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COUGH AND VALSALVA MANEUVERS ARE DIFFERENT: FREQUENCY SPECTRUM ANALYSIS

AIMS OF STUDY: Cough and Valsalva maneuvers are often used in the dynamic testing of stress urinary incontinence (SUI). One apparent difference between these maneuvers is the speed of the pressure rise. However, it is uncertain whether the female lower urinary tract responds with the same physiologic process for these maneuvers, as it has been observed clinically that cough leak point pressure is higher than Valsalva leak point pressure or vice versa. We believe that a biomechanical analysis of pressure transmission occurring during stress maneuvers will prove useful in discerning the changes occurring in both normal and incontinent women, and affect our understanding of the pathophysiology of SUI. The primary purpose of this research was to characterize the relationships between the urethrovesical pressure signals in the frequency domain, and to determine the functional input-output relationship (transfer function) between these pressures for the normal female continence mechanism.

METHODS: Frequency spectrum analysis based on the discrete finite Fourier transform was used to study the intravesical and urethral pressure measurement during cough and Valsalva in 15 premenopausal healthy and continent

women (mean age 34.8 years, range 19-48; mean parity 1.6, range 0-3). Urodynamic measurements were made using an 8F dual-tip microtransducer and custom-made amplifier system, having a frequency response of 0 to 1 kHz and a resolution of 0.25 cmH_2O, with a sampling rate of 128 Hz, a rate far higher than commercially available urodynamic systems. The raw measurement data was exported to an IBM PC for post urodynamic processing to determine the degree of technical artifacts for careful data screening of successful trials, and to estimate various urodynamic parameters. Cross spectral density, coherence, and transfer functions were estimated. All the numerical calculations were performed using MATLAB V4.3 signal processing toolbox programs.

RESULTS & CONCLUSIONS: The coherence spectra between the two pressure signals are well correlated below 14 Hz and 7 Hz for cough and Valsalva, respectively. This indicates that a higher sampling rate of greater than 28 Hz (at least twice the frequency band from the Nyquist principle) is needed for urodynamic measurements in stress continent women but most commercially available urodynamic systems do not have this capability. Therefore, a new technology applying a higher sampling frequency may be required for future urodynamic investigations of normal and pathologic outlet function.

Frequency distributions from the coherence plots during cough and Valsalva are shown in Table 1. Importantly, the spectral distributions of the two maneuvers are statistically different with the cough coherence spectra having higher magnitudes and wider frequency bands than the Valsalva spectra. The transfer function gain spectra in the frequency bands are essentially flat for cough, meaning the two pressure increases has a certain fixed ratio or strong linearity [1,3]. Though having a similar trend, the Valsalva gain spectra has more variations in their flat spectra so that a much weaker or nonlinear relationship between the two pressures may exist. In a concurrent study with 46 stress incontinent women, the cough leak point pressure is correlated with pressure transmission (correlation coefficient, ρ = 0.55) but not with MUCP (ρ = 0.07), while Valsalva leak point pressure is associated with MUCP (ρ = 0.63) but not with pressure transmission (ρ = -0.17). Therefore, the two dynamic tests may address different aspects of female continence, and the urodynamic results can not be extrapolated from each other.

The phase quantity of the transfer function within the frequency bands is essentially negligible for both cough and Valsalva, while some small variations are noted again for the flat Valsalva spectra. The phase quantity is a measure of time delay between the two signals. The estimated time delay is on the order of a few milliseconds. Skeletal muscles have 40~100 msec time delay between the mechanical stimulus and muscle force production. It has been reported that the striated urethral sphincters are composed of type I slow twitch fibers [2]. Therefore, during stress events active muscle activity may not contribute primarily to the urethral pressure increase. Other indirect evidence is that most anti-incontinence surgeries can cure SUI successfully without augmenting neuromuscular components.

In conclusion, this research strongly suggests that cough and Valsalva induce different dynamic responses in the pelvic floor and furthermore, that pressure transmission during stress appears primarily attributable to a passive structural propagation of the abdominal pressure increase [4].

Table 1. Frequency distributions of the urethrovesical pressure signals from coherence (γ^2) plots.

	Frequency where γ^2 = 0.5 [Hz]	Frequency where $\gamma^2 \approx 0.0$ [Hz]
Cough	14.0 (3.9)†	21.7 (3.3)‡
Valsalva	6.8 (5.4)	11.8 (9.9)

REFERENCES : [1] Enhöming, Acta Chir Scand (Suppl.) 276:1-61 [2] Hale et al., Am J Obstet Gynecol 180:342-8, [3] Kim et al., J Biomech 30: 19-25, [4] Kim et al., J Biomech 31:861-5.