



Original Article

Sport-related concussion in Brazilian professional soccer: A four-year prospective epidemiological analysis



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ABSTRACT

This study aimed to investigate the incidence and other significant features of craniomaxillofacial trauma (CMFT), particularly Sport-Related Concussion (SRC), among professional soccer players from two major leagues in Brazil. This is a prospective epidemiological study which assessed two divisions of the national championship and large regional one over four seasons. Data were gathered from soccer clubs and their medical staff using two online forms. Data related to players (age and position) and injuries (diagnosis, type, body location, laterality, field location, tests performed, need for surgery, time lost in sports, and recurrence) were collected. Between 2016 and 2019, a total of 15 seasons, comprising 3 828 matches and 126 324 hours (h) of gameplay, were analyzed. A total of 299 CMFT cases were reported, with a median incidence of 2.37 per 1 000 h of play. Among them, there were 178 head and 121 face traumas, which led to 87 SRC (representing 29.10% of all CMFT), with an incidence of 0.69. Defensive midfielders (14.43%) and goalkeepers (14.00%) had the highest prevalence rates of CMFT. Only 3.68% of the injuries, mostly lacerations and fractures, required surgical treatment. This study identified that the average time lost in sports due to SRC was 5.12 days, with a recurrence rate of 12.71%. SRC are a frequent consequence of CMFT in Brazilian professional soccer. Although most cases are mild, there is a high recurrence rate, which may have long-term implications.

1. Introduction

Sports participation is responsible for approximately 6% of emergency department attendances with craniomaxillofacial trauma (CMFT).¹ In soccer, head and neck injuries account for 4%–22% of all injuries at a rate of 1.7 per 1 000 playing hours.² Mild CMFT can present as a concussion and, in a sport-related activity, it is defined as a traumatic brain injury caused by a direct blow to the head, neck or body resulting in a force transmitted to the brain and happens in exercise-related activities; Symptoms and signs may present immediately, or evolve over minutes or hours, and commonly resolve within days, but may be prolonged.^{3,4}

The rate of sports-related concussions (SRC) is believed to be 0.5 per 1 000 playing hours, although its accuracy is limited by differences in the

diagnostic criteria and documentation of head injuries.² This type of CMFT has an inherent risk of recurrence and development of chronic traumatic encephalopathy, a neurodegenerative disease linked to repeated head trauma, initially identified in football players,⁵ but it is associated with various sports.⁶

The majority (80%–90%) of SRC resolve in a short period (7–10 days) without specific treatment. However, the failure to associate mild symptoms with trauma and delay in ceasing the players' activity can lead to a new traumatic incident before complete resolution of the initial clinical condition, potentially culminating into more serious long-term effects.⁷ Therefore, there is an increased interest in conducting research on SRC.

Brazil has a worldwide representation in soccer, leading the sales of athletes abroad. The country was responsible for moving 223 million

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Abbreviations

CMFT	craniomaxillofacial trauma
SRC	sport-related concussions
BSC	Brazilian Soccer Championship
PSC	Paulista Soccer Division
TRP	time to return to play

Euros in early 2019 alone.⁸ For this reason, it is an ideal place for further research on the topic. Therefore, this study aimed to analyze the epidemiology of CMFT, particularly SRC, in two major professional Brazilian Soccer Leagues.

2. Methods

We conducted a prospective longitudinal epidemiological study that evaluated two male professional divisions over four seasons (2016–2019), within the national championship - Brazilian Soccer Championship (BSC) - and the larger regional championship - Paulista Soccer Division (PSC).

Data regarding the players (age and position on the field) and injuries (diagnosis, type, body location, field location, need for surgery, time to return to play [TRP], and recurrence) were collected. Injury was defined as any musculoskeletal complaint occurring during a match that caused the player to miss at least one training session or another match play.⁹ All registered cases of CMFT were evaluated. A concussion was defined according to the definition provided by the Consensus Statement on Concussion in Sport⁴ as a brain injury caused by a direct blow to the head, face, neck, or elsewhere on the body, resulting in the rapid onset of impaired neurological function. The diagnosis of a concussion was a clinical judgment, made by the medical professional, based on the Sport Concussion Assessment Tool - 5th Edition (SCAT5).¹⁰

The soccer club members and their medical staff were invited to participate and guidance on appropriate online data entry methods were provided. Transfermarkt (Transfermarkt GmbH & Co. KG) and SurveyMonkey (Momentive.AI) were used. Two types of forms were used: the first was completed during each match and after each medical attention in the field, and the second one after the injured athlete returned to the sport. Monthly reminders were sent to club doctors to complete the forms.

Four BSC seasons were played during the study period, involving 20 clubs per division each year, with 38 matches per season. As for the PSC, four seasons were played involving 16–20 clubs per division each year, with 17–22 matches played per season. Over the course of four years (2016–2019), there were 15 seasons, comprising 3 828 matches and 126 324 h of gameplay.

Excel 2016 (Microsoft Corporation, Redmond, WA, USA) was used for descriptive statistical analysis of the quantitative variables. SPSS V20 (International Business Machines Corporation, Armonk, NY, USA) was used for statistical inference of continuous variables. Qualitative variables were analyzed using *chi*-squared tests. An analysis of variance test was performed for multivariate analysis with a 95% confidence interval (95% CI) and a significance level of 5% ($p < 0.05$). In addition, the Shapiro-Wilk test was used to establish normality. The incidence of lesions was analyzed according to the FIFA Incidence Formula: Incidence = (total injuries × 1 000 h)/total hours played.¹¹ Injuries were classified according to severity based on the athlete's TRP as follows: mild (0–3 days), minor (4–7 days), moderate (8–28 days), major (4–8 weeks), and severe (> 8 weeks).¹²

2.1. Ethical approval

This study was guided by ethical standards and national and

international laws. It was approved by the Research Ethics Committee of the Federal University of São Paulo under registration number "CAAE 56723616.3.0000.5505". All study participants provided informed consent.

3. Results

In this study, 7 899 medical attentions on the field were recorded, of which 2 486 injuries were diagnosed. Over the years, there was a progressive and significant reduction in the total number of injuries, from 108 in 2016 to 47 in 2019. There was no difference in the incidence between months, except for June, which had the highest incidence (14.70%), and December, which had the lowest (1.30%) (Fig. 1).

3.1. Diagnosis and age

A total of 299 CMFT cases were reported, representing 12.00% of the total injuries, with a FIFA incidence of 2.37. Head trauma represented 59.50% of total CMFT cases, while the remaining 40.50% were face trauma. Twelve different injury diagnoses were identified, being SRC the most prevalent injury, accounting for 48.90% of the total head trauma and 29.10% of the total CMFT cases, with an incidence of 0.69 (Table 1).

The mean age was not significantly different for head trauma, face trauma, or CMFT (26.9 vs 26.7 vs 27.2 years) ($p = 0.55$). There was also no statistically significant relationship between age and the severity ($p = 0.57$) of the injury or its recurrence ($p = 0.07$) for all injuries.

3.2. Player's position, location on the field, and moment of injury

In terms of player positions, Defensive Midfielders (14.43%) and Goalkeepers (14.00%) had the highest prevalence of CMFT among all injuries, whereas the lowest prevalence was among Forward players (10.05%). SRC was the most prevalent injury among all positions, representing 21.30% of CMFT in Defenders and 38.3% in Midfielders (Table 2).

There was a significant correlation between CMFT incidence and match timing ($p = 0.003$). The time range between 31 and 45 minutes (min) of the first half of playtime had the highest incidence of the CMFT (22.40%) (Table 3 and Fig. 2). The relation between player position and location on the field was statistically significant ($p < 0.001$). Most CMFT (64.20%) occurred on the defensive side of the field (Fig. 3), especially in the defending area (43.10%), except for the Midfielders - mostly injured in the midfield - and Forward players - mostly injured in the offensive zone (Table 3).

3.3. Recurrence, surgery and time to return to play

Recurrence rate for CMFT and SRC was 12.71% and 11.49%, respectively. Other smaller traumas, such as head (21.28%) and eyebrow

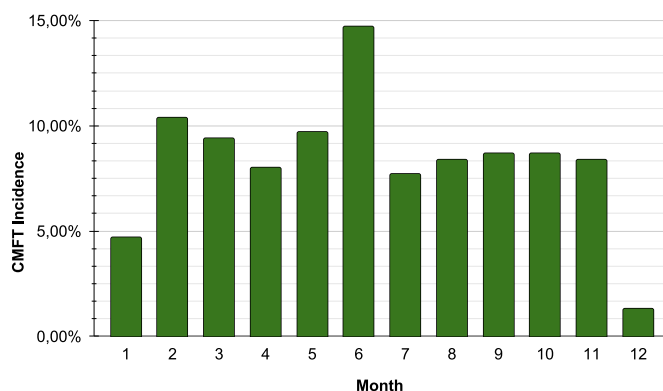


Fig. 1. Craniomaxillofacial Trauma (CMFT) incidence throughout the year.

Table 1
General features.

Diagnosis	n (%)	FIFA Incidence	Recurrence (%)	Surgery (%)	Severity (TRP)				
					Mild (< 4 days)	Minor (4–7 days)	Moderate (8–28 days)	Major (4–8 weeks)	
Head	Concussion	87 (29.10%)	0.69	10 (11.49%)	1 (1.15%)	34 (39.08%)	42 (48.28%)	10 (11.49%)	1 (11.49%)
	Bruise	47 (15.70%)	0.37	10 (21.28%)	3 (6.38%)	26 (55.32%)	17 (36.17%)	4 (8.51%)	0
	Laceration	44 (14.70%)	0.35	5 (11.36%)	0	24 (54.55%)	16 (36.36%)	4 (9.09%)	0
	Total Head Injuries	178 (59.50%)	1.41	20 (11.23%)	4 (2.25%)	84 (47.19%)	75 (42.13%)	18 (10.11%)	1 (0.56%)
Face	Bruise	10 (3.30%)	0.08	0	0	8 (80.00%)	1 (10.00%)	1 (10.00%)	0
	Nose bruise	11 (3.70%)	0.09	1 (9.09%)	0	7 (63.64%)	4 (36.36%)	0	0
	Eye bruise	9 (3.00%)	0.07	0	0	4 (44.44%)	4 (44.44%)	1 (11.11%)	0
	Mouth laceration	5 (1.70%)	0.04	0	0	4 (80.00%)	0	1 (20.00%)	0
	Face laceration	43 (14.40%)	0.34	7 (16.28%)	3 (6.98%)	22 (51.16%)	14 (32.56%)	7 (16.28%)	0
	Eyebrow laceration	5 (1.70%)	0.04	1 (20.00%)	1 (20.00%)	2 (40.00%)	3 (60.00%)	0	0
	Tooth fracture	12 (4.00%)	0.10	1 (8.33%)	1 (8.33%)	9 (75.00%)	2 (16.67%)	1 (8.33%)	0
	Nose fracture	19 (6.40%)	0.15	3 (15.79%)	1 (5.26%)	2 (10.53%)	4 (21.05%)	10 (52.63%)	3 (15.79%)
	Zygomatic fracture	7 (2.30%)	0.06	0	1 (14.29%)	1 (14.29%)	1 (14.29%)	4 (57.14%)	1 (14.29%)
	Total Face Injuries	121 (40.50%)	0.86	18 (14.87%)	7 (5.78%)	59 (48.76%)	33 (27.27%)	25 (20.67%)	4 (3.31%)
	Total	299 (100%)	2.37	38 (12.71%)	11 (3.68%)	143 (47.82%)	108 (36.12%)	43 (14.38%)	5 (1.67%)

Table 2
Player position vs diagnosis.

Diagnosis		Player position					
		Goalkeeper	Defender	Sideback	Defensive Midfielder	Midfielder	Forward
Head	Concussion	7 (8.00%)	10 (11.50%)	19 (21.80%)	13 (14.90%)	18 (20.70%)	20 (23.00%)
	Bruise	4 (8.50%)	9 (19.10%)	16 (34.00%)	5 (10.60%)	3 (6.30%)	10 (21.30%)
	Laceration	2 (4.50%)	9 (20.50%)	6 (13.60%)	3 (6.80%)	10 (22.70%)	14 (31.20%)
	Total Head Injuries	13 (9.50%)	28 (15.70%)	41 (23.00%)	21 (11.80%)	31 (17.40%)	44 (24.70%)
Face	Bruise	2 (20.00%)	1 (10.00%)	2 (20.00%)	1 (10.00%)	0	4 (40.00%)
	Nose bruise	0	1 (9.10%)	1 (9.10%)	1 (9.10%)	5 (45.50%)	3 (27.30%)
	Eye bruise	2 (22.00%)	1 (11.00%)	2 (22.00%)	1 (11.00%)	1 (11.00%)	2 (22.00%)
	Mouth laceration	0	0	1 (20.00%)	1 (20.00%)	1 (20.00%)	2 (40.00%)
	Face laceration	3 (7.00%)	7 (16.30%)	10 (23.30%)	7 (16.30%)	3 (7.00%)	13 (27.70%)
	Eyebrow laceration	0	0	1 (20.00%)	1 (20.00%)	3 (60.00%)	0
	Tooth fracture	0	1 (8.30%)	3 (25.00%)	1 (8.30%)	3 (25.00%)	4 (33.30%)
	Nose fracture	1 (5.30%)	6 (31.60%)	1 (5.30%)	7 (36.80%)	0	4 (21.10%)
	Zygomatic fracture	0	2 (28.60%)	1 (14.30%)	1 (14.30%)	0	3 (42.90%)
	Total Face Injuries	8 (6.60%)	19 (15.70%)	22 (18.20%)	21 (17.40%)	16 (13.20%)	35 (28.90%)

Percentual data related to each diagnosis.

Table 3
Player position vs time and field zone.

variables		Goalkeeper	Defender	Sideback	Defensive Midfielder	Midfielder	Forward
Time	0–15'	4 (19.00%)	3 (6.40%)	6 (9.50%)	2 (4.80%)	12 (25.50%)	13 (16.50%)
	16–30'	5 (23.80%)	9 (19.10%)	5 (7.90%)	10 (23.80%)	10 (21.30%)	15 (19.00%)
	31–45'	2 (9.50%)	16 (34.00%)	11 (17.50%)	6 (14.30%)	9 (19.10%)	23 (29.10%)
	1st ET	2 (9.50%)	3 (6.40%)	11 (17.50%)	8 (19.00%)	5 (10.60%)	2 (2.50%)
	46–60'	2 (9.50%)	4 (8.50%)	1 (1.60%)	5 (11.90%)	1 (2.10%)	1 (1.30%)
	61–75'	4 (19.00%)	6 (12.80%)	12 (19.00%)	9 (21.40%)	5 (10.60%)	11 (13.90%)
	76–90'	2 (9.50%)	6 (12.80%)	16 (25.40%)	2 (4.80%)	5 (10.60%)	12 (15.20%)
	2nd ET	0	0	1 (1.60%)	0	0	2 (2.50%)
Field Zone	Defending Area	21 (100%)	23 (48.90%)	41 (65.10%)	11 (26.20%)	18 (38.30%)	15 (19.00%)
	Attacking Area	0	0	3 (4.80%)	7 (16.70%)	4 (8.50%)	29 (36.70%)
	Defending Midfield	0	9 (19.10%)	12 (19.00%)	11 (26.20%)	19 (40.40%)	15 (19.00%)
	Attacking Midfield	0	15 (31.90%)	7 (11.10%)	13 (31.00%)	6 (12.80%)	20 (25.30%)

Percentual data related to each position. ET: Extra-time.

(20.00%) bruises, had the highest recurrence rates. Goalkeepers (23.81%), followed by Defensive Midfielders (16.67%) had the highest rate of recurrence, while Sidebacks had the lowest recurrence rate (9.52%). There was a longer TRP with a statistically significant difference between recurrent (7.5 days) and non-recurrent (4.8 days) injuries ($p = 0.002$).

Only 3.68% of injuries, highlighting lacerations and fractures, required a surgical approach. These injuries required a longer TRP (8 days vs. 5 days). The average TRP was 5.12 days. Mild injuries (TRP < 4 days) were the most prevalent (47.82%). Only 1.67% of the injuries required more than one month to recover. Players' position and TRP had no statistically significant correlation ($p = 0.19$).

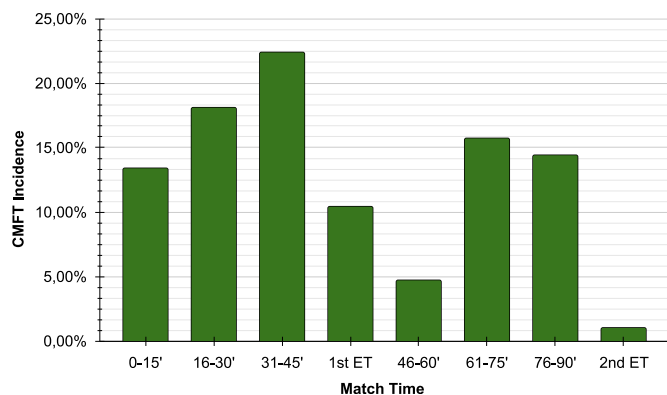


Fig. 2. Craniomaxillofacial Trauma (CMFT) incidence during each match time.

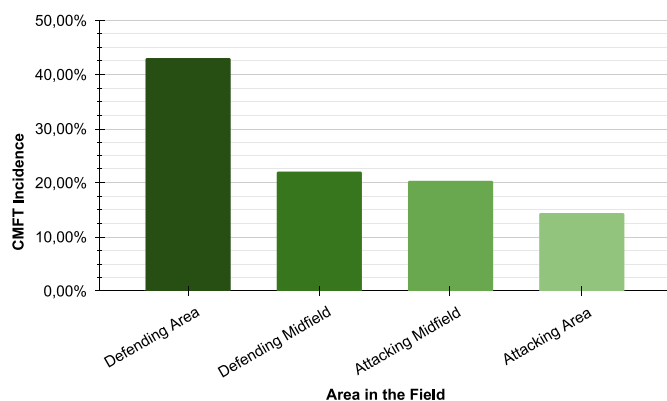


Fig. 3. Craniomaxillofacial Trauma (CMFT) incidence in each area of the playing field.

4. Discussion

The main findings of this study were the high incidence of CMFT, specially SRC, in soccer players; there was an important decrease in the number of injuries over the years; CMFT was similar along the months, except for June; Forward and Sidebacks had the highest prevalence of injury, while Goalkeepers and Defensive Midfielders had the highest relative risk to get injured; CMFT had a high rate of recurrence, mainly in Goalkeepers; TRP was low overall, but it was high when the injury was recurrent.

The incidence of CMFT and SRC along the four years was 2.37 and 0.69 per 1 000 h played, respectively. Recent studies found incidence rates between 1.77 and 2.46 for CMFT^{13,14} and 0.15–1.47 for concussion.^{15,16} Thus, our sample showed similar results to the literature. Differences in incidence rate throughout the studies can be attributed mainly to distinctive aspects of matches in each league, duration of the season, age and gender group, lack of standard definition for injuries and accuracy of data gathering during the tournaments. In comparison with other types of injuries, studies have found a FIFA index of 0.41, 0.85, 1.34, and 7.66 for anterior cruciate ligament injury,⁸ shoulder injuries,¹⁷ upper limb injuries,¹⁸ and muscle injuries,¹⁹ respectively.

Although our study did not find any relationship between the players' age and the risk of concussion, there may be higher rates of concussion in high school and collegiate athletes compared to adult ones.^{20,21} This may be due to immature neck muscles, behavioral issues, and poor cognitive skills.¹³ American data shows a higher risk of SRC in athletes aged 15–19 years-old.^{22,23} Another study showed that 18-year olds have double incidence of concussions compared to 13-year olds.²⁴ Older young athletes may be more prone to SRC because they are bigger and stronger, have more playing time, and more competitive level that could increase

the risk of concussion. Some older athletes may have sustained a concussion earlier in their school years, thus increasing their risk of concussions in subsequent head injuries.²⁵

Despite having the most absolute number of CMFT and SRC, Attackers had the lowest risk for these injuries. Defensive Midfielders and Goalkeepers had the highest risk for CMFT. Goalkeepers, Defensive Midfielders and Midfielders had the highest risk for SRC. Whilst some studies have similar results from ours,²⁶ others present highest incidence of CMFT in defenders and lower in goalkeepers.^{16,27} In female soccer players, goalkeepers seem to sustain more SRC compared to field players.²⁸ In a study by Russel et al.,²⁹ the risk of neurodegenerative disease was highest for defenders and lowest for goalkeepers. Regarding career length, risk was highest among former soccer players with professional career lengths longer than 15 years. The role of the player position in the propensity to CMFT and SRC is yet unclear and data heterogeneous.

In this study, almost half of all CMFT occurred at the end of the first and second half of playtime. This pattern may be induced by mental and physical fatigue, which is known to cause deleterious effects on performance,^{30,31} as well as pressure to achieve better results before halftime or match ends. Other studies have observed similar results for other types of injuries.^{17,32–35}

Injury incidence along the year was mostly constant, except for a low incidence in January and December, and a peak of injuries in June. In Brazil, the regional championships (PSC for example) begin at the end of January and finishes at the beginning of April; the national championship (BSC) begins just after the regionals and finishes at the beginning of December. That justifies the low incidence of injuries in the first and last months of the year. Furthermore, in June there is the Libertadores da América Cup - a South America Continent Championship - that overlaps with the BSC. This may explain the higher incidence of injuries at this time of the year, since players are more fatigued.

General musculoskeletal injury recurrence in soccer ranges from 12% to 30%,¹¹ and for SRC it is approximately 17%.²⁵ These numbers are similar to our findings of 12.71% recurrence rate for CMFT and 11.49% for SRC. American Football, another contact sport, has a similar recurrence rate for SRC of 14.70%.²³ A Swedish data indicates that concussions are a risk factor for subsequent injuries, which are 2.2 times more frequent in professional soccer players with previous concussions.³⁶ In addition to an increased risk, the studies by Cross et al.³⁷ and Rafferty et al.³⁸ demonstrated that there was a reduced number of days before a subsequent injury following concussion when compared with non-concussive injuries.

The reason for this increased injury risk is not yet fully understood. Apoptosis and atrophy in the brain seem to be more prominent 6–12 months after a traumatic head injury than initially.^{39,40} Thus, it could be that the fast return to play protocol may be insufficient for full recovery. Increases in weekly workload greater than 10% are associated with an increased injury risk,⁴ therefore a longer graded return to play protocol could reduce some of the subsequent injury risk.³⁸ Furthermore, it is suggested that after a SRC athletes should be monitored for at least one year, since symptoms are often subtle. Preseason tests for cognitive function could be valuable in determining readiness to return to play and subsequent injury risk.³⁶

Most SRC cases reported in our study were mild with mean TRP of 5.06 days, and 87.35% resolved in less than two weeks. Literature shows a mean TRP of 19.8 days³ but some studies show 80%–90% TRP in 7–10 days. Unrestricted return to sport may take up to 30 days, but symptoms may persist for up to 3 months in 15% of cases.⁴¹ Our early TRP may be due to several reasons: First, our sample has a relative old mean age and all male athletes, and it is known that younger athletes and women normally take longer to recover from SRC.^{42,43} Second, differences in diagnostic criteria and return-to-play protocols by each club physician could have contributed to this result. Third, early in-game diagnosis and intervention, following the recommendation of early return to physical activities in the next 2–10 days after trauma³ may play a role in

shortening recovery times.

5. Limitations

This study has several limitations. The main ones are those inherent of epidemiological researches such as data collection bias. Several club physicians were responsible for filling in the forms, and due to the great number of data collectors, errors and missing data may have occurred. Furthermore, during the study period, some of the physicians were replaced by the clubs, but we ensured that all of them received training on how to complete the survey.

Another limitation is the definition of injury. Although there is a consensus by Fuller et al.⁹ that proposes a standard definition for injury in soccer, we decided to slightly adapt this definition to better match our study methodology. This adaptation in the present study and in other studies in the literature is common and may hinder possible comparisons between studies.

Our study is limited by a superficial analysis of each injury. Important data such as history of previous injury, trauma mechanism, number of recurrences, image analysis, injury classification and treatment method were not collected. Additionally, data were not collected for injuries that occurred during training sessions, and so we may have underestimated the total number of CMFT. Despite these limitations, this was an extensive prospective study lasting four years and included a large sample of athletes and injuries, in which we were able to collect unpublished data from two major professional football championships in Brazil.

6. Conclusion

SRC are a frequent consequence of craniomaxillofacial trauma in Brazilian professional soccer. Defensive midfielders were found to be at a higher risk among others, especially at the end of the first half of play-time. Although most cases are mild, there is a high recurrence rate, which may have long-term implications.

Ethical approval statement

This study was guided by ethical standards and national and international laws. It was approved by the Research Ethics Committee of the Federal University of São Paulo under registration number “CAAE 56723616.3.0000.5505”. All study participants provided informed consent.

CRedit authorship contribution statement

Guilherme Corrêa de Araújo Moury Fernandes: Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Ewerton Borges de Souza Lima:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Paulo Henrique Schmidt Lara:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis. **Ana Camila de Castro Gandolfi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Data curation, Conceptualization. **Jorge Roberto Pagura:** Validation, Supervision, Project administration, Data curation, Conceptualization. **Gustavo Gonçalves Arliani:** Visualization, Validation, Supervision, Conceptualization. **Moisés Cohen:** Visualization, Validation, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interest.

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