Características vocais de atletas de uma equipe de futebol americano

Vocal characteristics of athletes from an american football team

Características vocales de atletas de un equipo de fútbol americano

Recebido: 13/02/2020 | Revisado: 02/03/2020 | Aceito: 02/03/2020 | Publicado: 11/03/2020

Débora Bonesso Andriollo
ORCID: https://orcid.org/0000-0002-6461-180X
Universidade Federal de Santa Maria, Brasil
E-mail: deborabandriollo@gmail.com
Gabriele Rodrigues Bastilha
ORCID: https://orcid.org/0000-0003-4207-8001
Universidade Federal de Santa Maria, Brasil
E-mail: fonogabriele@gmail.com
Letícia Fernandez Frigo
ORCID: https://orcid.org/0000-0001-5407-6607
Universidade Franciscana, Brasil
E-mail: leticia_frigo@hotmail.com
Carla Aparecida Cielo
ORCID: https://orcid.org/0000-0002-7219-0427
Universidade Federal de Santa Maria, Brasil
E-mail: cieloca@yahoo.com.br

Resumo

O objetivo deste estudo foi verificar as medidas vocais de atletas de uma equipe de futebol americano de um município de interior de estado. Participaram oito homens, com idades entre 18 e 39 anos (média de 24,25 anos). Foi realizada a coleta do Tempo Máximo de Fonação das vogais /a/, /i/, /u/, /s/, /z/, /e/ e a contagem de números em *pitch* e *loudness* habituais e o Tempo Máximo de Fonação do [ė]. O Nível de Pressão Sonora modal e a extensão dinâmica foram obtidos por meio da emissão de /a:/. Realizou-se avaliação acústica de fonte glótica e espectrográfica. Os tempos máximos de fonação ficaram abaixo da normalidade; a relação s/z dentro da normalidade; a relação ė/e abaixo da normalidade; a diferença entre vogais e contagem de números, o nível de pressão sonora modal e a extensão dinâmica ficaram acima da normalidade. A análise vocal acústica mostrou comprometimento da fonte glótica enquanto as espectrografias foram consideradas normais. Nesses atletas de futebol americano, verificou-se incoordenação pneumofonoarticulatória com características hiperfuncionais e sinal acústico com presença de instabilidade, aperiodicidade e falhas na emissão vocal, provavelmente devido aos usos vocais incorretos praticados no esporte.

Palavras-chave: Acústica; Atletas; Fonação; Futebol Americano; Voz.

Abstract

The objective of this study was to verify the vocal measurements of athletes from an american football team from a municipality in the countryside of the state. With participation of eight men, aged between 18 and 39 years old (average of 24.25 years old). The collection of maximum phonation time of the vowels /a/, /i/, /u/, /s/, /z/, /e/ and number counting in normal pitch and loudness and the maximum phonation time of the [ė] was performed. Modal Sound Pressure Level and dynamic range were obtained by emission of /a:/. Acoustic evaluation of glottal and spectrographic sources. Maximum phonation times were below normality; the s/z ratio within the normality; the ratio ė/e below normality; the difference between vowels and number counting, the modal sound pressure level and the dynamic range were above normality. The acoustic vocal analysis showed impairment of the glottic source while the spectrographs were considered normal. In these American football athletes, pneumo-phono-articulatory incoordination with hyperfunctional characteristics and acoustic signal with presence of instability, aperiodicity and vocal emission failures were found, probably due to the incorrect vocal uses practiced in the sport.

Keywords: Acoustic; Athletes; Football; Phonation; Voice.

Resumen

Este estudio tuvo como objetivo verificar las mediciones vocales de atletas de un equipo de fútbol americano en un municipio del interior del estado. Con la participación de ocho hombres, con edades comprendidas entre 18 y 39 años (promedio de 24.25 años). El tiempo máximo de fonación de las vocales /a/, /i/, /u/, /s/, /z/, /e/ y el recuento de números en tono y volumen habituales y el tiempo máximo de fonación de la vocal [ė]. El nivel de presión sonora modal y la extensión dinámica se obtuvieron mediante la emisión de /a:/. Evaluación acústica de fuente glótica y espectrográfica. Los tiempos máximos de fonación fueron inferiores a lo normal; la relación s/z dentro de la normalidad; la relación ė/e por debajo de lo normal; la diferencia entre las vocales y el recuento de números, el nivel de presión sonora

modal y la extensión dinámica estaban por encima de lo normal. El análisis vocal acústico mostró deterioro de la fuente glótica mientras que las espectrografías se consideraron normales. En estos jugadores de fútbol, hubo una falta de coordinación neumophonoarticulatory con características hiperfuncionales y una señal acústica con la presencia de inestabilidad, aperiodicidad y fallas de emisión vocal, probablemente debido a los usos vocales incorrectos practicados en el deporte.
Palabras clave: Acústica; Atletas; Fonación; Fútbol Americano; Voz.

1. Introduction

Among team sports such as Handball and Basketball, American Football (AF) is on the rise in Brazil (Pinto, Berdacki, Biesek, 2014). Due to the particularities of the game that involves many vocalizations, aspects of vocal production require research that advances knowledge and guides possible behaviors and treatments.

Study says that football coaches and fitness coaches experience problematic situations in relation to vocal health: they do not have proper guidance in this regard; have inappropriate vocal habits; have lack of knowledge and lack of care with the voice; have intense demands on the use of voice in the profession; face vocal risk conditions at work; have complaints, signs and symptoms (Penteado, Silva, 2014). These data suggest that if the team leaders do not have the necessary care with their own voice and, probably, with that of their athletes.

Vocal emission is a constant and extremely common event for most people, yet it has quite complex physiology. Criteria and measurements related to vocal production such as frequency (f0), maximum phonation time (MPT) and sound pressure level (SPL) may be fine-tuned according to the vocal fold vibration pattern (Behlau et al., 2013, Cielo, Frigo, Christmann, 2013).

Respiratory support interferes with the measurement of MPT, commonly used in speech therapy clinic to determine vocal efficiency and the degree of dysphonia (Cielo, Frigo, Christmann, 2013, Pinho, 2013). Vocal quality is sustained by an air column and adequate vocal fold vibration. Wide and deep breathing, with the use of the correct costo-diaphragmatic breathing pattern, allows the subglottic pressure exerted properly for vocal projection and SPL (Fontana, Marin, 2013).

Factors such as subglottic air pressure, transglottic airflow, glottic resistance, contraction of intrinsic laryngeal muscles, glottic adduction pattern, vibratory mass, stiffness and elasticity of the vocal folds and acoustic coupling of the cavities above and below the vocal folds should operate synchronously phonation (Cielo, Frigo, Christmann, 2013). Changes related to these aspects may favor distortions and are present in dysphonia, also influencing the SPL, altering the usual loudness (Cielo, Frigo, Christmann, 2013).

The acoustic analysis of the voice can be used to verify the glottal source, extracting different measurements that, when analyzed together, make it possible to understand the frequency, aperiodicity, stability and harmonic energy of the vocal signal (Cielo et al., 2015, Cielo, Lima, Christmann, 2016, Freitas et al., 2015, Lima, Cielo, Christmann, 2016).

The evaluation of the spectrographic tracing informs about the nature of the sound source and the contribution of the resonance system, providing data in two aspects: the distribution of harmonics in the spectrum and analysis of the formants (F) of the sound. The higher the number of harmonics, the richer the vocal quality is, and the more individualized and linear, the higher the harmonic component of emission and the stability of sustain, and the lesser the amount of aperiodic energy or noise (Beber, Cielo, 2012, Beber, Cielo, 2012).

In men, the results of acoustic vocal analysis follow certain patterns that result from their anatomical and physiological characteristics. These characteristics refer to the position and size of the larynx and vocal tract, and the length and width of the vocal folds, which are larger in men. However, there are few studies in the literature with this population (Beber, Cielo, 2012, Beber, Cielo, 2012).

Even rarer are studies aimed at coaches, fitness coaches and especially team sports athletes such as the AF. There is no thorough understanding of the vocal characteristics, demands, working conditions and health-disease processes experienced by sports workers. and the performance of health professionals in these categories is a little explored field (Penteado, Silva, 2014).

In vocal terms, AF players perform aerobic work and may have had their aerodynamic measurements normal or above normal for respiratory gain. On the other hand, AF is a sport that also involves increased physical strength, increased vocal tension with increased loudness and shouting, which could increase SPL measurements and worsen acoustic vocal findings due to vocal hyperfunction.

Justifying the need for research on the vocal repercussions of athletes of collective sports, as shown above, this study aimed to verify the vocal measurements of athletes of an AF team from a municipality in the countryside of the state.

2. Method

Study from a larger study previously approved by the Ethics Committee on Research with Human Beings of the home institution (0306.0.243.000-10). The study group consisted of athletes from an AF team from a medium-sized municipality in the countryside of the state who performed aerodynamic and acoustic vocal assessment. The subjects received clarifications about their participation in the research and signed the Informed Consent Form (ICF).

The convenience sample consisted of eight male AF athletes aged between 18 and 39 years old (average 24.25 years old). Inclusion criteria for the subjects were: men 18 years old or older; AF practitioners for a period of more than one uninterrupted year; and who signed from ICF. The following were excluded: records with incomplete data; men under 18 years old; practitioners of the sport for less than one year; smokers or drinkers.

Audiometric screening was performed by pure tone scanning by air at frequencies of 500, 1000, 2000 and 4000 Hz at 25 dB in an acoustically treated room (Fonix audiometer, FA –12 type I). Screening was performed to exclude athletes with possible hearing loss that could interfere with voice self-monitoring (Beber, Cielo, 2012, Behlau et al., 2013, Cielo, Frigo, Christmann, 2013, Lima, Cielo, Christmann, 2016, Pinho, 2003). Among the evaluated athletes, there was no detection of hearing loss.

From 14 subjects, eight men who met the inclusion and exclusion criteria were selected. Six athletes of AF were excluded for presenting incomplete data.

Measurements of Maximum Phonation Times (MPT), modal Sound Pressure Level (SPL), Dynamic Extension (SPL minimum and SPL maximum), acoustic vocal analysis of glottal and spectrographic sources were collected. The objective was to perform a multidimensional voice evaluation considering the complementarity of the different evaluations when a vocal profile is desired (Beber, Cielo, 2011, Beber, Cielo, 2012, Behlau et al., 2013, Cielo, Frigo, Christmann, 2013, Cielo, Lima, Christmann, 2016, Freitas et al., 2015, Lima, Cielo, Christmann, 2016, Pinho, 2003).

All emissions were captured in a quiet place with environmental noise below 50 dBSPL, measured by a digital sound pressure level meter (Icel, DL-4200) (Beber, Cielo, 2011, Beber, Cielo, 2012, Behlau et al., 2013, Lima, Cielo, Christmann, 2016). Subjects were instructed to sustainly emit the vowels /a/, /i/, /u/, /s/, /z/, /e/ and number counting in normal pitch and loudness and the MPT of the [ė] (/e/ voiceless) in the standing position after deep inhalation in MPT until the end of expiration. Each MPT was collected three times, in the same way for all athletes with a stopwatch (*Stop Watch*, VL512) and the highest value of each

(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i4.2813

measurement was considered (Behlau et al., 2013, Cielo, Frigo, Christmann, 2013, Cielo, Gonçalves, Christmann, 2015, Martins, Couto, Gama, 2014, Pinho, 2003).

A professional digital recorder of (*Zoom*, H4n) (96 kHz, 16 bits, 50% input signal pickup level), with attached microphone (*Behringer*, ECM 8000) (flat frequency response from 15 to 20 kHz) was used. The microphone was positioned at an angle of 90º in front and 4 cm from the mouth for vowel emission and at 10 cm for fricatives and number counting (Beber, Cielo, 2012, Behlau et al., 2013, Lima, Cielo, Christmann, 2016).

In MPT, the male normality pattern used was between 25 and 35 s for vowels /a/, /i/ and /u/ and 15 to 25 s for /z/ and /s/ (Behlau et al., 2013), and for /e/ and [ė] the range of 16 to 18 s was used (Pinho, 2003). In the number counting, the normality pattern considered was 1 to 3 s greater than the average of the vowels /a, i, u/, since the difference greater than 4 s is considered indicative of phonation hyperfunction (Behlau et al., 2013).

Values below the normality in voiced phonemes were considered as probable air escape to phonation and above as a possible presence of glottic hyperfunction (Behlau et al., 2013, Cielo, Frigo, Christmann, 2013). For the non-voiced ones, the reduced values were considered as suggestive of lack of expiratory control and the increased values as better than expected airflow control (Cielo, Frigo, Christmann, 2013).

The modal SPL was obtained through the emission of the vowel /a:/, with sound pressure meter (Icel, DL-4200), positioned 90º in front of the subject's mouth and 30 cm away (Beber, Cielo, 2011, Behlau et al., 2013, Cielo et al., 2015, Cielo, Frigo, Christmann, 2013, Martins, Couto, Gama, 2015). The normality value of modal SPL for men was 64 dB (Behlau et al., 2013). Also, with the sound pressure meter, the weakest and strongest possible emission of /a:/ was requested, composing the dynamic range of the subject. Normality for men at minimum SPL = 54 dB (lowest possible loudness) and maximum SPL = 76 dB (strongest possible loudness) (Behlau et al., 2013).

Several acoustic source and vocal filter measurements were used due to the fact that there is no consensus on which measurements adequately represent the acoustic, biological and auditory-perceptual phenomena of the human voice. Several measurements refer to the same phenomenon with different algorithms or different analyzes. Thus, they should be interpreted together in relation to the phenomenon/parameter that is intended to be verified for greater accuracy.

For acoustic evaluation of glottal source, Kay Pentax® Multi Dimensional Voice Program Advanced (MDVPA) software was used, with 44 kHz pickup rate and 16-bit analog-digital conversion. A vowel /a:/ analysis was performed, edited without the vocal attack and the end of the emission to avoid stretches of higher instability in the signal (Beber, Cielo, 2011, Behlau et al., 2013). The standard time for analysis was 3 s.

These measurements were interpreted together, according to the acoustic phenomenon to which they were related. **Frequency measurements** were taken: fundamental frequency (f0), maximum f0 (fhi), minimum f0 (flo), standard deviation of f0 (STD); **frequency perturbation measurements**: absolute jitter (Jita), percentage or relative jitter (Jitt), f0 relative average perturbation (RAP), f0 perturbation quotient (PPQ), smoothed f0 perturbation quotient (sPPQ), f0 variation (vf0); **amplitude perturbation measurements**: absolute or dB shimmer (ShdB), percentage or relative shimmer (Shim), amplitude perturbation quotient (APQ), smoothed amplitude perturbation quotient (sAPQ), amplitude variation (vAm); **noise measurements**: noise-harmonic ratio (NHR), voice turbulence index (VTI), soft phonation index (SPI); **voice break measurements**: degree of voice breaks (DVB), number of voice breaks (NVB); **measurements of unvoiced segments**: number of unvoiced segments (NUV), degree of unvoiced segments (DUV); **sub-harmonic segment measurements**: degree of sub-harmonic components (DSH), number of sub-harmonic segments (NSH). Thus, it was possible to analyze the levels of aperiodicity/noise, harmonic energy, frequency and stability of the voice signal. The f0 was considered as the reference standard of 80 to 150 Hz for men and, for the other measurements, the normality proposed by the MDVPA was considered (Beber, Cielo, 2011, Behlau et al., 2013, Cielo et al., 2015, Freitas et al., 2015).

Spectrographic analysis was performed using Kay Pentax® Real Time Spectrogram (RTS) software. The emission of the vowel /a:/ was analyzed resulting in images of the spectrographic acoustic voice analysis. In a broadband filter, 100 points (646.00 Hz) were used and in a narrowband filter 1024 points (63.09 Hz), both with 11 kHz pickup rate, 16-bit analog-digital resolution and 5 kHz analysis window. The following indicators were analyzed in the broadband spectrography (BS): intensity of the formant tracing color (F) (1st Formant-F1, 2nd Formant-F2, 3rd Formant-F3 and 4th Formant-F4), of low, medium and high frequencies and the whole vocal spectrogram; tracing regularity at whole vocal spectrogram and at low, medium and high frequencies; definition, regularity and bandwidth of F1, F2, F3 and F4; and anti-resonance immediately above F1 at whole vocal spectrogram and at low, medium and high frequencies. In narrowband spectrography (NS), the intensity of the tracing color, definition, regularity and number of harmonics, presence of sub-harmonics, presence of noise and replacement of harmonics by noise at low, medium and high frequencies and at whole vocal spectrogram (Beber, Cielo, 2011, Beber, Cielo, 2012, Behlau et al., 2013, Cielo, Frigo, Christmann, 2013).

For the analysis, low frequencies were considered below 1500 Hz, medium frequencies between 1500 and 3000 Hz and high frequencies above 3000 Hz (Beber, Cielo, 2012).

Two speech therapists judges with training and experience in spectrographic vocal analysis (average of ten years) and non-authors of the study visually analyzed the spectrographs. They received the images of NS and BS without the presentation of the subjects' voices, in order to avoid being influenced by the presence of the sound signal (Beber, Cielo, 2012). The judges were instructed to mark a vertical line crossing an analog-visual scale (10 cm horizontal line with limits on the right and left) where it best represented their perception for each item evaluated, which may vary from zero to ten (Beber, Cielo, 2012, Pinho, 2001). The average between the judges' evaluations for each item analyzed was calculated. As normality values were considered smaller than 34 mm (Pinho, 2001).

The collected data were gathered in an evaluation form and later organized in tables with descriptive analysis and the percentage of non-normal individuals for a better understanding of the results (measurements of MPT, SPL and MDVPA).

3. Results

Table 1 shows the results of the MPT and SPL measurements of the AF athletes. All MPT were below normality and the ratio ė/e, the comparison between vowel average and number counting and SPL measurements were above normality.

Table 1 – Descriptive measurements of MPT and SPL of AF athletes

MPT and SPL							
	Min	**Max**	**X**	**SD**	**CV%**	**NL**	**%**
MPT/a/ (s)	9.2	28.7	16.1	6.6	40.6	25 to 35	87.5
MPT/i/ (s)	7.5	26.5	15.6	7.4	47.3	25 to 35	87.5
MPT/u/ (s)	8.5	31.8	16.4	7.9	48.2	25 to 35	87.5
MPT/s/ (s)	9.3	17.7	12.8	2.8	21.8	15 to 25	75

MPT/z/ (s)	7.7	21.6	13.3	5.3	39.8	15 to 25	75
MPT/e/ (s)	8.1	22.3	13.5	4.9	36.1	16 to 18	100
MPT/ė/ (s)	1.1	15.8	9.8	4.3	44.2	16 to 18	100
n (s) counting	6.6	24	18.7	6.0	32.0	25 to 35	100
/a/, /i/ and /u/ (s) average	8.9	26.2	16	6.7	42.0	25 to 35	87.5
s/z	0.5	1.6	1.1	0.4	37.2	0.8 to 1.2	62.5
ė/e	0.1	1.4	0.7	0.4	53.3	0.8 to 1.2	75
Difference between the /a/, /i/ and /u/ average and the n (s) counting	2.1	7	5.1	2.0	39.0	1 to 3 s	75
SPL (dB)	66	87	77	7.3	9.5	64	100
Min. SPL (dB)	52	69	60.1	6.6	11.0	54	100
Max. SPL (dB)	72	106	89.1	13.3	15.0	76	100

Legend: MPT: maximum phonation time; s: seconds; SPL: sound pressure level; Min: minimum value; Max: maximum value; X: group average; SD: standard deviation; CV%: coefficient of variation; NL: normality; %: percentage of non-normal individuals; dB: decibel; ė: /e/ voiceless; n counting: number counting.

Table 2 shows the results of acoustic vocal measurements of glottic source using MDVPA. The STD, vf0, sAPQ, vAm, SPI, DUV and NUV measurements were above normality.

Table 2 – Descriptive measurements of MDVPA in AF athletes

Vocal Acoustic Analysis by MDVPA							
	Min	**Max**	**X**	**SD**	**CV%**	**NL**	**%**
f0 (Hz)	85.7	129.1	112.7	15.7	13.9	80 to 150	0
fhi (Hz)	89.6	137.6	120.0	16.9	14.1	0 to 150.1	0
flo (Hz)	82.3	119.9	104.5	14.2	13.5	0 to 140.4	0
STD (Hz)	1.2	4.8	2.1	1.1	53.1	0 to 1.3	87.5
Jita (us)	41.3	115.2	82.4	23.4	28.3	0 to 83.2	37.5
Jitt (%)	0.5	1.2	1	0.2	26.5	0 to 1	25
RAP (%)	0.3	0.7	0.5	0.2	32.0	0 to 0.7	0
PPQ (%)	0.3	0.7	0.5	0.1	25.8	0 to 0.8	0
sPPQ (%)	0.6	1.1	0.9	0.2	22.1	0 to 1	37.5
vf0 (%)	1.3	4	2	0.9	47.8	0 to 1.1	100
ShdB (dB)	0.2	0.4	0.3	0.1	27.3	0 to 0.3	50
Shim (%)	2.2	4.9	3.6	1.0	26.7	0 to 3.8	50
APQ (%)	2.1	3.8	3	0.5	16.5	0 to 3.1	37.5
sAPQ (%)	4.5	9	6.7	1.6	24.4	0 to 4.2	100
vAm (%)	13.4	32.1	21.2	6.2	29.4	0 to 8.2	100
NHR (%)	0	0.2	0.1	0	53.4	0 to 0.2	0
VTI	0	0	0	0	0	0 to 0.1	0
SPI	7.6	56.7	22.5	15.0	66.9	0 to 14.1	75

DVB (%)	0	0	0	0	0	0 to 1	0
DSH (%)	0	0	0	0	0	0 to 1	0
DUV (%)	0	4	1.1	1.6	146.0	0 to 1	37.5
NVB (%)	0	0	0	0	0	0 to 0.9	0
NSH (%)	0	0	0	0	0	0 to 0.9	0
NUV (%)	0	4	1.1	1.6	146.9	0 to 0.9	37.5

Legend: f0: fundamental frequency (Hz); fhi: maximum f0 (Hz); flo: minimum f0 (Hz); STD: standard deviation of f0 (Hz); Jita: Absolute Jitter (us); Jitt: Percent or Relative Jitter (%); RAP: pitch relative average perturbation (%); PPQ: f0 perturbation quotient (%); sPPQ: smoothed f0 perturbation quotient (%); vf0: f0 variation (%); ShdB: Absolute or dB (dB) shimmer; Shim: Percentage or relative shimmer (%); APQ: amplitude perturbation quotient (%); sAPQ: smoothed amplitude perturbation quotient (%); vAm: amplitude variation (%); NHR: noise-harmonic ratio (%); VTI: voice turbulence index; SPI: soft phonation index; DVB: degree of vocal breaks (%); DSH: degree of sub-harmonic components (%); DUV: degree of unvoiced segments (%); NVB: number of vocal breaks (%); NSH: number of sub-harmonic segments (%); NUV: number of unvoiced segments (%); Min: minimum value; Max: maximum value; X: group average; SD: standard deviation; CV%: coefficient of variation; NL: normality; %: Percentage of non-normal individuals.

Table 3 shows the results of the average of the judges in the evaluation of the BS of AF athletes. All parameters evaluated presented up to 9.1 mm of alteration, considered normal.

Table 3 – Descriptive measurements of broadband filter spectrography of AF athletes using RTS

RTS Broadband Spectrography					
	Min	**Max**	**X**	**SD**	**CV%**
Tracing color intensity of F1	5.7	8.5	6.9	1.0	14.0

Tracing color intensity of F2	5	8.5	6.5	1.2	18.2
Tracing color intensity of F3	4	7.7	5.7	1.3	22.3
Tracing color intensity of F4	3.5	5.7	4.7	0.8	17.5
Tracing color intensity of low f	4.9	8.3	6.5	1.2	19.2
Tracing color intensity of medium f	4.8	7	6	0.8	13.9
Tracing color intensity of high f	3.7	6.2	4.8	1.0	21.2
Tracing color intensity at a whole vocal spectrogram	5	7.7	6.5	1.2	18.0
Definition and regularity of F1	6	8.5	7.2	0.9	13.0
Definition and regularity of F2	5.2	7.8	6.6	1.0	15.1
Definition and regularity of F3	4.4	8	5.9	1.2	20.2
Definition and regularity of F4	2.7	7.2	4.9	1.4	28.2
Regularity of vertical striation tracing at low frequencies	5.5	7.9	6.6	0.9	13.3
Regularity of vertical striation tracing at medium frequencies	5	7.8	6.2	1.0	15.6
Regularity of vertical striation tracing at high frequencies	3.9	6.5	5.1	0.8	15.2
Regularity of vertical striation tracing in the spectrogram as a whole	5.4	8	6.2	0.9	15.2
Bandwidth of F1	5.5	9.1	6.2	1.1	17.4
Bandwidth of F2	5.1	8.5	6.4	1.0	16.0

Bandwidth of F3	4.5	8.4	5.6	1.2	21.8
Bandwidth of F4	2.2	8	4.8	1.82	36.1
Anti-resonance above F1	1.4	5.3	2.9	1.2	40.9
Anti-resonance at low f	1.9	5.2	3.4	1.1	33.2
Anti-resonance at medium f	2.7	5.8	3.9	1.1	28.6
Anti-resonance at high f	3.5	6.5	4.8	0.9	19.4
Anti-resonance in the vocal spectrogram as a whole	2.5	6.5	4	1.2	30.1

Legend: f = frequency; F = formant; Min: minimum value; Max: maximum value; X: group average; SD: standard deviation; CV%: coefficient of variation.

Table 4 presents the NS acoustic analysis (average judge values) of the AF athletes. All parameters evaluated presented up to 8 mm of alteration, considered normal.

Table 4 – Descriptive measurements of narrowband filter spectrography of AF athletes using RTS

RTS Narrowband Spectrography					
	Min	**Max**	**X**	**SD**	**CV%**
Tracing color intensity of low f	3.9	7.7	6.2	1.3	21.3
Tracing color intensity of medium f	3.9	6.9	5.5	1.2	21.5
Tracing color intensity of high f	0	7.6	3.8	2.3	59.9
Tracing intensity at a whole vocal spectrogram	3.4	6.9	5.4	1.2	21.6
Presence of noise at low f	3.2	5.4	4.1	0.8	18.7

Presence of noise at medium f	3.5	5.7	4.3	0.8	18.0
Presence of noise at high f	0.3	6.9	4.3	2.0	47.0
Noise in the whole vocal spectrogram	3.2	5.2	4.5	0.8	18.1
Substitution of h for noise at low f	2	4.2	2.8	0.7	24.1
Substitution of h for noise at medium f	3	4.5	3.8	0.5	13.1
Substitution of h for noise at high f	0.1	5.5	4.3	1.8	40.9
Substitution of h for noise at whole vocal spectrogram	3.7	6	4.4	0.8	18.8
Definition and regularity of h at low f	4	7.7	6	1.2	20.2
Definition and regularity of h at medium f	2.9	6.6	5.1	1.3	24.7
Definition and regularity of h at high f	1.2	5.5	3.6	1.6	43.7
Definition and regularity of h at whole vocal spectrogram	3.7	6.5	5	1.1	22.7
Number of h at low f	3.9	8	6.3	1.3	21.0
Number of h at medium f	3.5	7.2	5	1.5	29.8
Number of h at high f	0.2	5.9	3.2	2.1	67.6
Number of h at whole vocal spectrogram	4	7	4.8	1.0	18.5

Presence of sub-h at low f	2.5	3.7	3.3	0.4	11.4
Presence of sub-h at low f	2.2	4.2	3.4	0.6	17.6
Presence of sub-h at low f	1.5	5.2	3.9	1.1	29.2
Presence of sub-h at whole vocal spectrogram	3	4.9	3.8	0.8	22.1

Legend: f = frequency; h = harmonic; Min: minimum value; Max: maximum value; X: group average; SD: standard deviation; CV%: coefficient of variation.

4. Discussion

The altered results of the present study, which will be discussed below, suggest the presence of pneumophonoarticulatory incoordination (IPFA) with probable hyperfunction. This is in accordance with the incorrect vocal uses of AF players related to increased physical strength, increased vocal tension with increased loudness and shouting generally observed during sports practice (Pinto, Berdacki, Biesek, 2014)..

In this group of athletes, all MPT (vowels, fricatives, [ė] and vowel average) were below normality. These results suggest transglottic air leakage and IPFA (Cielo et al., 2015, Cielo, Frigo, Christmann, 2013, Martins, Couto, Gama, 2015, Pinho, 2003) (Table 1) and are in agreement with research (Christmann et al., 2013) in which MPT /a/, /i/ and /u/ were significantly decreased in men.

In this study, the s/z ratio was within normality, but the ė/e ratio was lowered, suggesting glottal hyperfunction. The difference between vowel average and number counting was above normal, also indicating vocal hyperfunction. The ė/e ratio and the difference between vowel average and number counting also indicate IPFA (Table 1) (Behlau et al., 2013, Christmann et al., 2013, Pinho, 2003).

Research (Christmann et al., 2013) showed a s/z ratio with normal values in men, meeting our results. This ratio enables the verification of the occurrence of the component of muscle hypercontraction and lack of vocal fold coaptation, being one of the relevant data for the diagnosis of dysphonia (Behlau et al., 2013, Christmann et al., 2013).

It is noteworthy that this measure should not be interpreted in isolation, since altered MPT/s/ and /z/ may result in a normal s/z ratio, leading to false negatives (Christmann et al., 2013), as can be observed in the analyze the other measurements. The analysis of all these data is important to evaluate risk factors for the development of dysphonia with increasing vocal demand, which will probably occur when these athletes are in a game practice.

Modal SPL, minimum SPL and maximum SPL were above normality in our study (Table 1). This result suggests that the AF athletes used the increased loudness voice without adequate use of the respiratory level and the vocal apparatus as shown by the reduced MPT and the measurements suggestive of glottal hypercontraction.

Vocal production occurs at three levels: respiratory, glottic and supraglottic. These levels promote voice SPL control. At respiratory level, increased SPL may occur with increased aerodynamic power. At the glottic level, an increase in SPL may occur when contraction of the laryngeal adductor musculature increases airflow resistance and the closed phase of the glottic cycle. This also interferes with the respiratory level, causing subglottic air pressure to increase to overcome glottic block. At the supraglottic, articulatory or resonant level, the increase in SPL is related to vocal tract resonance with important effects on acoustic energy distribution, so that the sound produced in the glottis is modulated according to the vocal tract configuration, resulting in vocal projection (Beber, Cielo, 2011, Behlau et al., 2013, Christmann et al., 2013, Pinho, 2003). Possibly this group of AF athletes mostly emphasize the glottic level, with IPFA and muscle hypercontraction, also reflecting in the acoustic vocal measurements of altered glottic source (Table 2).

In this investigation, STD, vf0, vAm, sAPQ, SPI, NUV e DUV measurements showed higher values than expected, that is, instability, aperiodicity/noise and vocal emission failures. The other measurements were within normal limits for males (Table 2).

Analyzing these results together, it is suggested that, due to the vocal effort expended in the practice of AF by these athletes and the IPFA, the glottic source began to present objective signs of vibratory irregularities that should be investigated by an otolaryngologist. These findings partially agree with those of research with men with larynx with no disorders and no vocal complaints in which most glottic source measurements were above normal MDVPA (Lima, Cielo, Christmann, 2016).

In the acoustic spectrographic analysis BS and NS (Tables 3 and 4), it was found that all aspects evaluated were well below the 34 mm adopted as acceptable, being considered within the normality or very discreet. These results partially disagree with research with young men without vocal complaints and larynx without disorders in which they were found: large amount of noise at a whole spectrum and at high frequencies, poorly defined F3, median noise at low frequencies, uneven tracing, median anti-resonance, low intensity at a whole spectrum and especially at high frequencies (Beber, Cielo, 2012).

Our result reinforces the vocal spectrography as a complementary instrument to the other evaluations (Beber, Cielo, 2011, Beber, Cielo, 2012, Behlau et al., 2013, Cielo, Lima, Christmann, 2016, Pinho, 2003), since it was observed that the altered spectrographic measurements in very discrete degree can be considered normal in men (Beber, Cielo, 2012) and not agreed with the other measurements that were altered.

Voice is the fundamental working tool for establishing a good and effective communicative and interactive relationship within a sports team. Poor environmental conditions, allied to the presence of inappropriate habits, lack of knowledge and lack of information about voice care configure risk conditions for vocal health. There is a need for studies on the relationship between work, care, health and vocal well-being of fitness coaches, football coaches (Penteado, Silva, 2014) and sportsmen who use their voice during physical practice.

The literature (Beber, Cielo, 2012, Freitas et al., 2015, Lima, Cielo, Christmann, 2016, Penteado, Silva, 2014) shows few studies on male voice and no investigation on the voice of AF athletes, making it difficult to compare results with other studies and exposing the gap to be filled with future research.

5. Conclusion

In this group of AF athletes, there were measurements suggestive of pneumophonoarticulatory incoordination with hyperfunctional characteristics and acoustic signal of glottal source with presence of instability, aperiodicity and vocal emission failures, possibly due to the incorrect vocal uses practiced in the AF.

The limited number of AF athletes in Brazil and in this study, as well as the lack of research on the voice of AF athletes, suggests the deepening of knowledge on the subject. Future studies with larger samples and the application of vocal self-assessment, auditory perceptual assessment and otorhinolaryngology may contribute to the establishment of vocal characteristics of these athletes and measurements of vocal health promotion.

References

Beber, B. C., Cielo, C. A. (2012). Features of wide and narrow band spectrography as for vocal emission of men with larynx without diseases. *Rev CEFAC*, 14(2), 290-297.

Beber, B. C.; Cielo, C. A. (2011). Vocal acoustic characteristic in men with normal voice and laryngeal. *Rev CEFAC*, 13(2), 340-351.

Behlau, M., Madazio, G., Feijó, D., Pontes, P. A. (2013). *Avaliação da Voz*. In: Behlau, M. Voz - o livro do especialista. Rio de Janeiro: Revinter, p. 85-245.

Cielo, C. A., Frigo, L. F., Christmann, M. (2013). Sound pressure level and maximum phonation time after Finger kazoo technique. *Rev CEFAC*, 15(4), 994-1000.

Cielo, C. A., Gonçalves, B. F. T., Lima, J. P. M., Christmann, M. K. (2015). Maximum phonation time of /a/, maximum phonation time predicted and respiratory type in adult women without laryngeal disorders. *Rev CEFAC*, 17(2), 358-363.

Cielo, C. A., Lima, J. P. M., Christmann, M. K. (2016). Comparison of effects of finger kazoo and tube phonation techniques in women with normal voice. *Audiol Commun Res*, 21:e1554.

Christmann, M. K., Scherer, T. M., Cielo, C. A., Hoffmann, C. F. (2013). Maximum phonation time of future professional voice users. *Rev CEFAC*, 15(3), 622-630.

Fontana, P., Marin, L. (2013). The influence of a training program in vocal quality respiratory and lung function of participants Coral Unochapecó. A influência de um programa de treinamento respiratório na qualidade vocal e função pulmonar dos participantes do Coral Unochapecó. *Fisis Enectus*, 1(2), 25-33.

Freitas, S. V,. Pestana, P. M., Almeida, V., Ferreira, A. (2015). Integrating voice evaluation: correlation between acoustic and audio-perceptual measures. *J Voice*, 29(3), 391–397.

Lima, J. P. M., Cielo, C. A., Christmann, M. K. (2016). Phonotherapy with phonation in tubes in a patient with surgical medial vocal fold paralysis: case study. *Rev CEFAC*, 18(6), 1466-1474.

Martins, P. C., Couto, T. E., Gama, A. C. C. (2015). Auditory-perceptual evaluation of the degree of vocal deviation: correlation between the Visual Analogue Scale and Numerical Scale. *CoDAS*, 27(3), 279-284.

Penteado, R. Z., Silva, N. B. (2014). Voice and work conditions of soccer coaches and physical trainers. *Dist Comun*, 26(4), 790-799.

Pinho, S. M. (2003). *Avaliação e tratamento de voz*. In: Pinho, S. M. Fundamentos de Fonoaudiologia - Tratando os distúrbios da voz. São Paulo: Guanabara Koogan, p. 3-40.

Pinho, S. M. R. (2001). *Tópicos em voz.* Rio de Janeiro: Guanabara Koogan, p. 19-38.

Pinto, S. I. F., Berdacki, V.S., Biesek, S. (2014). Avaliação da perda hídrica e do grau de conhecimento em hidratação de atletas de futebol americano. *Rev Bras Nutr Esport*, 8(45),171-179.

Porcentagem de contribuição de cada autor no manuscrito

Débora Bonesso Andriollo –25%

Gabriele Rodrigues Bastilha – 25%

Letícia Fernandez Frigo – 15%

Carla Aparecida Cielo – 35%