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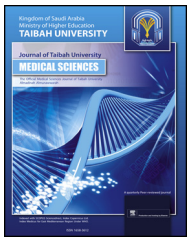

Original Article

Upper crossed syndrome in secondary school students: A mixed-method study

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الملخص

أهداف البحث: كان الهدف هو تحديد مدى انتشار متلازمة التقاطع العلوي والعوامل المرتبطة بها في المراهقين الإسبان.

طريقة البحث: استخدمت الدراسة تصميم طريقة مختلطة تفسيرية متسلسلة. تتألف المرحلة الكمية من دراسة مقطعية تم فيها قياس 45 طالبا باستخدام المسح التصويري وتقييمهم باستخدام استبانات "كيدو-كندل" و "فيزا-تيين". بعد ذلك ، تم إجراء العديد من الاجتماعات لمناقشة النتائج الكمية.

النتائج: أظهرت النتائج انتشارا بنسبة 37.8٪ لمتلازمة التقاطع العلوي، وانتشار 48.9٪ لوضع الرأس الأمامي وانتشار وضع الكتف الأمامي بنسبة 80٪. تم أخذ وضع الكتف الأمامي في الاعتبار عندما كانت الزاوية التي يمثلها تقاطع الخط بين نقطة المنتصف لعظم العضد والعملية الشائكة لـ"سي 7" أقل من 52 درجة. كان وضع الكتف الأمامي أعلى بشكل ملحوظ في الأولاد منه في الفتيات. عند الأولاد، كانت هناك ارتباطات معتدلة ملحوظة بين وضعية الكتف الأمامية ومؤشر كتلة الجسم وعادات النظافة، وبين وضعية الرأس الأمامية وأسوأ مع استخدام التكنولوجيا. أولئك الذين قدموا متلازمة التقاطع العلوي كان لديهم فروق ذات دلالة إحصائية فيما يتعلق بالأداء المدرسي. بعد تحليل النتائج النوعية، تم تحديد 33 رمزا و 5 فئات.

الاستنتاجات: يمكن أن ترتبط متلازمة التقاطع العلوي بعوامل مثل مؤشر كتلة الجسم والأداء المدرسي واستخدام التكنولوجيا والنشاط البدني. يتم إعطاء أهمية كبيرة للتمارين البدنية والوضعية الصحية للجلوس والوقوف في بيئة المراهقين.

الكلمات المفتاحية: وضعية التوازن؛ الوضعية؛ متلازمة التقاطع العلوي؛ وضعية الرأس الأمامية؛ وضعية الكتف إلى الأمام؛ مجموعات التركيز

Abstract

Objective: The study objectives were to identify the prevalence of upper crossed syndrome (UCS) and its associated factors in a population of Spanish adolescents, and to explore these associations through focus groups.

Methods: The study used a sequential explanatory mixed method design. The quantitative phase consisted of a cross-sectional study in which 45 students underwent photogrammetry measurements and evaluations with the Kiddo-KINDL and VISA-TEEN questionnaires. Subsequently, several focus groups were conducted to discuss the quantitative results.

Results: The results indicated a 37.8% prevalence of UCS, a 48.9% prevalence of forward head posture (FHP) and an 80% prevalence of forward shoulder posture (FSP). A positive FSP was indicated by an angle represented by the intersection of the line between the midpoint of the humerus and the spinous process of C7 of $<52°$. FSP was significantly higher in boys (mean [M] = 43.59, standard deviation [SD] = 6.9) than in girls (M = 47.98, SD = 6.33; $p < 0.05$). Boys showed significant moderate associations of FSP with body mass index (BMI) ($r = -0.48$, $p < 0.05$) and hygiene habits ($r = -0.46$, $p < 0.05$), and of FHP with worse use of technology ($r = 0.53$, $p < 0.05$). Those with UCS showed significant differences in school performance (M = 47.22, SD = 8.33, $p < 0.05$). Analysis of the qualitative results led to the identification of 33 codes and five categories.

Conclusions: UCS was associated with factors such as BMI, school performance, use of technology and physical activity. Correcting posture in adolescence was generally believed to

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be necessary. Physical exercise and postural health were considered highly important among adolescents.

Keywords: Focus groups; Forward head posture; Forward shoulder posture; Postural balance; Posture; Upper crossed syndrome

Introduction

Upper crossed syndrome (UCS) is defined as a problem involving an imbalance among muscle groups in the shoulder girdle and cervical spine.[1] These imbalances cause forward head posture (FHP) and forward shoulder posture (FSP), associated spinal changes and changes in shoulder girdle function.[2] These muscle groups are formed by the upper trapezius and pectoralis major and minor (the tonic musculature that tends to tighten and shorten), and the deep neck flexors and middle and lower trapezius (the phasic musculature that tends to weaken).[1] UCS has been studied by photogrammetry in both adolescents and children; approximately 65% of children and adolescents have been estimated to have forms of incorrect posture,[3] predominantly FSP and FHP.[4]

Previous studies have indicated that UCS in adolescents is associated with aspects such as physical exercise, depression and body mass index (BMI).[5] Other studies have found that carrying a backpack is a risk factor, because it may be associated with shoulder elevation and FHP regardless of how the backpack is worn.[6] Shoulder elevation increases as the load increases[7] and the physical ability decreases.[8] Incorrect posture during studying or in everyday situations,[9] indiscriminate use of smartphones,[10,11] stress and anxiety caused by mentally demanding work,[12] and a lack of self-esteem[13] have been observed to generate problems such as FHP and FSP. These problems are aggravated in the presence of overweight or obesity.[14]

The mixed-method design is a favourable approach in health and medical research, because most health-associated conditions are generated by and within a social context. Moreover, this approach enables assessment of the experience and understanding of the disease within a person's environment, identification of risk behaviours and discovery of perceptions regarding the causes of disease.[15] The aim of this research was to identify the prevalence of UCS and its associated factors through the use of photogrammetry and standardised questionnaires in a population of Spanish adolescents, and to explore these associations through focus groups.

Materials and methods

Study design

This study used mixed methods with a two-stage sequential explanatory design. In the quantitative portion, a cross-sectional study was performed with photogrammetry and two standardised tests. The qualitative portion consisted of a phenomenological study with focus groups, on the basis of the results obtained in the quantitative portion. The research was performed at a Spanish middle school from November 2021 to June 2022.

Quantitative methods

Participants

The sample size was 45 participants, on the basis of calculations with the GRAMNO calculator (Institut Municipal d'Investigació Mèdica, Barcelona, Spain) indicating that this sample size would be sufficient on the basis of a 90% confidence interval (10% precision). All participants met the following inclusion criteria: being a student at a middle school in Cornellà de Llobregat between 14 and 16 years old, being in good health at the time of the study and signing the informed consent form. Students with developmental disorders, neurological disorders, surgical interventions and/or previous spinal fractures were excluded from the study. After receiving verbal information regarding the nature of the study, the participants provided written informed consent. No participants were excluded from the study.

Data collection

Data were obtained by a physiotherapist specialising in postural issues. FHP and FSP were measured through a photogrammetry study with a camera and postural software. Two adolescent quality of life questionnaires were used to collect information on the other variables of backpack use, poor postural habits, physical exercise, BMI and overuse of technology.

Variables and instruments

A participant was considered to have UCS when both FHP and FSP were positive. Positive FHP was defined by a cervical angle formed at the intersection of the horizontal line passing through the spinous process of C7 and the tragus line of the ear of $<50°$. A positive FSP was defined by an angle represented by the intersection of the line between the midpoint of the humerus and the spinous process of C7 of $<52°$. Two standardised questionnaires validated in the Spanish population, Kiddo-KINDL[16] and VISA-TEEN,[17] were used to collect data regarding self-esteem, social relations, academic performance, BMI, physical activity, rational use of technology, postural habits and backpack weight data.

Procedures

The participants were examined only once. The same room was always used, so that the light, noise and heat conditions were the same for all participants. One at a time, participants stood on a mark on the floor in a normal position, gazing straight ahead. Before being photographed, visible marks were placed at the following anatomical points: tragus of the ear, canthus of the eye, spinous process of C7 and midpoint of the humerus. To ensure accurate positioning of the marks, the participants were asked to wear a tank top and to wear their hair up if they had long hair.[18]

A Canon PowerShot G15 camera was used to take photographs. The camera was placed 3 m in front of the mark on the ground used to position the participants. The camera was

supported by a Quick Media Pro extendable tripod with a built-in level, set 125 cm above the ground. Both the camera and the tripod were adjusted with a level. A Dexter self-stabilising laser level was attached to the tripod to mark the vertical and to rectify the position if necessary. To capture the most natural posture possible, before the photograph, we asked each participant to look straight ahead and walk to the same point five times. The photograph was taken after 5 s of walking.

The photographic analysis was performed with the Postural Assessment Software (PASS/SAPO) program, which determines the coordinates of the anatomical points of the photographs. The reference values were as follows: for a forward head, an angle of $<50^{\circ}$ formed by the lines joining the tragus, the spinous process of C7 and the horizontal; for forward shoulders, an angle of $<52^{\circ}$ formed by the line joining the acromial process and C7 and the horizontal.[19]

Questionnaires

All participants who were photographed responded to two validated questionnaires on adolescent quality of life: Kiddo-KINDL[16] and VISA-TEEN.[17] The Kiddo-KINDL questionnaire contains 24 questions in six dimensions: physical well-being, emotional well-being, self-esteem, family, friends and school. The questions are scored on a scale of 0−100, with a higher score indicating higher quality of life.[16] The VISA-TEEN questionnaire scores the components of BMI, physical activity, substance abuse, rational use of technology and hygiene on a scale from 0 to 5. Its total score ranges from 0 to 4517.

Data analysis

SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA) was used for the statistical analysis. Descriptive analysis was performed by calculation of frequencies for the demographic data. The relationships between UCS and the different variables were evaluated with Student's t-tests or chi-square tests. The relationship between FHP or FSP and the variables was evaluated with Pearson correlations and chi-square tests. The accepted level of significance was $p < 0.05$ (calculated on the basis of a 95% confidence interval).

Qualitative methods

The qualitative portion of the study was performed via focus groups comprising students, family members and teachers.

Participants

Theoretical sampling was performed in 26 selected participants who were contacted through the school's mailing list. They were divided into five focus groups: three groups of students, GFA1, GFA2 and GFA3, with five, seven and six participants, respectively; a group of family members, GFF, with three participants; and a group of teachers, GFP, with five participants. The small number of participants in each group gave the participants the opportunity to express themselves and provide different points of view (because larger or smaller numbers can have negative consequences on the quality of the data produced). Groups were formed until data saturation was reached.[15] After the details of this part of the study were explained to the participants, they provided written informed consent. No individuals refused to participate.

Data collection

The data were collected at a Spanish middle school until the saturation point was reached, in which participants' observations and/or sentiments coincided, thus resulting in redundancy or duplication of ideas.

Focus groups

Focus groups were conducted to outline the main motivations, analyse the results obtained in the qualitative portion, identify the main topics in the population and establish contextual interpretations to attempt to explain the different sentiments expressed. Each focus group was performed in the same room at the same school. The room was set up with a table and chairs arranged in a circle. A discussion was held with each group for 1.5 h, according to a pre-established script. The scripts for each focus group were generated on the basis of the results of the quantitative portion of the research and the participants' backgrounds. The first author (LD) conducted the focus groups.

Data recording

Each discussion session was recorded with a voice recorder, and notes were taken in a notebook. Immediately after, the recordings were transcribed verbatim into a word processor. The transcriptions and notes were coded, and the data were stored in files created for this purpose.

Data analysis

Atlas.ti software was used to analyse the qualitative data. In the first stage of open coding, the data were fragmented into small units, each of which was assigned a descriptor or code. During the second stage of axial coding, the codes were grouped into categories. Finally, in the third stage of selective coding, codes were developed to provide the content of each cluster. In this way, we were able to assess both the overall saturation and the saturation across the particular clusters.

Validity and reliability

The description of the project's mixed methods was developed on the basis of the recommendations of the Good Reporting of a Mixed Methods Study (GRAMMS) statement.[20] The Consolidated Criteria for Reporting Qualitative Research[21] were also considered to report the qualitative methods and the STROBE observational study methods.

Results

Quantitative results

A total of 45 participants were analysed, comprising 27 boys and 18 girls. The characteristics of the sample and the prevalence of UCS, FHP and FSP are presented in Table 1.

Student's t-test was used to evaluate the associations between UCS and the quantitative variables. The results are shown in Table 2. The BMI was higher in the group with than without UCS. Analysis of the groups according to sex indicated that boys had a significantly higher prevalence of FSP than girls (Table 2).

Table 1: Demographic data of the sample.

		Frequency	%	Median	St. deviation
Sex	Male	27	60.0		
	Female	18	40.0		
Manual dominance	Right	42	93.3		
	Left	3	6.7		
UCS	Yes	17	37.8		
	No	28	62.2		
	FHP or FSP	24	53.3		
	Normal	4	8.9		
FHP	Yes	22	48.9	49.73	5.60
	No	23	51.1		
FSP	Yes	36	80.0	45.34	6.96
	No	9	20.0		
Kiddo-KINDL				64.03	11.08
VISA-TEEN				36.8	3.829

% = percentage; UCS = upper crossed syndrome; FHP = forward head posture; FSP = forward shoulder posture.

Table 2: Student's t-test analysis between UCS and variables.

	UCS	N	Mean	Standard deviation	p-value	CI 95%	
						Lower	Upper
BMI	Yes	17	22.80	3.89	0.017	.45	4.32
	No	28	20.42	2.55			
School backpack weight feeling	Yes	17	5.59	1.91	0.261	−1.8	.51
	No	28	6.25	1.88			
Correct posture when sitting feeling	Yes	17	4.59	1.80	0.051	−2.0	0.004
	No	28	5.57	1.45			
Comfortable standing feeling	Yes	17	4.82	2.65	0.051	−0.007	3.01
	No	28	3.32	2.29			
Physical well-being	Yes	17	64.2157	10.10	0.931	−6.65	7.25
	No	28	63.9137	11.82			
Emotional well-being	Yes	17	69.1176	19.57	0.705	−9.22	13.53
	No	28	66.9643	17.58			
Self-esteem	Yes	17	55.8824	18.94	0.350	−16.5	5.99
	No	28	61.1607	17.70			
Family relations	Yes	17	78.6765	9.39	0.521	−6.37	12.39
	No	28	75.6696	21.40			
Social relations	Yes	17	72.7941	15.77	0.468	−13.30	6.21
	No	28	76.3393	15.71			
School performance	Yes	17	44.4853	8.81	0.092	−1.14	14.66
	No	28	37.7232	14.58			
Kiddo-KINDL	Yes	17	64.2157	10.10	0.931	−6.65	7.25
	No	28	63.9137	11.82			
Eating habits	Yes	17	2.1171	0.28	0.73	−.16	.23
	No	28	2.0829	0.35			
Rational use of technology	Yes	17	1.7453	0.65	0.17	−.62	.11
	No	28	1.9993	0.55			
Toxic habits	Yes	17	3.0000	0.00	0.065	−.013	.42
	No	28	2.7946	0.56			
Hygiene habits	Yes	17	2.5294	0.51	0.871	−.32	.27
	No	28	2.5536	0.46			
Physical activity	Yes	17	2.8035	0.33	0.475	−.18243	.38
	No	28	2.7021	0.52			
VISA-TEEN	Yes	17	37.0588	2.68	0.728	−1.98	2.81
	No	28	36.6429	4.42			

Therefore, the same statistical analysis was performed on participants according to sex (Table 3). The results indicated that boys with UCS had better school performance (Table 4).

A correlation between each quantitative variable and the FHP and FSP angles was observed when the groups were separated by sex (Table 5). Boys with FHP showed worse use of technology, and boys with FSP had higher BMI and better

Table 3: Comparison between males and females.

	Sex	N	Mean	Standard deviation	p-value	CI 95%		Cohen's d
						Lower	Upper	
FHP	Male	27	50.0296	5.55	.672	−2.78	4.26	0.13
	Female	18	49.2889	5.79				
FSP	Male	27	43.5852	6.91	.037	−8.50	−0.29	−0.66
	Female	18	47.9778	6.34				

Table 4: Student's t-test analysis between UCS and variables. separated by sex.

	UCS	N	Male					Female					
			Mean	SD	P	IC 95%		N	Mean	SD	P	IC 95%	
						Lower	Upper					Lower	Upper
BMI	Yes	9	22.44	2.94	.258	−1.04	3.73	8	23.21	4.94	.057	−.15	8.19
	No	18	21.10	2.79				10	19.19	1.48			
School backpack	Yes	9	4.89	2.20	.220	−2.93	.707	8	6.38	1.19	0.583	−1.56	.91
weight feeling	No	18	6.00	2.14				10	6.70	1.25			
Correct posture	Yes	9	4.56	1.50	.130	−2.1	.300	8	4.63	2.20	0.235	−2.92	.77
when sitting feeling	No	18	5.50	1.46				10	5.70	1.49			
Comfortable	Yes	9	4.56	3.12	.218	−0.85	3.50	8	5.13	2.17	0.157	−.70	3.95
standing feeling	No	18	3.22	2.29				10	3.50	2.41			
Kiddo-KINDL	Yes	9	69.33	7.64	.415	−5.42	12.71	8	58.46	9.76	0.662	−13.05	8.52
	No	18	65.68	11.98				10	60.73	11.42			
Physical well-being	Yes	9	69.33	7.64	.415	−5.42	12.71	8	58.46	9.76	0.662	−13.05	8.52
	No	18	65.68	11.98				10	60.73	11.42			
Emotional well-being	Yes	9	74.31	17.24	0.372	−8.78	22.67	8	63.28	21.51	0.73	−21.11	15.17
	No	18	67.36	19.36				10	66.25	14.79			
Self-esteem	Yes	9	63.19	16.07	0.925	−15.70	14.32	8	47.66	19.46	0.31	−26.08	8.89
	No	18	63.89	18.63				10	56.25	15.59			
Family relations	Yes	9	81.25	8.84	1.000	−10.56	10.56	8	75.78	9.70	0.25	−8.27	28.58
	No	18	81.25	17.81				10	65.62	24.51			
Social relations	Yes	9	77.78	16.27	0.692	−11.48	17.04	8	67.19	14.07	0.09	−25.07	1.94
	No	18	75.00	17.28				10	78.75	12.91			
School performance	Yes	9	47.22	8.33	0.04	0.27	20.57	8	41.41	8.80	0.62	−6.57	10.63
	No	18	36.81	17.27				10	39.37	8.36			
VISA-TEEN	Yes	9	36.67	2.60	0.82	−3.92	3.13	8	37.50	2.88	0.35	−1.89	5.09
	No	18	37.06	4.76				10	35.90	3.87			
Eating habits	Yes	9	2.00	.233	0.66	−0.30	.20	8	2.25	0.29	0.50	−.24	.47
	No	18	2.05	.327				10	2.13	0.39			
Rational use	Yes	9	1.67	.745	0.09	−0.95	.07	8	1.83	0.56	0.89	−.52	.59
of technology	No	18	2.11	.537				10	1.80	0.55			
Toxic habits	Yes	9	3.00	.00	0.11	−0.048	.44	8	3.00	0.00	0.39	−.31	.76
	No	18	2.81	.49				10	2.77	0.71			
Hygiene habits	Yes	9	2.50	.43	0.76	−0.42	.32	8	2.56	0.62	0.96	−.55	.57
	No	18	2.56	.45				10	2.55	0.50			
Physical activity	Yes	9	2.89	.24	0.38	−0.19	.49	8	2.71	0.42	0.77	−.47	.62
	No	18	2.74	.47				10	2.63	0.62			

hygiene habits. Girls with FSP said that they performed more physical activity.

Qualitative results

The coding process yielded 33 codes, which were analysed and distributed into five categories. Next, the categories and codes that emerged in the analysis of the discourse with the focus groups were determined. Each code is shown together with the percentage of the code's presence in the discourse. Table 6 shows several representative quotations for each code.

Aspects of posture

The adolescents were aware of the high **prevalence of UCS** (2.03%). In general, the high prevalence of FSP among the analysed students was unexpected. Their family members and teachers had general sentiments that **inappropriate postures are adopted** (8.24%). However, pupils believed that they could not avoid these postures, and they felt uncomfortable correcting them.

Families and teachers indicated a relationship between UCS and **personality and/or character** (0.68%), on the basis of emotions such as shame, shyness or depressive aspects.

Table 5: Correlations among FHP, FSP, and variables by sex.

	Male n = 27				Female N = 18			
	FHP		FSP		FHP		FSP	
	Correlation	p	Correlation	p	Correlation	p	Correlation	P
BMI	−.20	0.31	−0.47	0.011	−0.21	0.39	−.29	.244
School backpack weight feeling	0.11	0.58	−0.06	0.74	0.23	0.35	0.31	0.22
Correct posture when sitting feeling	0.03	0.89	0.32	0.10	0.37	0.13	0.30	0.23
Comfortable standing feeling	−0.01	0.97	−0.13	0.52	0.010	0.97	−0.42	0.08
Kiddo-KINDL	−0.13	0.52	−0.05	0.80	−0.15	0.55	0.07	0.77
- Physical well-being	−0.13	0.52	−0.05	0.80	−0.15	0.55	0.07	0.77
- Emotional well-being	−0.15	0.46	0.13	0.52	−0.17	0.50	−0.15	0.55
- Self-esteem	−0.11	0.59	−0.075	0.71	0.049	0.85	−0.02	0.94
- Family relations	0.09	0.65	−0.18	0.36	−0.26	0.29	0.16	0.52
- Social relations	−0.08	0.70	0.11	0.59	0.13	0.59	0.09	0.73
- School performance	−0.19	0.35	−0.27	0.17	−0.34	0.16	−0.23	0.35
VISA-TEEN	0.07	0.73	−0.23	0.25	−0.38	0.12	0.07	0.77
- Eating habits	−0.10	0.63	0.19	0.35	−0.15	0.55	0.22	0.38
- Rational use of technology	0.52	0.004	−0.23	0.25	−0.20	0.44	−0.02	0.93
- Toxic habits	−0.29	0.14	−0.02	0.93	−0.31	0.20	0.30	0.22
- Hygiene habits	0.13	0.53	−0.45	0.02	−0.03	0.92	0.14	0.58
- Physical activity	−0.24	0.22	−0.203	0.31	−0.09	0.71	−0.47	0.052

They also believed that it could generate different **musculoskeletal disorders** (1.76%), such as limitations in movement of the limbs and spine and muscle shortening. This belief led to family members and teachers encouraging the adolescents to **try to rectify UCS by standing up straight** (2.70%). However, respondents also indicated a belief that FHP and/or FSP might be part of the **individual's own posture** (0.88%).

Associated factors

The respondents emphasised **physical exercise** (10.68%) as necessary and beneficial for good postural health. Considerable importance was also ascribed to **sitting** (6.42%) was also. The participants believed that adolescents spend many hours sitting and in a poor posture. An associated issue was a **sedentary lifestyle** (3.38%), which was a concern indicated in all discussion groups: the respondents believed that spending so many hours at school and then at home studying, and the small amount of sport participation, led the adolescents to adopt a sedentary lifestyle. However, the adolescents felt that this lifestyle is **difficult to avoid** (3.78%), because they must comply with timetables and homework. Moreover, during the school day, they have no ability to move around. The participants believed that the **rational use of technology** (6.15%) could contribute to UCS—a concerning prospect.

The participants discussed a strong relationship between UCS and **academic performance** (2.30%): they believed that studying makes one adopt poor positions, and that UCS is also associated with the stress of studying. Regarding **mental health** (1.89%), the participants mentioned stress, anxiety and mental exhaustion.

The finding that the **use of school bags** (4.66%) was not associated with UCS generated different points of view: some students believed that school bags had an influence, whereas others believed that school bags did not have an influence. Adults indicated concerns among families, whereas teachers did not perceive school bags as a negative factor.

External factors

Comments were made about **furniture** (2.91%), both at school and at home. The participants believed that furniture comfort and size influence adolescents' back health.

The participants believed that the **society** in which they live and **the way of life** (0.88%) of adolescents and the **educational system** (0.68%) keep adolescents from being able to move around. They also believed that adolescents spend most of their **leisure and free time** (1.08%) performing sedentary activities. The students indicated that they are **influenced by their environment** (3.65%), mainly by their families, as well as other areas, in terms of maintaining good postural hygiene; their families and teachers agreed.

Regarding **confinement due to COVID-19** (1.35%), students believed that the pandemic might have strongly influenced their postural attitude. In contrast, family members and teachers did not believe that this confinement played a role in this aspect. We obtained comments regarding various **media, including social networks and TV** (1.01%), including TikTok and YouTube, in which adolescents have seen content related to postural health; this finding generated surprise among adults.

Problems, concerns and needs

The participants discussed how UCS, FHP or FSP may cause **pain and pathology** (5.95%) in adolescents. They believed that spinal deformities and muscle or joint pain can coexist. Therefore, the respondents expressed widespread concern that UCS might affect adolescent **growth and physical development** (1.42%). In contrast, both students and family members agreed that **insufficient importance** (0.81%) is placed on postural health. Family members and teachers indicated a belief that **adolescents lack knowledge** (1.55%) and are unaware of this.

Adolescents believed that UCS, FHP or FSP generates a negative **external posture appearance** (2.36%). This sentiment was unknown to both family members and teachers, who believed that adolescents look good with UCS, FHP or FSP.

Table 6: Representative quotations for each code.

No.	Code	Verbatim transcription
1	Prevalence of UCS	*"I think half or more […] have problems with posture. They are always with their shoulders forward."* GFA1 *"I don't know, I was struck by what I saw as …. That there was a very high percentage of … about 80%."* GFA2 *"Yes, I am surprised that there is this difference between 40%, almost 50 with the head forward and 80% of shoulders forward. I thought it was kind of more related, that it's the whole-body attitude that pulls forward both head and shoulders."* GFP
2	Adopting inappropriate postures	*"I see it in my oldest son. […] Sometimes we say it to him. […] It's just that he goes, sometimes he gets up and walks a bit turned to one side."* GFF *"Yes, because I … I don't know if I'm the only one, but I, it's hard for me to stand up straight. It's like I'm more easily able to stand like that [hunched forward] than to stand like that [upright]."* GFA1
3	Personality and character	*"Well, I think it's partly embarrassment because she's a girl; when she gets breasts, then they curve."* GFF *"I also think a little bit, the shyness of some people. I think that it could also be that maybe your own shyness makes your body itself … make you … put it like that." GFF* *"I don't know, it seems that, if you pull yourself forward, you're like more depressed in your soul, dulled."* GFP
4	Musculoskeletal disorders	*"And in the long run, at a functional level, the shoulder joint can be limited if you have your shoulders forward. […] Therefore, I think more about the limitation that the syndrome generates at the range of motion."* GFP *"Then you lose muscle mass, and it is not only in the back but in general in the whole body."* GFA1
5	Trying to rectify upper crossed syndrome by standing up straight	*"I correct postures. I say: hey, stand up straighter. […] Support your back well. I say it many times: don't slouch, or you'll get it later. […] But I correct them, and I'm doing it all day long."* GFP *"When someone tells us, 'Put your back straight', we stand up straight, and it starts to hurt us because we're not used to it."* GFA1
6	Individual's own posture	*"For each person, standing up straight is different. Because not everyone has the same back."* GFA2 *"I think that in the end, it's also what I've told you: that it goes in each person […] morphology, a bit like your body."* GFF *"Nowadays, for an adolescent to have his shoulders forward, if he doesn't have any pathology, well, that's good. […] I don't mind having my back forward […] beyond aesthetics."* GFP
7	Physical exercise	*"Exercise helps to prevent you from having bad posture."* GFA1 *"It accentuates the problem if it is not a specific physical activity to correct backwards. If you don't do specific work to correct yourself, any exercise you do will accentuate the problem."* GFP
8	Sitting	*"Sitting for so long tires your back, and then when you get up, you don't feel well."* GFA3 *"Our children spend a lot of time sitting and a lot of time studying rather than doing physical activity or sport. A day is maybe up to 16 h sitting […] and two doing sport."* GFP
9	Sedentary lifestyle	*"A long time without moving, without doing anything else, […] even if it's not sitting, […] they spend many hours in the same position and doing the same thing."* GFF *"And those who don't do any sport even more so. Because those who don't do sport, the hobbies they have […] are all with screens."* GFP
10	Difficulties in avoiding a sedentary lifestyle	*"There are times when it can't be avoided. Here we have to come and stay for 7 h. It's obligatory, […] and sometimes one teacher comes in, and the other is still in the class, and you don't have time to get up."* GFA1 *"It would be good to have activities that can be done outside: you are no longer seated in the same way, you have to go down stairs, but then you get to the playground, and you have no space, or there is a lot of noise, or they are doing gymnastics. Really, if we had more outdoor spaces, we could do many more activities in different situations and with more movement."* GFP *"I am aware that we make the children sit for 6 h a day in the worst case, 5 in the best case."* GFP
11	Rational use of technology	*"They have had a computer since sixth grade, they work long hours; now in middle school, they work practically with the computer, […] and they also spend long hours with their mobile phones, […] and they are enraptured with their mobile phones. They stay in the same posture for a long time."* GFF *"The more hours you stay, the worse posture you have while using the mobile phone, so you also have a worse posture."* GFA2
12	Academic performance	*"Yes, by studying more and spending more time like this [makes the gesture of slouching at the table], with the computer and everything, and doing homework and writing."* GFA1 *"When they have exams, when they get very nervous, it affects them more. […] They are a bit tense."* GFF
13	Mental health	*"If you're in class for so long, and there comes a point when your head is going to explode, well, I just get in any way because … my head can't take it anymore. So many hours."* GFA2 *"When they have exams or homework, she gets nervous and thinks that she won't have time. […] So there are days when she has a lot of homework, and she decides not to go to the gym."* GFF

14	Use of a backpack	*"I don't think it doesn't matter how you carry the backpack. If you carry it with only one handle, you put the weight only on one shoulder and put it forward."* GFA1 *"The reason could also be the backpack … and several people have already told me this, because it's not just that they carry a lot of weight, they carry a lot of weight, it's the way they put it on. Because they hang it too down. And then that has repercussions."* GFF *"I don't see it. Because they don't carry it for so long either."* GFP
15	Furniture	*"For example, the … where you rest your back, there are people who are taller and it is uncomfortable, and others who are smaller and are not comfortable."* GFA2 *"Our kids in* 4th *grade are using the same table as very young children in* 1st *grade. The same table and the same chair. There are children who lift the table with their knees."* GFP
16	Educational system	*"The way the institute is made is wrong. The school is wrong. The study itself is wrong. If you don't do a degree in sport, you're not going to get out of the school. It's that sitting for 8 h … I can't sit for 8 h listening to someone, taking notes and writing. I can't. I need to get out."* GFA3 *"To do a postural education class, right? The schools […] to give them some guidelines on how to sit and avoid all this, […] but I think that, from the school, apart from us, from the school too."* GFF *"But today we have a somewhat pigeonholed timetable structure that makes it difficult. And we have a population that is demanding, because they really need movement within the classroom space; these 5–10-min breaks that they ask for movement within the classroom, they can't do it."* GFP
17	Influence of the environment	*"I've had this problem of carrying my shoulders forward for a long time. Yes, that's what my father tells me. He says, 'Stick out your chest'."* GFA3 "*I sometimes tell him, 'H, in the end you're going to end up like grandma'."* GFF *"Well, sometimes I tell him that. I remind him that it will hurt later."* GFF
18	Leisure and free time	*"When they get home, they have to continue with their homework. Most days, they have work or exams; they don't have much free time to say, 'Well, today we're going to play a game or we're going to … '. So they get into the dynamic that they don't go out much. When they do have time, they don't even remember. Because they have little time."* GFF *"But of course, it's very difficult because mobiles and games attract their attention, so they don't spend all their time outdoors, playing sports."* GFF *"Now the leisure time is more about activities with a screen or sitting down or …"* GFP
19	Media: social networks and TV	*"I got a TikTok that said that you had to put your chin in [makes the gesture], and you had to do exercises like that."* GFA3 *"You see a lot of things, and they allow themselves to be influenced by this. I already tell mine, don't believe everything you see there, because there will be people who are really specialized and know how to do it […] and there are people who talk for the sake of talking, and it's not even their specialty, nor is it true what they are saying. Don't believe everything there."* GFF
20	Society and way of life	*"I think that society is set up in such a way that, depending on what they do, they are also going to be in bad positions. So …"* GFF *"I think it also depends a lot, I think, on the society we live in. Here in Cornellà, you go here to play, and where do you go? Nowhere can you use a ball. It's forbidden everywhere. […] I don't know if this study was done on children who live in the countryside, if it would have the same …"* GFP
21	Confinement because of the COVID-19 pandemic	*"Yes, as it was about three months, it was every day at home. So, whatever you did, with the computer, or I don't know, you were always a bit like that [slouches], and so many hours also accumulate."* GFA2 *"I mean, it hasn't benefited them either, because it's true that they're even more so with technology, isn't it? But the problem comes from before."* GFF *"We do perceive that now, in the interviews we have had with the families, that the children who used to do physical activity and who have stopped because of the confinement are now finding it very difficult to resume their activity."* GFP
22	Pain and pathology	*"Due to the bad posture of being in the same posture all the time and so on, the spine ends up in a posture that it shouldn't be in, and this can cause more problems in the long run."* GFA1 *"Maybe over time, it can harm them in some ailment, or cause them something like pain or hernias."* GFF
23	Growth and physical development	*"In the future, yes [it worries me]. When we are older, we will have problems with our back."* GFA1 *"The worrying thing would be that this would lead to problems later on. […] The adolescent is still developing, and his body is not yet fully formed."* GFF

(*continued on next page*)

Table 6 (*continued*)

No.	Code	Verbatim transcription
24	Not given importance	*"Do teachers think, 'My students are sitting for 6 h?' Do teachers think about that? No!"* GFA3 *"They don't think about it. They are young. They don't think about 'I'm going to be in pain in a few years'."* GFF
25	Knowledge of the adolescent	*"I think they do it unconsciously, because sometimes I see my daughter sitting doing her homework, and she has her leg like this on top of her. For example, on the chair sometimes. And I say … and of course maybe she is comfortable."* GFF *"I don't think they are aware. […] You mean the students were already aware of this problem before you came to do this study? Well, I didn't expect that."* GFP
26	External appearance of posture	*"It's just that, look at the way I am: shoulders forward. I'm already hunchbacked. […] It's really not very aesthetic […] yes! It's better to see a straight person, there, with their chest out than with their shoulders forward."* GFA3 *"Then the typical postures, because in adolescence it's 'cooler' to be badly positioned. […] For them, the slouchy posture, to stand in any way, attracts them more than being … more serious, more elegant, more formal … that doesn't attract them."* GFF
27	Need to improve body posture	*"It is a problem that we have to try to avoid from the beginning, […] so we have to try to correct it."* GFA1 *"[Talking about correcting posture] Man, let's see, if it's going to have repercussions, it's going to cause a problem, yes, […] but if it's for aesthetics, well, in the end aesthetics is up to each individual."* GFF *"I think that, in this problem, there is no doubt that if we improve the postural health of the students, it will have repercussions on their health as a whole. Not only in the shoulders and the head."* GFP
28	Proposals to improve posture	*"We should do standing classes and sitting classes. You could change your posture; you could correct it. If you are sitting differently than standing, you can't stop … balance a bit."* GFA3 *"The subject of technology at home. It is also a task for parents."* GFF *"Well, maybe it wouldn't be so complicated to put some bars in the playground where they could hang."* GFP
29	Postural education	*"To have a posture education class in schools. They should be given guidelines on how to sit and avoid this."* GFF *"One solution would be to raise awareness. Raise awareness of the importance of postural health. […] If this is extended, the importance of the fact of movement, the fact of correct postural habits … to raise awareness in the end."* GFP
30	Ideas to avoid sedentary lifestyles	*"What I would like to do would be that when we have a subject on plants or whatever it is in nature, instead of staying in class, we go to the forest or the mountains to see it. That way, we go out and walk around. And at the same time, we study."* GFA1 *"Active breaks. This is a concept that does appear in some schools. Active breaks would be the space between two classes to promote a type of movement activity. This is sometimes done by projecting a movement video on the digital blackboard, or …"* GFP
31	Orthoses	*"[…] And I took one of these compressor T-shirts that corrects the posture. But it bothered me a lot, and I don't wear it. No. […] My father used to say to me, 'You wear it while you're playing the play and you're sitting down'. I wore it, which was … two days, three, for an hour. I didn't wear it much because it bothered me, and I was sitting, and it was uncomfortable."* GFA3 *"And is there something … are there corsets or something to correct? Because sometimes my son has told me, 'Mum you have to buy me a … '"* GFF
32	Manual therapy	*"In the end, the physiotherapist is not magic. That is to say, it also has to be the person him/herself who makes the effort to progressively. … I don't think it is quick at all to have a good posture."* GFA1 *"[Talking about changing posture] No, I don't think it doesn't change her. I don't think it doesn't change her. Yes, it helps him to be more relaxed, more … but it would have to be something very constant. I don't know … if at a postural level it would change a lot. I think that with gymnastics."* GFF
33	Therapeutic exercise	*"Let's see, sometimes I do it. … The more strength you have in your back the more, the more … the more power it has over your posture, right?"* GFA3 *"[Talking about therapeutic exercise] Man, I think it would work, I understand. […] It is difficult to find half an hour to do the activities. And although this would be a solution, it is difficult for adolescents to do the exercises. One option would be for it to be in a group […] with groups of their age, more dynamic or more fun activities."* GFP

In general, the participants believed that a **need exists to improve body posture** (2.64%) to avoid these problems that are thought to occur.

Proposals and solutions

During the debates, the participants provided several **proposals for improving posture** (1.76%) associated with some of the aforementioned topics, particularly sedentary lifestyles, furniture and adopting inappropriate postures. Among these proposals, **postural education** (1.15%) was notable. **Other ideas to avoid sedentary lifestyles** (5.41%) were based on movement. The participants mentioned the use of posture-correcting **orthoses** (3.38%)—tools that were known among the adolescents, partly through social networks, but little known among the adults. Among the participants, the **manual therapy** (3.24%) was known as a passive treatment strategy for pain and posture. However, more importance was placed on **therapeutic exercise** (3.24%), which was the most widely considered tool.

Discussion

The first part of this discussion focusses on the quantitative results. Adolescents with high BMI were more likely to present UCS. When the groups were separated by sex, we observed significant correlations between FHP and worse use of technology, and between FSP and better hygiene habits and higher academic performance, in boys. The implications of the qualitative portion of this study are discussed later in this section. These findings contribute to understanding of the beliefs, fears and concerns of the participants.

Several studies have evaluated the prevalence of incorrect posture in adults, as well as in children and adolescents.[3,6,14,22–24] The prevalence of poor posture in this study differed from those found in other studies. Whereas Yang et al.[3] have reported a higher prevalence of poor posture (65%), Mujawar and Sagar[24] have reported a lower prevalence (28%). These differences might be due to differences in the ages and situations among participants. Specifically, Mujawar and Sagar[24] evaluated an adult population of laundry workers, whereas Yang et al.[3] studied a school-age population. Hence, the context of the participants in studies should be considered; notably, before the this study was conducted, the students had been confined to their homes because of the COVID-19 pandemic.[25] The need to use technology to attend classes virtually might affect different aspects of posture.[26]

The prevalence of FSP (80%) and FHP (48.9%) in this study is in line with that reported by Batistão et al.,[6] who have found a higher prevalence of FSP (74.3%) than FHP (53.5%). They have also observed higher prevalence of FSP in the age group between 13 and 15 years than in other age groups between 10 and 13 years. Yang et al.[3] have also reported higher prevalence of FSP in students 10–15 years of age (64.8%), and those older than 15 (71.1%) years of age than in those younger than 10 years of age. The prevalence of FHP in this study was consistent with the results reported by Kalichman et al.,[23] who have observed a prevalence of 48.8%.

BMI was significantly higher in the group with UCS and was moderately correlated with UCS in boys. These results differ from those reported by Batistão et al.,[6] who have observed a significantly lower BMI in participants with than without FHP. Maciałczyk-Paprocka et al.[14] have reported a higher prevalence of postural defects in overweight or obese children than in children with a normal weight. However, on the basis of their meta-analysis, Molina-Garcia et al.[27] have argued that no association exists between overweight or obesity and FHP, although associations do exist with FSP. The use of only BMI to classify obesity masks differences in body composition in individuals and does not consider physical activity status.[28]

In agreement with the results obtained by Batistão et al.,[6] we observed significant sex differences, wherein boys showed a higher FSP prevalence than girls. The strength of the shoulder musculature is greater in men than in women, and is even greater in young people.[29] However, the FSP prevalence in this study differs from that reported by Yang et al.,[3] who have found a higher prevalence in girls than in boys. This sex difference might be because girls have been reported to have poorer body self-perception, lower physical self-confidence and lower overall physical fitness than boys.[30]

When the sample was separated by sex, boys with UCS had higher school performance dimension scores. Kalichman et al.[23] have observed similar results for FHP, and have found no significant differences during the school year versus during examination periods. These findings suggest that UCS does not depend on the time of study.

In the group of boys, we observed a significant correlation between FHP and the use of technology. Guan et al.[31,32] have observed that males tend to keep the cervical spine more flexed than females when manipulating mobile devices. This factor might facilitate the onset of FHP in boys. In contrast, Alonazi et al.[33] have observed significant differences in cervical angles between adolescents with than without addiction to smartphones: those who are addicted show greater FHP. Moon et al.[11] have reported similar results, including a significant correlation between greater smartphone use and higher upper trapezius tone. According to Vahedi et al.,[34] this significant increase in FHP occurs during sitting and standing, and in tasks such as writing, looking or reading.

FSP showed a significant correlation with the hygiene habit dimension in boys: those with higher FSP had better hygiene habits. No other published studies have described this relationship. These results might have been conditioned by the COVID-19 pandemic, which has forced the population to increase their hygiene habits, particularly hand washing.[35]

In the group of girls with FSP, we observed a positive but non-significant correlation with increased physical activity, a finding consistent with those of Babagoltabar and Norasteh[22] indicating that FHP and FSP significantly increase as physical activity increases.

Most adolescents believed that they have back problems such as UCS or FSP. Even so, according to the focus groups, the prevalence of FSP was not expected by the adolescents themselves, or their families and teachers, although some participants considered that forward shoulders or a forward head might be specific to the individual. We observed a widespread belief that inappropriate postures are adopted, thus resulting in attempts to correct these postures.

Encouraging adolescents to stand up straight makes them uncomfortable. In fact, they verbalised that they find both maintaining these "correct" postures and avoiding "incorrect" postures difficult. The need to correct posture is not supported by the literature: to date, improper posture has not yet been demonstrated to lead to long-term problems.[36,37] In fact, the perception of what is considered, or not considered, poor posture, and the need to correct posture, varies among individuals.[38]

Importance was placed not only on how one sits but on the amount of time spent sitting. The focus group participants believed that the number of hours students spent studying at school and at home, and the overuse of technology, encourage sedentary lifestyles and inadequate postures. These factors are associated, because sedentary people tend to have poorer posture.[39] The students felt that they have difficulties in avoiding a sedentary lifestyle, and require time and space to move around. They indicated that they have little time between classes and inadequate recreational spaces. Although they see this need as an evident problem, their teachers are not able to solve it. All participants believed that the education system's setup is an impediment to solving this problem. After studying this same issue, Nielsen-Rodríguez[40] have proposed a change in educational methods to integrate physical activity into the classroom from pre-school age. Outside classrooms, the society in which children and adolescents live is not believed to provide facilities for them to move. The type of area in which one lives influences stress and activity levels: urban areas generate greater stress and a sedentary lifestyle.[41] Blanco et al.[42] have observed that physical activity levels and obesity differ according to the type of family environment.

Importance was also attached to carrying a backpack. On the basis of the focus groups, students and their families believed that carrying a backpack can be detrimental to students' postural health, although the results obtained in this study indicated no relationship. Although carrying a backpack does favour the forward movement of the head,[7,43] this phenomenon does not necessarily generate problems in the long term.[44] Similarly, the participants also believed that inadequate chairs or tables can affect adolescents' back health, thus also favouring UCS. The use of the same furniture by primary school children and adolescents may facilitate the adoption of forced positions and may cause long-term discomfort. This assessment is consistent with findings from a study by Gutiérrez-Santiago et al.,[45] who have found a high mismatch between secondary school classroom furniture and the students' anthropometric dimensions. Panagiotopoulou[46] have also observed that most students do not have furniture appropriate for their anthropometric size.

The main problems believed to be caused by UCS were joint range of motion limitations, pain and growth impairment. Although a decrease in range of motion does occur, UCS alone has not been demonstrated to cause pain.[47,48] This unsubstantiated belief that UCS causes pain in adolescents might lead to pain through a nocebo effect.[49] In fact, adolescents in families with experiences of pain are at higher risk of developing musculoskeletal pain. This association has been speculated to be due not to genetic factors, but to behavioural and psychosocial factors.[50,51] No evidence indicates that alterations in growth can occur in the long term. Nonetheless, families worried that insufficient importance is placed on back health, and that their children are not aware of the problems that their families believe could be caused by adopting forced postures.

UCS has been associated with the mental health and personality of adolescents: exam periods generate stress and stooped postures. Moreover, shyness, laziness or passivity are associated with UCS. Visual stimuli that generate different emotional reactions also generate a reaction of the phasic musculature, which is responsible for body posture.[52] These reactions, which would generate postural instability, can be modulated by a person's emotional state and personality[53]; shyness or discouragement are traits believed to be associated with UCS. Maturation of multisensory integration for central motor control of posture is slow and immature in adolescence.[54] Nevertheless, the adolescents claimed that they did not look good with FSP. In contrast, their families believed that they pretend their posture to look better. These are two contradictory aspects that contrast with the finding that an unassertive attitude favours postures such as UCS. The finding that adolescents believed that they do not look good, coupled with the influence of social networks and the media, has led to a demand for external items such as corsets, braces or posture shirts. Indeed, these products are coming back into fashion.[55] This phenomenon raised concern among family members, who believed that without appropriate recommendations, the use of these items could be harmful.

Families believed that the implementation of postural education in schools is necessary. Despite several studies on the subject, the effectiveness of postural education cannot be affirmed, because of the studies' high risk of bias; thus, the positive effects of the acquired knowledge and postural habits cannot be used to reliably support postural education.[56] Another option to consider is therapeutic exercise aimed at improving posture. Although some competitive sports favour UCS,[22,57] all participants believed that physical exercise can be beneficial for adolescent postural health. This belief is supported by Sheikhhoseini et al.,[58] who have concluded, on the basis of a systematic review and meta-analysis, that physical exercise generates long-term improvements. The participants also believed that therapeutic exercise is more beneficial for adolescents if it occurs in a group of people in the same age range. This belief is consistent with the results obtained by Yorks et al.,[59] who have found that group exercise generates greater physical and mental benefits than individual exercise.

The participants believed that manual therapy, physiotherapy or osteopathy might be useful for the treatment of UCS, although they did not believe that these treatments were final. Sikka et al.[60] have concluded that manual therapy must be complemented by therapeutic exercise and postural education to achieve positive results. However, most physiotherapists believe that working on a particular posture is essential in their clinical practice.[37]

Finally, the adolescents in the focus groups believed that the confinement due to the COVID-19 pandemic, and consequently having been in virtual classes during the school year, might have negatively affected their posture. In contrast, their family members and teachers did not believe this to be the case. Benden et al.[26] have argued that the changes in workspaces brought about by COVID-19 might

have exacerbated postural problems in the general population.

The quantitative portion of this study has several limitations. First, the study was conducted on a population of adolescents 13–15 years of age from a single educational centre; therefore, the results are extrapolatable to only populations with similar ages and sociodemographic characteristics to those of the study population. Moreover, photogrammetry assesses static posture. Given that the musculoskeletal system is an active system, performing the same assessment dynamically might prove interesting. Another study limitation was the difficulty in clearly seeing the landmark located in the spinous process of C7. However, controversy exists regarding the need to use a highly accurate palpation to evaluate standing static posture. Photogrammetry studies have verified that different methods of locating the spinous process of C7 produce highly similar results, with differences smaller than the margin of error of the tests themselves.[61]

Conclusion

The findings from the first quantitative phase of this study indicated a high prevalence of FSP in adolescents, which was still lower than the prevalence of FHP and UCS. These postural alterations are associated with factors such as BMI, school performance, technology use and physical activity. Although no evidence indicates that UCS can generate pain or pathology, participants held a general belief that correcting UCS is necessary to avoid long-term health problems in adolescents. The participants believed that changes should be made, such as modifying the furniture in school or avoiding a sedentary lifestyle. The participants placed great importance on physical exercise and postural health among adolescents.

Recommendations for future studies

In future research, we recommend expanding the sample and age range to cover the entire school stage, and to include pain as a study variable. We also recommend qualitative study of emotions to determine how they influence body posture, and study of adherence to physical exercise among adolescents.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

The Ethical Committee of Clinical Research of Bellvitge University Hospital approved the research protocol on March 25, 2021 (reference number PR117/21). All participants provided written informed consent before data collection began. The anonymity of the participants and the confidentiality of the data were ensured. The study complied with the Declaration of Helsinki.

Authors contributions

LDLI and FRC were responsible for the design and conception of the article. LDLI was responsible for data collection. LDLI and CB were responsible for transcriptions and data analysis. LDLI, FRC and CB discussed the coherence of the final categories. LDLI and CB drafted the manuscript. FRC revised the manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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