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The physical activity of Spanish speleologists: accomplishment of recommendations and differences by sociodemographic variables

Miquel Pans ^{1,2*}, Laura Antón-González ¹, and Maite Pellicer-Chenoll ^{1,3}

¹Department of Physical and Sports Education. Universitat de València. c/Gascó Oliag, 3, 46010, València, Spain

²Societat Espeleològica de València, C/ del Túria, 46008 València, Spain

³Càtedra Dona i Esport. Universitat de València, c/Gascó Oliag, 3, 46010, Spain

Abstract: Outdoor adventure activities are becoming more popular due to their potential health benefits, although there is little scientific information on speleology as a physical activity (PA). The purpose of this study is to expand the scientific evidence in this field in two ways: (a) describe the PA performed by speleologists, taking into account the variables of interest such as gender, age, education, speleological level, participation in 'Alpine' explorations and body mass index (BMI) and (b) identify how far the World Health Organization's (WHO) PA recommendations were accomplished (i.e., 150 min of moderate-intensity aerobic PA or 75 min of vigorous-intensity aerobic). A cross-sectional study was conducted on 436 speleologists (305 men, 130 women). The participants completed an electronic survey on PA after which a descriptive analysis and cross-sectional pairwise comparisons (Mann-Whitney U and Kruskal-Wallis tests) were performed on the non-normal data. The mean metabolic equivalent (MET)-minutes/week was 4070.80 (± 3078.80) for total PA, 1937.65 (± 1992.39) for vigorous PA, 827.66 (± 1049.81) for moderate PA and 1304.87 (± 1031.65) for PA walking intensity. 73.4% of the participants met the PA recommendations. Nonparametric tests revealed differences by gender, age, educational level and speleological standard. Women, the middle group age, doctorate and vocational training students, and beginners were less active than their counterparts. The findings provide important contributions towards the positioning and understanding of speleology as a sport and physical activity practice.

Keywords: Spelunking, caving, exploration, exercise, public health

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INTRODUCTION

Outdoor adventure sports are currently experiencing an explosion in their popularity due to the benefits they offer. Regular contact with the natural environment is associated with mental and physical health benefits and wellbeing (Hartig et al., 2014). These activities have also become an antidote to the certainty of everyday life and offer today's citizens a multitude of experiences to provide meaning to their humdrum lives (Betrán & Betrán, 2016). The search for nature after the confinement of the pandemic (Tansil et al., 2022), or the fact that many adventure sports (e.g., hiking, rock climbing, river rafting and others) have become objects of tourist consumption could be one of the reasons for this phenomenon (Lu et al., 2022).

Speleology, the subject under study in this paper, represents a growing and diversified field of research, although with a lack of academic institutionalisation (Mattes, 2015). In the scientific literature on speleology,

hundreds of studies have focused on karst and the natural sciences (i.e., geology, biology and hydrology) and some on archaeology, palaeontology or geography (<https://digitalcommons.usf.edu/ijss/>). However, very few of these studies on speleology have been published in scientific databases (e.g. WOS, Scopus and Google Scholar) from the perspective of other scientific disciplines. In the latest studies on speleology as a physical nature-based outdoor activity, it has been shown that speleology is associated with spatial skills and orientation attitudes. Expert practitioners have greater mental rotation and perspective-taking abilities and less spatial anxiety than expert mountaineers (Muffato et al., 2022). Viviani and Tommaso (2017) analysed speleologists' body image and their degree of satisfaction or dissatisfaction with their bodies and was the first article that used the International Physical Activity Questionnaire (IPAQ) on a sample of speleologists. The results briefly describe the questionnaire and state that Italian

*miquel.pans@uv.es

speleologists are among the most active, 81.4% of the participants reported doing at least one day per week of vigorous physical activity. Mencarini et al. (2021) studied speleology as a human practice from a cultural perspective. Their most relevant conclusions were that the excitement of discovery and the unpredictability of an explorative trip are the strongest motivations for this sport. They also highlight the relevance of technological devices as a speleological support. A Spanish study also revealed that both male and female speleologists had significantly lower levels of state and trait anxiety than the general population (de la Torre-Cruz et al., 2021).

In the educational field, materials have been created to use speleology as an educational resource, although these materials are oriented towards teaching geology, geography, history and environmental sciences (De Waele, 2010). Regarding the field of physical education and its application to this discipline, studies can be found on caving classes for secondary schools, in which the authors propose progressing through a simulated cave and its difficulties in the high school gymnasium (Baena & Granero, 2009). A didactic unit has been published that offers one more resource to work on speleology within the different content blocks, both in primary and secondary education (Escaravajal-Rodríguez & Baena-Extremera, 2016). A progressively difficult intervention on speleology carried out in the higher education cycle (i.e., vocational training) has also been published (Fuentesal-García & Zamorano-Sande, 2020), while Cuenca (2022) has pointed out that by including this lesser-known sport in the school environment it can be used as a learning tool.

The definition of the subject matter of the study, Speleology (or Caving) as a physical activity in the natural environment has been defined as “sporting science”, “underground astronauts” or “citizen science” (Cant, 2006; Mattes, 2015; Mencarini et al., 2021) that studies the nature, the origin and formation of caves and everything related to them. As this study is approached from the physical activity (PA) and sports science perspective, we thus define this discipline as a PA and sport that takes place in a natural space and consists of exploring the route of an underground cavity, whether for scientific or recreational purposes, using specific physical skills. In terms of physical demands, as it has been studied in both its real environment and in the laboratory, it requires from its practitioners a motor commitment that is fundamentally aerobic in nature, although it also requires a certain percentage of anaerobic work (Balcells et al., 1986; Yzaguirre & Balcells, 1989).

Therefore, with the aim of expanding the scientific evidence in this field, the main objective of our study was to describe the PA performed by those who practice speleology, considering some variables of interest such as gender, age, education, speleological expertise, participation in ‘Alpine’ explorations and body mass index (BMI). To facilitate comparisons with those who practice other sports, we investigate the percentage of speleologists who accomplish the WHO’s PA health recommendations. These guide recommend that all adults should engage in regular PA, with a minimum of

between 150 min of moderate-intensity aerobic PA or 75 min of vigorous-intensity aerobic PA over the course of the week to obtain health benefits (WHO, 2020).

METHODS

Participants

The study involved 436 Speleologists (305 men, 105 women) aged 18 to 76 years ($M = 45.39$; $SD = 11.21$) with between 1 to 58 years’ experience ($M = 15.71$; $SD = 13.44$). The fieldwork was carried out between October 2022 and November 2022, prior to which all the procedures and materials followed the Ethics of the University of València Committee. Prospective participants were contacted through the Spanish speleologist associations, which emailed their associates with a link to an online survey (administered by LimeSurvey, Version 5.4.13+). Participants were also contacted by posts in social networks (e.g., Twitter and Facebook). To access the full survey the participants clicked on a box giving their informed consent containing the conditions of participation (e.g., confidentiality, anonymity, and the right to refuse or abandon). Prior to analysis, all the data were checked for anomalies, and we had an experimental death of 110 subjects due to failure to complete the survey correctly. Table 1 shows the sociodemographic characteristics of the sample, revealing that most of the participants were male (70%). Their speleological experience was distributed as follows: beginners (11.2%), intermediate (43.1%) and advanced (4.5%).

Instruments

A cross-sectional study was carried out using the sociodemographic and speleological data and the International Physical Activity Questionnaire-Short form (IPAQ).

Sociodemographic (gender, age, educational level, and BMI) and speleological variables (speleological level, and participation in ‘alpine’ speleology exploration) were assessed by a series of items. Age was divided into three categories using the 33 and 66 percentiles. Speleological level was determined by the participants’ responses to items pertaining to beginner, intermeddled and advanced. Weight and height were collected as perceived data for subsequent calculation of BMI: weight (kg)/height (cm²). The BMI cut-off values were those indicated by the WHO (World Health Organization, 2003). The participants were then grouped into four weight categories: underweight, normal range, overweight and obese.

Physical activity, overall and particular PA domains (i.e., vigorous PA, moderate PA, and walking intensity PA) were measured by the IPAQ (Craig et al., 2003). This questionnaire is a worldwide self-report instrument used to collect PA data (Craig et al., 2003), which asks for the time, in minutes the respondents spent on walking, moderate and vigorous PA in the last seven days of at least 10 minutes duration. In addition, when walking, moderate and vigorous PA exceeding 180 minutes was recoded to 180 minutes, as in the protocol. This instrument has been used previously in a speleological participants (Viviani & De Vivo, 2017).

The instrument includes all types of PA, not only PA during caving. The participants were also classified as “meet recommendations” when they reported at least

150 minutes of moderate or 75 minutes of vigorously intense aerobic PA/week, according to the WHO (World Health Organization, 2019).

Table 1. Sample characteristics and accomplishment of recommendations according to variables (N = 436).

Variable	N	% total	WHO PA recommendations	
			% meet	% not meet
Gender				
<i>Male</i>	305	70	73.1	26.9
<i>Female</i>	130	29.8	74.6	25.4
<i>Missing</i>	1	0.2		
Age				
18-35	86	19.7	81.4	18.6
36-46	150	34.4	69.3	30.7
>46	199	45.6	72.9	27.1
<i>Missing</i>	1	0.2		
Education				
<i>School certificate</i>	45	10.3	80	20
<i>Baccalaureate</i>	45	10.3	66.7	33.3
<i>Vocational training</i>	188	43.1	75.5	24.5
<i>University</i>	130	29.8	74.6	25.4
<i>PhD</i>	26	6	50	50
<i>Missing</i>	2	0.5		
Speleological Level				
<i>Beginner</i>	49	11.2	71.4	28.6
<i>Intermeddled</i>	188	43.1	69.7	30.3
<i>Advanced</i>	199	45.6	77.4	22.6
<i>Missing</i>	0	0		
'Alpine' speleological explorations				
<i>Yes</i>	160	36.7	71.9	28.1
<i>No</i>	276	63.3	74.3	25.7
<i>Missing</i>	0	0		
Body Mass Index				
<i>Underweight</i>	8	1.8	62.5	37.5
<i>Normal Range</i>	272	63.1	75.6	24.4
<i>Overweight</i>	139	31.9	70.5	29.5
<i>Obese</i>	14	3.2	64.3	35.7
<i>Missing</i>	0	0		

Statistical analyses

Statistical analyses were performed on SPSS Version 28.0 software (SPSS Inc.) with alpha set at $p < 0.05$, applying the Bonferroni correction when appropriate. As the Kolmogorov–Smirnov test showed a nonnormal distribution, descriptive statistics were expressed as medians and interquartile ranges (IQR). Mann–Whitney U and Kruskal–Wallis tests were used for cross-sectional inference.

RESULTS

Table 1 shows the sociodemographic characteristics of the sample and the accomplishment of the WHO's physical activity recommendations based on each

variable. Overall, 73.4% of the participants met the recommendation of 75 min/week of vigorous physical activity or 150 min/week of moderate physical activity, whereas 26.6% did not satisfy either of these recommendations.

Table 2 highlights the descriptive statistics of total physical activity as vigorous, moderate, and walking intensity for the whole sample in metabolic equivalent (MET)-minutes/week.

As visible in Table 3, the Mann-Whitney U tests revealed a statistically significant difference in moderate-to-vigorous physical activity (MVPA) as a function of gender. Males reported significantly higher MVPA than women ($z = -2.07$; $p < 0.038$). The Kruskal-Wallis tests, also shown, revealed

statistically significant differences in MVPA by age, studies and speleological level. Those in the middle age group (26-46 years) reported lower MVPA than the youngest group (18-25 years) ($z = 2.53$; $p < 0.034$). Those with a doctorate ($z = 3.06$; $p < 0.022$) and those with vocational training ($z = 2.95$; $p < 0.031$)

reported lower PA values than people with a secondary education only. Beginner speleologists reported significantly lower values than the intermeddled ($z = -2.54$; $p < 0.033$) and advanced ($z = -2.64$; $p < 0.025$). No statistical significance was found for participation in 'Alpine' speleological explorations or weight status.

Table 2. Descriptive statistics of physical activity (MET-minutes/week) (N = 436).

Physical activity domains	M	SD	Med	IQR
Total	4070.18	3078.80	3155	4040.75
Vigorous	1937.65	1992.39	1440	2460
Moderate	827.66	1049.81	480	1200
Walking	1304.87	1031.65	957	1584

Table 3. Differences of MVPA by variables of interest.

Variables of interest	N	Med	IQR	Mann-Whitney U / Kruskal-Wallis p-value
Gender				$p < 0.038^*$
Male	304	360	660	
Female	128	240	348.75	
Age				$p < 0.031^*$
Youngest group (18-25 years)	84	330	600	
Middle group (26-46 years)	149	240	465	
Oldest group (>46 years)	199	360	465	
Education				$p < 0.015^*$
School certificate	44	480	877	
Baccalaureate	45	360	515	
Vocational training	188	295	423.75	
University	129	300	710	
PhD	26	180	630	
Speleological Level				$p < 0.006^*$
Beginner	49	240	340	
Intermeddled	186	280	480	
Advanced	197	370	615	
'Alpine' speleology explorations				$p < 0.950$
Yes	156	300	592.5	
No	276	300	492.5	
Weight Status				$p < 0.316$
Underweight	8	405	830	
Normal range	271	300	570	
Overweight	139	300	480	
Obese	14	225	281	

*Indicates significant differences

DISCUSSION

As far as we know, this is the first study to measure PA and compliance with the WHO's PA recommendations by a group of variables such as gender, age, education level, BMI and speleological characteristics in Spanish cavers. The main finding of this study is that 73.4% of the participants met the WHO's recommendations. These results are not surprising as speleologists tend to be physically very active, mainly due to the amount of vigorous PA they

engage during their underground activities. This finding is in line with previous results obtained from a sample of Italian cavers (Viviani & De Vivo, Tommaso, 2017). Nevertheless, the results are far from the 86% compliance rate in a study involving 100 Portugues from a nature sport company in rafting activities (Faria et al., 2022), the 97% compliance rate in a study carried out with 66 Brazilian surfers (Bazanella et al., 2017), or the 100% of 170 Colombian hikers (Murillo et al., 2020). Nevertheless, our results are higher than ~40-50% recorded by university students in Croatia

and Spain (Pedisić et al., 2014, Práxedes et al., 2016). This could be attributed to the inherent curiosity and inquisitiveness of speleologists, often referred to as "underground astronauts" (Mencarini et al., 2021). Additionally, their engagement in speleology is closely linked to physically demanding activities, such as scaling mountains to access caves and chasms.

Regarding the cross-sectional PA comparisons, the results show differences by gender, age, studies and speleological level and that men performs more PA than women speleologists. These findings are in agreement with the results of the general population (Azevedo et al., 2007; Dagmar et al., 2011), with studies carried out on other outdoor sporting activities, and more specifically with the results found in Italian female speleologists (Viviani & De Vivo, 2017). Our results reproduce the 'gender gap' in the use and enjoyment of natural environments (Colley et al., 2022; Moscoso-Sánchez, 2008) and the same gap exists in almost every federated sport in Spain (Ministerio de Cultura y Deporte, 2021). It may be that despite the efforts made by governments and federations to promote speleology among women, these plans need to be reviewed. One of the reasons may be due to the lack of references, visibility, and coverage, as has been found in other sports (Brace-Govan, 2010). Another possible explanation is related to women's lower perception of competence in motor skills and technical issues, which could influence their lower practice of this sport, as speleology requires great self-confidence in one's technical skills and physical condition (Pesce et al., 2018). In addition, many studies have shown that women carry out lower levels of physical activity in general due to the family responsibilities that still today fall mainly on women (Ball et al., 2006).

Age-related disparities were observed as well, with speleologists in the 26-46 age range exhibiting lower levels of physical activity compared to the younger group. These findings align with existing literature on physical activity and sports participation, which indicates a decrease in engagement as individuals approach university entrance age (Cocca et al., 2014).

Significant differences were found in the speleological level of beginners and the other levels, as expected, since expert cavers practice on a more regular basis and are more likely to comply with the PA recommendations only through their sports practice. In addition, higher-level athletes usually have a better physical preparation, which allows them to achieve a higher performance or, in the case of speleology, to practice their sport with more confidence and better guarantees of success and progress.

Contrary to what is usually found in studies conducted on the general population (Shaw & Spokane, 2008), in our sample of speleologists, those with lower educational qualifications showed higher PA values than those with further studies. This may be due to the number of young cavers who answered our questionnaire and are the ones with the highest PA levels and who have not yet completed their higher education. Another possibility is simply that the sample of cavers behaves differently from the general population. Further research is needed to explore this PA aspect.

Interestingly, no differences in PA were found with respect to weight status or in having participated in 'Alpine' speleology. This could be because caving practitioners do not follow the typical body canons of sports or comply with the high recommendations of this population. Also, if we look more closely at the groups, we see that only 3.2% of the sample were classified as obese and 1.8% as underweight. Because 63.1% of the sample belongs to the normal weight range, the high compliance of this population with the recommendations is more in line with the possible cause. Nevertheless, further studies are needed to establish the causal relationships in this interesting area.

In terms of participation in 'Alpine' exploration, the findings indicate no discernible variation in behavioral patterns. It was anticipated that individuals engaged in extensive exploratory campaigns would exhibit significantly higher levels of PA. However, these differences might not be attributed to the strict adherence of this population to PA recommendations.

Lastly, the reader should note that the IPAQ and results under discussion considers all PA performed by cavers in their daily lives, and not only the PA performed inside the caves and chasms. Therefore, future studies should study in more detail only the PA performed by speleologist in the caves or speleodromes, following the lines of the studies carried out by Yzaguirre and Balcells (1989). And, it will be interesting taking into account the time inside the cave, the number of bags and weight carried, the vertical relief (metres of descent/ascent), and the possible environmental impact of this activity in such a vulnerable environment. Thus, this study has some potential limitations that warrant consideration. First, the biggest limitation in carrying out bibliographic searches in speleology is the lack of access to publications on the subject and the fact that many of them are not found in public scientific fields. Second, the non-normal distribution of the data required the use of non-parametric tests and prevented the implementation of more sophisticated analyses (Siegel, 1956). However, since this is the first correctional study to examine PA of Spanish speleologist, our results represent a relevant contribution. Finally, although the use of self-reported measures is not exempt from bias, the IPAQ has been used worldwide and allows national and international comparisons (Craig et al., 2003).

CONCLUSIONS

Speleology has been analysed from different perspectives, mainly dealing with the nature, origin and formation of caves. However, very few studies approach this discipline from the perspective of physical activity and sport. In this regard, the present study represents the first approach to physical activity domains in a large sample of Spanish speleologists.

The study led to the following two main conclusions: 1) people who practice speleology are a very active population, with a large number of the participants complying with the World Health Organization's

physical activity recommendations of more than 73% in both men and women (i.e., 150 min of moderate-intensity aerobic PA or 75 min of vigorous-intensity aerobic weekly). This is mainly due to their long practice of vigorous physical activity; 2) women, middle age group, doctorate and vocational training level of studies, and beginner speleologists were less active than their counterparts.

Our results situate speleology as a physical activity within various sports discipline that allows those who practice it to comply with the physical activity recommendations of the WHO. Promoting speleology, especially targeting some of the less active groups, will encourage its practice and, consequently, its benefits. Nevertheless, future plans for the promotion of speleology should be accompanied by awareness and protection of the natural environment.

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