



Scapular notch, spinoglenoid notch, and scapular dimensions: implications on the safe zone of the suprascapular nerve

Jhonatan Duque-Colorado¹, Laura García-Orozco¹, Andrés Riveros², Mariano del Sol^{1,3}

¹Universidad de La Frontera, Facultad de Medicina, Programa de Doctorado en Ciencias Morfológicas, Temuco, ²Departamento de Anatomía Normal y Medicina Legal, Facultad de Medicina, Universidad de Concepción, Concepción, ³Universidad de La Frontera, Facultad de Medicina, Centro de Excelencia en Estudios Morfológicos y Quirúrgicos (CEMyQ), Temuco, Chile

Abstract: The suprascapular nerve corresponds to one of the supraclavicular branches of the brachial plexus, and its route exposes it to being injured during some surgical procedures. Morphometric analysis of the scapula has been proposed as a tool for preventing injuries to the suprascapular nerve. The present investigation aimed to determine the safe distances for approaching the suprascapular nerve at the level of the scapular notch (SPN) and spinoglenoid notch, in addition to establishing its relationship with the type of SPN and with two scapular dimensions: major longitudinal axis (MLA) and major transverse axis (MTA). For this purpose, a descriptive-correlative, quantitative, non-experimental and transversal study was carried out, in which 82 dry scapulae from adult individuals of Chilean origin were investigated. The main results of this study found that prevalences were highest for SPNs types II (36.2%), I (29.3%), and III (26.0%), with average distances that were considered safe in all types of SPNs. Furthermore, there was a positive correlation, with $P < 0.05$, between the MTA ($r = 0.526$; $r = 0.634$), MLA ($r = 0.284$) and the safe distances for the suprascapular nerve at the level of the SPN and incisura spinoglenoid of the scapulae studied. Scapular dimensions such as the MTA and the MLA could, therefore, be used to predict a safe zone for the suprascapular nerve, potentially contributing to a reduction in the current rate of injury of the suprascapular nerve in surgical procedures involving the deltoid and scapular regions.

Key words: Anatomy, Morphometry, Scapula, Notch, Nerve

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Introduction

The scapula is a flat bone that is located in the scapular re-

gion, a region of back. Among its bone repairs, the scapular notch (SPN) stands out, which is located on the upper margin of the scapula, medial to the base of the coracoid process, and the spinoglenoid notch (SGN), a bone repair that is located between the spine of the scapula and glenoid fossa.

The suprascapular nerve is a mixed nerve originating from the C5 and C6 roots of the brachial plexus. This nerve has a sensory component that is responsible for the sensitivity of the glenohumeral and acromioclavicular joints, in addition to a motor component that is responsible for the innervation of the supraspinatus and infraspinatus muscles. Along its path, the suprascapular nerve passes through the SPN and the SGN, ending in the infraspinous fossa [1, 2].

Corresponding author:

Mariano del Sol 

Universidad de La Frontera, Facultad de Medicina, Centro de Excelencia en Estudios Morfológicos y Quirúrgicos (CEMyQ), Temuco 4780000, Chile

E-mail: mariano.delsol@ufrontera.cl

Jhonatan Duque-Colorado 

Universidad de La Frontera, Facultad de Medicina, Programa de Doctorado en Ciencias Morfológicas, Temuco 4780000, Chile

E-mail: j.duque01@ufromail.cl

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The SPN and the SGN are relevant in the clinical setting as they are common sites of iatrogenic injuries to the suprascapular nerve during various surgical procedures. The SPN is a site of injury to the suprascapular nerve in surgical procedures such as arthroscopic Bankart repair, repair of anteroposterior tears of the superior glenoid labrum, repair of arthroscopically assisted rotator cuff tears, and decompression of the suprascapular nerve [3, 4]. Similarly, the SGN is a point at which the suprascapular nerve is susceptible to iatrogenic injuries during the Latarjet surgical procedure [5].

In order to preserve the integrity of the suprascapular nerve during surgical approaches in the deltoid and scapular regions, at least two safe zones have been established. According to Gumina et al. [4] safe zones are defined as spaces where there is a low probability that the nerve will be injured during a surgical procedure. One of these safe zones is determined by the distance between the SPN and the most prominent portion of the supraglenoid tubercle. A second safe zone is determined by the distance between the SGN and the posterolateral margin of the glenoid fossa [6].

The rate of injuries to the suprascapular nerve in surgical procedures involving the deltoid and scapular regions has been reported to range between 8% and 20% [5, 7, 8]. Some morphometric reports have referred to safe distances at the scapular level in relation to the different types of notches [9-11] that could be useful for avoiding iatrogenic injuries to the suprascapular nerve. However, we have not found information regarding safe distances with respect to scapular dimensions such as the major longitudinal axis (MLA) and the major transverse axis (MTA).

The objective of the present work was to determine the safe distances for approaching the suprascapular nerve at the level of the SPN and SGN, establishing its relationship with the type of SPN according to the classification method of Rengachary et al. [12] and with the scapular dimensions, MLA and MTA.

Materials and Methods

A descriptive-correlational, quantitative, non-experimental and cross-sectional study was carried out. The methodological planning of this research followed the guidelines established in the AQUA guide for carrying out original anatomical studies [13].

A total of 82 dry scapulae from adult individuals were collected and examined between January and April 2023; these

corresponded to 46 scapulae obtained from the Anatomy Osteotheque of the Faculty of Medicine of the Universidad de La Frontera, Chile, and 36 scapulae from the osteotheque of the Department of Normal Anatomy and Legal Medicine of the Faculty of Medicine of the Universidad de Concepción, Chile. Only adult individuals scapulae that presented complete margins and angles were eligible for subsequent analysis. In Chile, according to the sanitary code, book nine, donated human bodies or parts can be used for teaching and scientific research. These scapulae come from cadavers used in teaching that were later reduced to bones. Therefore, the approval of a scientific ethics committee is not necessary.

SPNs were classified as described by Rengachary et al. [12] into six types. Type I: wide depression on the upper margin of the scapula, from the superior angle of the scapula to the base of the coracoid process; type II: wide, V-shaped notch with blunt tip; type III: symmetrical notch, U-shaped, with parallel margins; type IV: shallow V-shaped notch, the shallow depth represents the bony impression of the suprascapular nerve; type V: notch with partial ossification of the medial area of the superior transverse scapular ligament; and type VI: bony foramen inferomedial to the base of the coracoid process, as a cause of total ossification of the superior transverse scapular ligament (Fig. 1).

Each scapula was subjected to the following morphometric measurements: (1) MLA: distance between the superior angle and the inferior angle of the scapula (Fig. 2A); (2) MTA: distance from the medial margin, at the level of the scapular spine, to the infraglenoid tubercle (Fig. 2B); (3) safe zone 1: distance from the SPN to the most prominent portion of the supraglenoid tubercle (SPN-ST) (Fig. 3A); (4) safe zone 2: distance from the SGN to the posterolateral margin of the glenoid fossa (SGN-GF) (Fig. 3B). Each measurement was carried out twice, by two researchers, using a TOTAL TMT321501 (TOTAL TOOLS CO., PTE. LTD.) digital caliper with a precision of 0.01 mm.

Statistical analysis

Results were recorded in a database generated in Microsoft® Excel 2019 (Microsoft) and were analyzed in the SPSS statistical software, version 21 (IBM Co.). Continuous measures were expressed as mean $\pm$ SD, as appropriate, and categorical variables were expressed as absolute value (n) and percentage (%).

The normality of the data in each variable was evaluated using the Kolmogorov-Smirnov test. Subsequently, the data

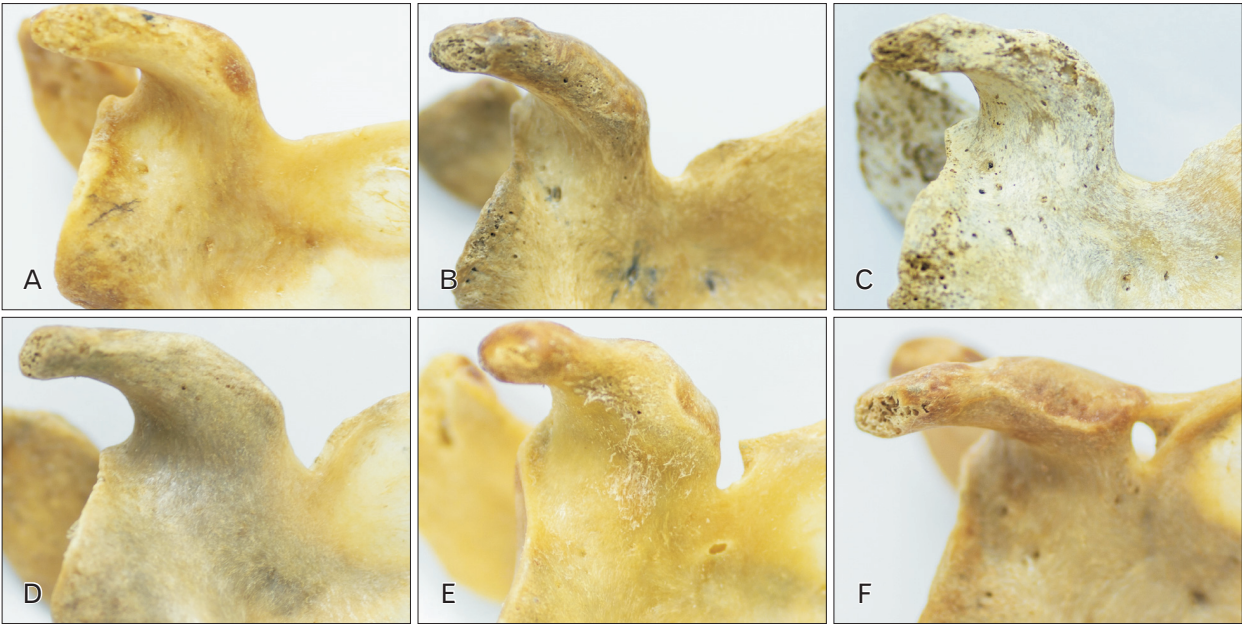


Fig. 1. Types of scapular notches according to the classification method of Rengachary et al. [12]. (A) Type I: wide depression. (B) Type II: wide V-shaped. (C) Type III: symmetrical U-shaped. (D) Type IV: shallow V-shaped notch representing the impression of the suprascapular nerve. (E) Type V: partial ossification of the superior transverse scapular ligament. (F) Type VI: osseous foramen, due to ossification of the superior transverse scapular ligament.

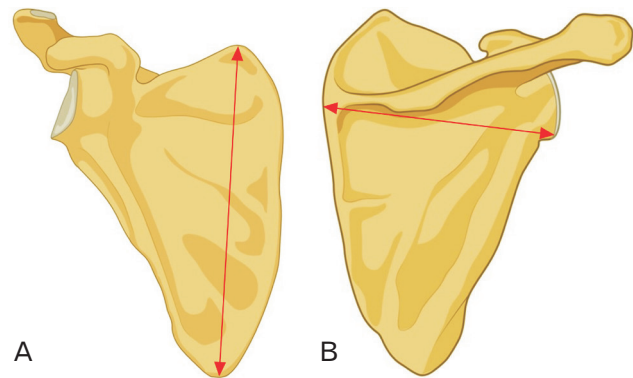


Fig. 2. Measurement of scapular dimensions. (A) Major longitudinal axis: distance between the superior angle and the inferior angle of the scapula. (B) Major transverse axis: distance between the medial margin at the level of the scapular spine to the infraglenoid tubercle.

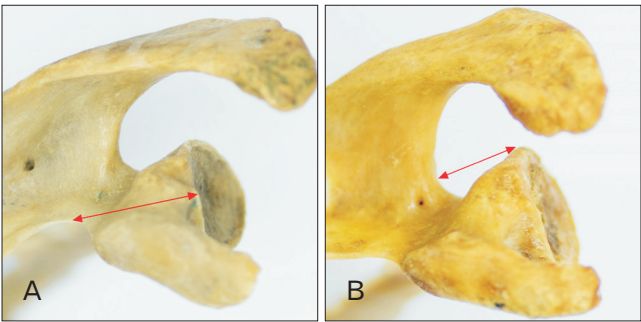


Fig. 3. Safe zone measurement for suprascapular nerve. (A) SPN–ST, distance from the scapular notch to the most prominent part of the supraglenoid tubercle. (B) SGN–GF, distance from the spinoglenoid notch to the posterolateral margin of the glenoid fossa.

Table 1. Frequency of scapular notch types according to the classification method of Rengachary et al. [12]

Authors	Population	Type I	Type II	Type III	Type IV	Type V	Type VI
Inoue et al. [16]	Japanese	11.4	23.5	30.1	14.8	15.9	4.3
Boyan et al. [15]	Turkish	34.3	23.3	13.7	20.5	2.7	5.5
Manikum et al. [14]	South African	5.0	65.0	5.0	18.0	7.0	0
Albino et al. [17]	Italian	12.4	19.8	22.9	31.1	10.2	3.6
Rengachary et al. [12]	American	8.0	31.0	48.0	3.0	6.0	4.0
This study	Chilean	29.3	36.2	26.0	3.4	1.7	3.4

Values are presented as percentage.

were analyzed using either the one-factor ANOVA test or the Kruskal–Wallis ANOVA followed by the Levene test for the analysis of homoscedasticity of variances. Additionally, the correlation of the data was established through the Pearson or Spearman correlation coefficient tests, using a significance level of $\alpha=0.05$.

Results

From the 82 scapulae assessed, 58 met the eligibility criteria whereas 24 were excluded from the study. Of the 58 scapulae analyzed, 31 (53.4%) presented left laterality and 27 (46.6%) presented right laterality.

A total of 53 (91.4%) scapulae presented SPNs corresponding to types I, II, or III. The remaining 5 (8.6%) scapulae

presented SPNs types IV, V, or VI. The distribution of these classifications is shown in Table 1 [12, 14–17].

In relation to scapular dimensions, measurements were observed for the MLA that varied between 131.08 mm and 177.24 mm, with a mean value of 150.44 ± 9.97 mm. In parallel, the measurements associated with the MTA ranged between 90.06 mm and 120.47 mm, with an average value of 106.81 ± 6.67 mm. Table 2 shows the values for the MLA and MTA according to the type of SPN. For this analysis, types I, II, and III were included as they were the most prevalent types within the studied sample. Homogeneity was observed in the MLA and MTA measurements between the types of SPNs ($P>0.05$); that is, the scapulae analyzed were of similar size regardless of the type of SPN.

The average SPN–ST distance measured was 30.38 ± 3.53 mm, with a minimum of 22.99 mm and a maximum of 38.15 mm. The average measured SGN–GF distance was 18.34 ± 2.35 mm, with a minimum of 13.60 mm and a maximum of 26.62 mm. Neither the SPN–ST nor the SGN–GF measurements differed significantly between the different types of SPNs ($P>0.05$), as is detailed in Table 2. Finally, analysis of the safety zones showed that the MTA of the scapulae was significantly correlated with the SPN–ST ($r=0.526$, $P<0.0001$) and also with the SGN–GF ($r=0.634$, $P<0.0001$) and also with the SGN–GF ($r=0.634$, $P<0.0001$). The MLA was similarly correlated with the SGN–GF ($r=0.284$, $P<0.05$), whereas the SPN–ST was not correlated with the measure-

Table 2. Morphometric measurements according to scapular notch type

Variable	Type I	Type II	Type III	P-value
MLA (mm)	150.76 ± 9.52	151.42 ± 11.25	149.38 ± 9.52	0.841
MTA (mm)	106.63 ± 4.77	107.65 ± 7.19	106.14 ± 7.57	0.783
SPN–ST (mm)	30.67 ± 3.50	30.32 ± 4.07	30.62 ± 3.03	0.948
SGN–GF (mm)	18.11 ± 2.05	18.81 ± 2.39	18.40 ± 2.76	0.666

Values are presented as mean $\pm$ SD. MLA, major longitudinal axis; MTA, major transverse axis; SPN–ST, distance from the scapular notch to the most prominent portion of the supraglenoid tubercle; SGN–GF, distance from the spinoglenoid notch to the posterolateral margin of the glenoid fossa.

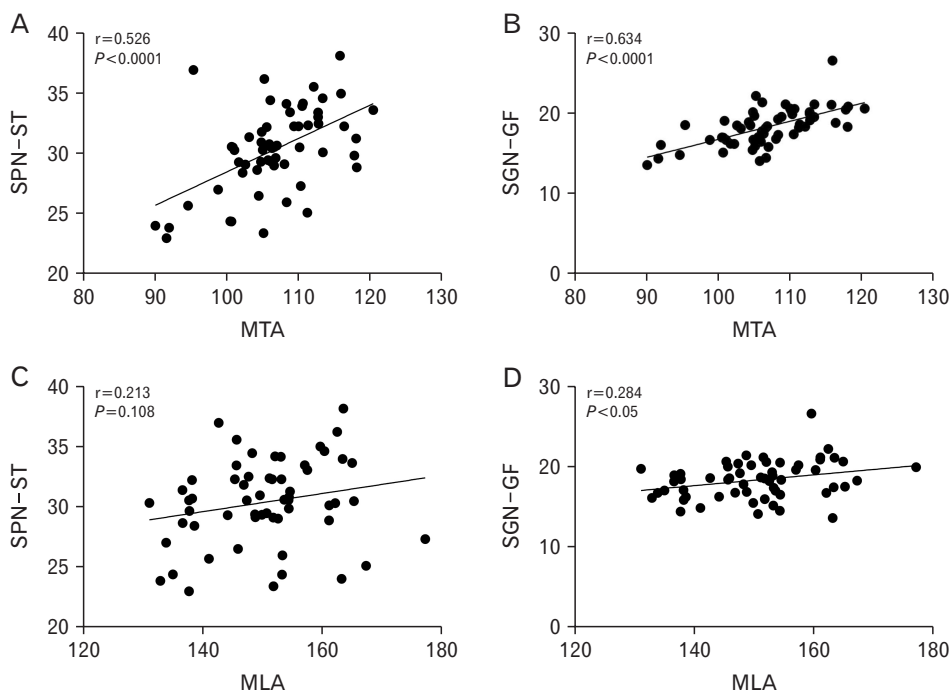


Fig. 4. Correlation between pairs of measurements. (A) MTA and SPN–ST. (B) MTA and SGN–GF. (C) MLA and SPN–ST. (D) MLA and SGN–GF; ($P<0.05$). MTA, major transverse axis; SPN–ST, distance from the scapular notch to the most prominent part of the supraglenoid tubercle; MLA, major longitudinal axis; SGN–GF, distance from the spinoglenoid notch to the posterolateral margin of the glenoid fossa.

ment of the MLA of the scapulae ($P>0.05$) (Fig. 4).

Discussion

Given that the SPN allows the passage of the suprascapular nerve through the scapula, and that its morphological characteristics are a possible predisposing factor to the entrapment of the suprascapular nerve, different parameters have been established for the characterization of the SPNs. Among these parameters is the classification method of Ren-gachary et al. [12], which is based on qualitative characteristics and can therefore generate subjective results. However, as there is currently no quantitative method for the classification of SPNs, our work was based on said classification. In the present study, type II SPN was the most prevalent (36.2%) type of SPN. This finding is similar to that obtained by Manikum et al. [14] in a South African population. The SPN with the lowest prevalence in our study was type V (1.7%), as was found in the work carried out by Boyan et al. [15] in a Turkish population. The literature shows important differences in the prevalences of the specific types of SPNs, which, according to Sangam et al. [10] vary depending on the origin of the study population, as can be seen in Table 1. Along these lines, Inoue et al. [16] determined that age is a factor that influences the type of SPN. In their study, they showed that individuals with SPN type VI scapulae had an average age of 68 years, individuals with type V scapulae had an average age of 65 years, and the SPNs types I, II, III, and IV were mostly seen in younger individuals. For this reason, we consider that there are differences in the results of our study, given that age was an intermittent statistic in the different studies. In addition, our samples correspond to the Chilean population, which is different from the populations used in these other studies.

Regarding scapular dimensions, our research agrees with a study carried out on dry scapulae from individuals from Malawi [18], as scapulae with SPN type III presented the lowest mean for MLA measurements. In contrast, our MTA-related findings differ from those of the study by Kaledzera et al. [18], in which the scapulae with SPN type IV exhibited the lowest average. Adewale et al. [19] studied scapulae of individuals from Uganda, and they found that the lowest MLA and MTA measurements corresponded with SPN type II scapulae in their study population. Thus, our results agree with the studies mentioned above in finding that MLA and MTA measurement did not differ significantly according to

the type of SPNs.

Shishido and Kikuchi [6] reported that the minimum distances required to create a safe zone for the suprascapular nerve are 21 mm for the SPN-ST distance and 14 mm for the SGN-GF distance. However, this definition is not standard, as Thanh et al. [20] dissected 30 shoulders (from nine males and six females) of Vietnamese origin and determined that the minimum SPN-ST required to safeguard the suprascapular nerve was 26 mm and for the SGN-GF this was 18 mm. In our study, the means for the SPN-ST and the SGN-GF were higher than these critical distances, and they exceeded the minimum values for a safe area that were stipulated by other studies. For this reason, we postulate that the minimum distances for a safe zone of the suprascapular nerve will vary according to the study population. With this in mind, we suggest that in the Chilean population the recommended distances required to safeguard the suprascapular nerve against surgical procedures that require intervention of the glenohumeral joint would be 30.38 mm for the SPN-ST distance and 18.34 mm for the SGN-GF distance.

Urgüden et al. [21] highlighted in their study on 100 scapulae that the safe distances for the suprascapular nerve were not related to the type of SPN. Observations similar to our study, where the SPN-ST and SGN-GF means did not present significant differences between the types of SPNs. This aspect differs from the conclusions of a study carried out on scapulae of African origin, which suggested that surgical procedures on scapulae with SPN type II required extra caution to protect against injury to the suprascapular nerve, as scapulae with this type of notch presented measurements outside of those required for a safe zone [9]. Along these lines, Sangam et al. [10] conducted a study on scapulae of individuals from India in which they determined that SPN type IV scapulae presented more critical values for SPN-ST, putting the suprascapular nerve at risk during surgical procedures that involved the glenoid process of the scapula.

The indices for the safety measures indicated that the SPN-ST and the SGN-GF compared to the MTA were statistically significant ($P<0.0001$), so a positive correlation of moderate intensity was observed, that is, as the dimension of the MTA increases, so do the SPN-ST and SGN-GF distances. Thus, during surgical procedures on the shoulder, the suprascapular nerve could be safer from injury in individuals who have much wider scapulae. We identified a significant ($P<0.05$) but weak relationship between the SGN-GF and the MTA, such that as the length of the scapula increases, so

does the SGN–GF distance. Consequently, the suprascapular nerve probably will be safer at the level of the SGN in scapulae that have greater lengths during surgical procedures involving the shoulder. However, the MLA measurement did not influence the critical measures to safeguard the suprascapular nerve at the SPN level. As a limitation of our study, it was unfortunately not possible to make comparisons in relation to this aspect, due to the absence of information available in the literature.

Based on what has been discussed in this chapter, we consider that as there is no agreement in the literature regarding the relationship of a type of SPN exclusive to a risk area or a safe area of the suprascapular nerve, the type of SPN should not be taken into account within surgical procedures when determining a safe zone for the suprascapular nerve. However, our findings allow us to suggest that the dimensions of the MTA and MLA of the scapula can be considered predictors of a safe zone for the suprascapular nerve and should therefore be considered during preoperative evaluation and planning. In this context, computed tomography is presented as a useful tool in clinical diagnosis, since it allows detailed identification of the dimensions and type of SPN [16], elements that are considered a risk factor for suprascapular nerve compression [1, 22], and also offers a precise characterization of the morphometric parameters of the scapula [23], which contributes to risk reduction and effective surgical planning.

In conclusion, the prevalences in our study population of SPNs type II (36.2% prevalence), type I (29.3% prevalence) and type III (26.0% prevalence) were high compared to those reported in other populations. In the Chilean population, the SPN–ST and SGN–GF distances required to preserve the suprascapular nerve in surgical procedures within the shoulder and scapula regions are 30.38 mm and 18.34 mm, respectively. The finding that MTA and MLA could be used to predict the safe zone that exists for the suprascapular nerve expands our understanding of the anatomy of the scapula; these findings could acquire clinical importance through contributing to the planning of more precise surgical strategies that involve the suprascapular nerve and the shoulder.

It is essential to increase the sample sizes in the populations under investigation in future studies. In addition, progress must be made in the exploration of fresh cadaveric material, and in conducting imaging studies, for which it would be ideal to use three-dimensional computed tomography, as has been performed in other cases [23], in order to identify

those morphometric characteristics in the scapula that indicate a safe zone for the suprascapular nerve.

ORCID

Jhonatan Duque-Colorado:

<https://orcid.org/0009-0002-5949-4407>

Laura García-Orozco:

<https://orcid.org/0009-0002-1449-2774>

Andrés Riveros: <https://orcid.org/0000-0003-3655-6871>

Mariano del Sol: <https://orcid.org/0000-0003-3686-6757>

Author Contributions

Conceptualization: JDC, MS. Data acquisition: JDC, AR. Data analysis or interpretation: JDC, MS, LGO. Drafting of the manuscript: JDC, AR, MS, LGO. Critical revision of the manuscript: JDC, AR, MS, LGO. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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