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Which Mathematical and Physiological Formulas are Describing Voice Pathology: An Overview

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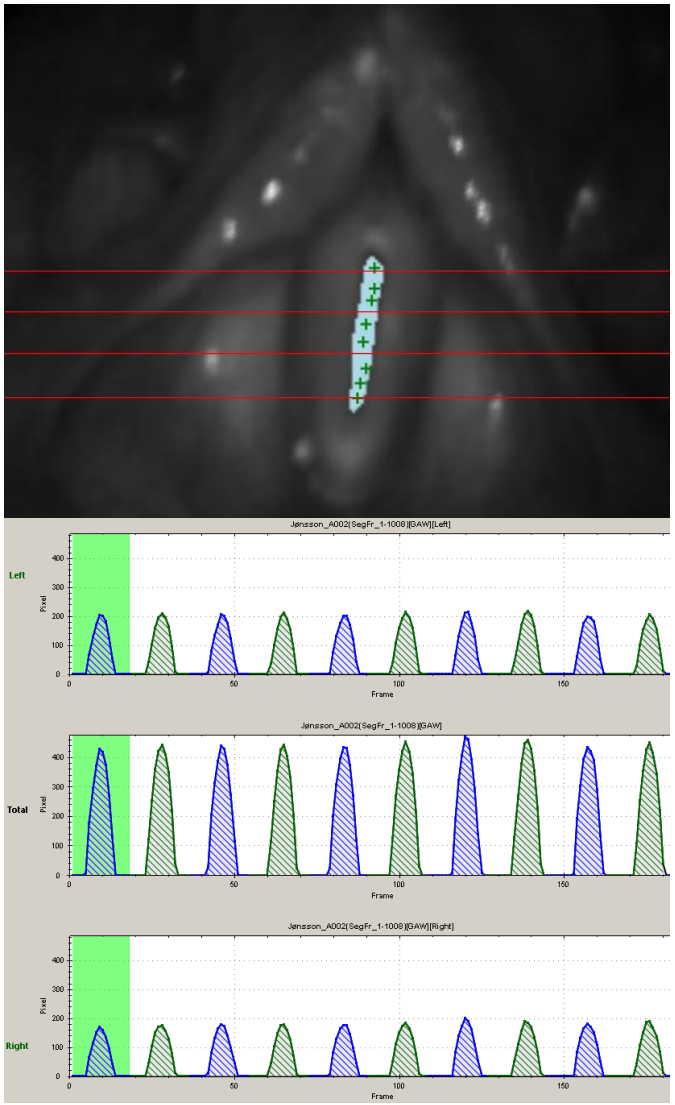
Abstract

This study focuses upon changes in quantifiable parameters of voice production comparing normal voices and patients with complaints of hoarseness for more than two weeks. Acoustical signals and high speed films were data sources for mathematical and physiological formulas statistics of the voices.

The software ”Glottis Analysis Tools” (Erlangen, Germany) includes acoustical measurements and data sources in Glottal Area Waveforms (GAW) and Phonovibrograms (PVG), based on high speed film data. High speed film data were captured with high speed camera and software from Wolf Ltd, Germany.

Data with statistical significant difference between 12 healthy voices and 12 patients with complaints of hoarse voices in a prospective case/control study were presented. The commonly used acoustical and physiological parameters showed hardly any statistical difference between the normal persons and the persons with complaints of hoarseness for more than two weeks.

This suggests that evidence on physiological and acoustical measures of voice pathology is insufficient. Focus should be upon newer methods and tissue function.



Glottal area waveform:
”Space curves” – the area between the vocal folds is calculated and plotted in a curve.
The curves switches between green and blue to indicate change between the different cycles in the software system from Erlangen, Germany

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All mathematical and physical formulas in "Glottis Analysis Tools" Erlangen, Germany

Source: Audio
APF(%)
APQ-11(%)
APQ-3(%)
APQ-5(%)
AVI
CHNR-v1(dB)
CHNR-v2(dB)
CPP(dB)
Cycle-duration(ms)
EPF(%)
EPQ-11(%)
EPQ-3(%)
EPQ-5(%)
Fundamental-Freq(Hz)
GNE
Harmonics-Intensity(%)
HNR(dB)
Jitt(%)
Jitt-Factor
Jitt-Ratio
max-Harmonic(Hz)
max-WMC
mean-Jitt(ms)
mean-Shim(dB)
mean-WMC
min-Subharmonic(Hz)
NNE(dB)
PPF(%)
PPQ-11(%)
PPQ-3(%)
PPQ-5(%)
PVI
RAP-v1
RAP-v2
Shim(%)
SNR-v1(dB)
SNR-v2(dB)
Spectral-Flatness(SFM)

Source: GAW
Amplitude-Length-Ratio
Amplitude-Periodicity
Amplitude-Quotient
Amplitude-Symmetry*
Amplitude-Symmetry-Index
APF(%)
APQ-11(%)
APQ-3(%)
APQ-5(%)
Asymmetrie-Quotient
AVI
CHNR-v1(dB)
CHNR-v2(dB)
Closing-Quotient(ClQ)
CPP(dB)
Cycle-duration(ms)
DynamicRange-Symmetry*
DynamicRange-Symmetry-Index
EPF(%)
EPQ-11(%)
EPQ-3(%)
EPQ-5(%)
Fundamental-Freq(Hz)
Glottal-Area-Index(AC/OQ)
Glottis-Gap-Index(GGI)
GNE
Harmonics-Intensity(%)
HNR(dB)
Jitt(%)
Jitt-Factor
Jitt-Ratio
max-Harmonic(Hz)
Maximum-Area-Declination-Rate
max-WMC
mean-Jitt(ms)
mean-Shim(dB)
mean-WMC
min-Subharmonic(Hz)
NNE(dB)
Open-Quotient(OQ)
Peak-Acceleration
Peak-Closing-Velocity
Phase-Asymmetry*
Phase-Asymmetry-Index
Plateau-Quotient(PQ)
PPF(%)
PPQ-11(%)
PPQ-3(%)
PPQ-5(%)
PVI
RAP-v1
RAP-v2
Rate-Quotient(RQ)
Shim(%)
SNR-v1(dB)
SNR-v2(dB)
Spatial-Symmetry*
Spatial-Symmetry-Index
Spectral-Flatness(SFM)
Speed-Index(SI)
Speed-Quotient(SQ)
Stiffness
Time-Periodicity
Waveform-Symmetry-Index

Souce: Phonovibrogram (PVG)
ContourAngles-Symmetry*
ContourAngles-Symmetry-Index
Contour-Angle(DEG)

Source: Trajectories 50%
Amplitude-Symmetry*
Amplitude-Symmetry-Index
DynamicRange-Symmetry*
DynamicRange-Symmetry-Index
Phase-Asymmetry*
Phase-Asymmetry-Index
Waveform-Symmetry-Index
Amplitude-Length-Ratio
Amplitude-Periodicity
Amplitude-Quotient
APF(%)
APQ-11(%)
APQ-3(%)
APQ-5(%)
Asymmetrie-Quotient
AVI
CHNR-v1(dB)
CHNR-v2(dB)
Closing-Quotient(ClQ)
CPP(dB)
Cycle-duration(ms)
EPF(%)
EPQ-11(%)
EPQ-3(%)
EPQ-5(%)
Fundamental-Freq(Hz)
Glottal-Area-Index(AC/OQ)
Glottis-Gap-Index(GGI)
GNE
Harmonics-Intensity(%)
HNR(dB)
Jitt(%)
Jitt-Factor
Jitt-Ratio
max-Harmonic(Hz)
Maximum-Area-Declination-Rate
max-WMC
mean-Jitt(ms)
mean-Shim(dB)
mean-WMC
min-Subharmonic(Hz)
NNE(dB)
Open-Quotient(OQ)
Peak-Acceleration
Peak-Closing-Velocity
Plateau-Quotient(PQ)
PPF(%)
PPQ-11(%)
PPQ-3(%)
PPQ-5(%)
PVI
RAP-v1
RAP-v2
Rate-Quotient(RQ)
Shim(%)
SNR-v1(dB)
SNR-v2(dB)
Spectral-Flatness(SFM)
Speed-Index(SI)
Speed-Quotient(SQ)
Stiffness
Time-Periodicity

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A material based on 12 normal persons in our clinic. Jitter values, based on three different data sources (glottal area waveform, trajectories 50% and audio)

Parameter	Source	Type	n	mean	std	min	max
Jitt(%)	[Audio]		12	8,17	8,1	0,65	27,8
	[GAW]		12	5,63	3,36	0	9,86
		[Left]	10	6,04	3,09	1,92	10,8
		[Right]	12	5,42	3,18	0	10,4
	[Traj-50%]	[Left]	11	9,17	5,11	3,84	20,1
		[Right]	12	8,75	3,82	3,82	16
Jitt-Factor	[Audio]		12	8,34	8,26	0,65	28,2
	[GAW]		12	5,52	3,32	0	9,61
		[Left]	10	5,98	3,12	1,78	10,8
		[Right]	12	5,37	3,16	0	10,3
	[Traj-50%]	[Left]	11	9,31	5,07	3,82	19,9
		[Right]	12	8,69	3,85	3,75	15,9
Jitt-Ratio	[Audio]		12	81,7	81	6,46	278
	[GAW]		12	56,3	33,6	0	98,6
		[Left]	10	60,4	30,9	19,2	108
		[Right]	12	54,2	31,8	0	104
	[Traj-50%]	[Left]	11	91,7	51,1	38,4	201
		[Right]	12	87,5	38,2	38,2	160

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A clinical material based on 12 normal persons. Shimmer and stiffness values, based on three different data sources (glottal area waveform, trajectories 50%) and audio also

			n	mean	std	min	max
Parameter	Source	Type					
Shim(%)	[Audio]		12	0,63	0,54	0,03	13,9
	[GAW]		12	0,68	0,6	0,28	2,28
		[Left]	10	1,71	0,93	0,7	3,45
		[Right]	12	2,39	1,62	0,82	5,51
	[Traj-50%]	[Left]	11	11,2	8,38	2,57	29,5
		[Right]	12	13,5	11,6	4,52	38,3
Stiffness	[GAW]		10	0,36	0,07	0,21	0,42
		[Left]	8	0,37	0,08	0,2	0,43
		[Right]	10	0,37	0,08	0,19	0,45
	[Traj-50%]	[Left]	9	0,41	0,06	0,32	0,5
		[Right]	10	0,39	0,06	0,3	0,48

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COMMONLY USED PARAMETERS

The commonly used parameters show no statistical difference between 12 normal persons and 12 persons with complaints of hoarseness in a prospective case control study (SAS program 9,4 Spearman Rank correlation coefficient test).

Parameter	Source	Type	Estimate	Standard Error	DF	t Value	Pr >|t|	Parameter	Source	Type	Estimate	Standard Error	DF	t Value	Pr >|t|
Jitt(%)	[Audio]		0,31	3,56	22	0,09	**0,93**	**Stiffness**	[GAW]		0,01	0,02	20	0,57	**0,57**
Jitt(%)	[GAW]		-1,42	1,44	22	-0,99	**0,33**	**Stiffness**	[GAW]	[Left]	0,02	0,03	18	0,58	**0,57**
Jitt(%)	[GAW]	[Left]	-1,84	1,51	20	-1,23	**0,23**	**Stiffness**	[GAW]	[Right]	0,01	0,03	20	0,37	**0,72**
Jitt(%)	[GAW]	[Right]	-2,04	1,32	22	-1,55	**0,14**	**Stiffness**	[Traj-50%]	[Left]	-0,01	0,03	19	-0,21	**0,84**
Jitt(%)	[Traj-50%]	[Left]	-0,74	1,87	21	-0,39	**0,7**	**Stiffness**	[Traj-50%]	[Right]	0	0,03	20	-0,15	**0,88**
Jitt(%)	[Traj-50%]	[Right]	-1,32	1,46	22	-0,9	**0,38**	**Amplitude-Length-Ratio**	[GAW]		-0,24	0,55	20	-0,44	**0,66**
Jitt-Factor	[Audio]		0,44	3,61	22	0,12	**0,9**	**Amplitude-Length-Ratio**	[GAW]	[Left]	-0,05	0,32	18	-0,16	**0,87**
Jitt-Factor	[GAW]		-1,6	1,47	22	-1,09	**0,29**	**Amplitude-Length-Ratio**	[GAW]	[Right]	-0,31	0,33	20	-0,93	**0,36**
Jitt-Factor	[GAW]	[Left]	-2,03	1,54	20	-1,32	**0,2**	**Amplitude-Length-Ratio**	[Traj-50%]	[Left]	-0,01	0,01	19	-0,92	**0,37**
Jitt-Factor	[GAW]	[Right]	-2,08	1,29	22	-1,62	**0,12**	**Amplitude-Length-Ratio**	[Traj-50%]	[Right]	-0,02	0,01	20	-1,6	**0,12**
Jitt-Factor	[Traj-50%]	[Left]	-0,65	1,9	21	-0,34	**0,74**	**Amplitude-Periodicity**	[GAW]		0,03	0,03	20	1,16	**0,26**
Jitt-Factor	[Traj-50%]	[Right]	-1,38	1,5	22	-0,92	**0,37**	**Amplitude-Periodicity**	[GAW]	[Left]	0,05	0,03	18	1,82	**0,09**
Jitt-Ratio	[Audio]		3,1	35,61	22	0,09	**0,93**	**Amplitude-Periodicity**	[GAW]	[Right]	0,03	0,03	20	0,98	**0,34**
Jitt-Ratio	[GAW]		-14,18	14,38	22	-0,99	**0,34**	**Amplitude-Periodicity**	[Traj-50%]	[Left]	0,03	0,03	19	1,19	**0,25**
Jitt-Ratio	[GAW]	[Left]	-18,45	15,06	20	-1,23	**0,23**	**Amplitude-Periodicity**	[Traj-50%]	[Right]	0,02	0,03	20	0,48	**0,63**
Jitt-Ratio	[GAW]	[Right]	-20,37	13,17	22	-1,55	**0,14**	**Amplitude-Quotient**	[GAW]		0,11	0,31	20	0,35	**0,73**
Jitt-Ratio	[Traj-50%]	[Left]	-7,37	18,67	21	-0,39	**0,7**	**Amplitude-Quotient**	[GAW]	[Left]	0,01	0,32	18	0,05	**0,96**
Jitt-Ratio	[Traj-50%]	[Right]	-13,19	14,59	22	-0,9	**0,38**	**Amplitude-Quotient**	[GAW]	[Right]	0,04	0,35	20	0,1	**0,92**
Shim(%)	[Audio]		1,27	21,82	22	0,06	**0,95**	**Amplitude-Quotient**	[Traj-50%]	[Left]	0,01	0,26	19	0,05	**0,96**
Shim(%)	[GAW]		-0,61	0,54	22	-1,13	**0,27**	**Amplitude-Quotient**	[Traj-50%]	[Right]	-0,2	0,29	20	-0,7	**0,49**
Shim(%)	[GAW]	[Left]	-1,21	0,65	20	-1,86	**0,08**	**Amplitude-Symmetry***	[GAW]		0,1	0,13	20	0,76	**0,46**
Shim(%)	[GAW]	[Right]	-0,73	0,86	22	-0,84	**0,41**	**Amplitude-Symmetry***	[Traj-50%]		-1316,17	1447,91	20	-0,91	**0,37**
Shim(%)	[Traj-50%]	[Left]	-6,53	6,34	21	-1,03	**0,31**	**Amplitude-Symmetry-Index**	[GAW]		0,03	0,04	20	0,79	**0,44**
Shim(%)	[Traj-50%]	[Right]	1,9	4,07	22	0,47	**0,64**	**Amplitude-Symmetry-Index**	[Traj-50%]		0,07	0,07	20	1,07	**0,3**

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CONCLUSION

"Glottis Analysis Tools" video analysis is an interesting supplement of voice analysis, as it operates on vocal fold level instead of acoustical level.

There are 2 problems:

1. The old measures of voice analysis do not show statistical difference between normal and pathological voices, complaining of hoarseness in our prospective case /control study. Still stiffness measures standard deviations are of interest.
2. Randomized studies are lacking. The new methods on the market should be focused upon: Overtones/ harmonics – Optical Coherence Tomography – Narrow Band Imaging

Find the slides on:
http://www.mpedersen.org
Thank you for your attention!