishing gender-specific programming or benchmarks may be warranted, given consistent male–female differences observed in physical fitness; programs for women can incorporate shorter, more frequent and diverse sessions, while men may benefit from longer, strength-focused routines, thus ensuring equitable access and maximized outcomes for both groups [69]

Strengths and limitations

The major strength of this work lies in its comprehensive comparative analysis across multiple physical fitness domains and institutions, providing new normative data specific to sports sciences students in France and Portugal. However, limitations include the cross-sectional design, potential unmeasured confounders (e.g., prior training history, sociocultural factors), and the absence of longitudinal tracking, which restricts inference about causality or fitness trajectories across the academic program.

Conclusions

This study identified significant differences in physical fitness and body composition among bachelor's sports sciences students from institutions in France and Portugal. Students from UMLP consistently outperformed their Portuguese peers in cardiorespiratory fitness, muscular strength, flexibility, and balance, while IPG students excelled in explosive power. These differences were influenced by gender, with males generally exhibiting higher performance across most domains. The findings suggest that cultural, institutional, and preparatory factors may impact physical readiness at university entry. Future research with a longitudinal design would help determine whether these fitness differences persist, converge, or widen throughout the course of the degree, thereby offering insights into the effectiveness of academic training programs in improving or maintaining physical fitness among students.

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Authors' contributions
Conceptualization, L.M., Y.G., J.E.M., R.F.B.B.; methodology, L.M., Y.G., J.E.M., R.F.B.B.; investigation, L.M., Y.G., J.E.M., R.F.B.B., O.L., A.S., M.H., J.A.A.B. and P.M.M; resources, L.M., Y.G., J.E.M., R.F.B.B.; data curation, L.M., Y.G., J.E.M., R.F.B.B., O.L., A.S., M.H., J.A.A.B. and P.M.M; writing—original draft preparation, L.M., Y.G., J.E.M., R.F.B.B., O.L., A.S., M.H., J.A.A.B. and P.M.M.. All authors reviewed the manuscript.

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Data availability
The data supporting reported results can be obtained directly from the correspondent author who deals with data storage.

Declarations

Ethics approval and consent to participate
All procedures were in accordance with the Declaration of Helsinki regarding human research, and the Institutional Ethics Board (Polytechnic Institute of Bragança) approved the research design (N.º P533182-R654085-D1985073). Written informed consent was obtained from all participants.

Consent for publication
Informed consent was obtained from all subjects.

Competing interests
The authors declare no competing interests.

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