FUZZY MODEL OF PELVIC FLOOR MUSCLES DURING SQUATTING

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Hypothesis/ aims of study

Squatting exercises are performed primarily for training the muscles of the hip and thigh. Biomechanical analysis indicates that squatting increases intra-abdominal pressure and recruits the pelvic floor muscles (PFMs). Therefore, understanding the activity of these muscles during exercise can prevent dysfunctions. One strategy to analyze the PFMs is using computational models based on fuzzy logic as decision-making tools. The objective of this original study was to develop a fuzzy logic model to assess the activity of the PFMs during squatting with a barbell.

Materials and methods

This cross-sectional study evaluated adult women. The study population was recruited from universities and gyms and was also referred by volunteers who participated in data collection. Women with self-reported orthopedic lesions or heart disease were excluded. In addition, the volunteers underwent individualized perineal evaluation, a physical squatting test, electromyography (EMG) of the surface of the PFMs, and electrogoniometry of the knee during squatting with a barbell. The models were analyzed using data from volunteers with and without symptoms of urinary incontinence.

The model was built by a specialist in women's health and the authors of this study. The fuzzy model of indicators of PFM activity during squatting with barbell was generated by defining input and output variables. The input variables were selected from the electromyographic records of the PFMs of ten full squats, physical evaluation of the strength of the PFMs by a physical therapist, and barbell weight used to perform the squat, which was determined after the 1RM test.

The data regarding the variable "muscle endurance" from the PERFECT classification were used in the variable FM PFM in the fuzzy model. The value varied from 0 to 15 seconds, with 0 indicating absence of contraction and 15 indicating maximum contraction time.

The value obtained by the volunteers using 70% of the 1RM load was used to feed the variable "WeightAg" in the fuzzy model.

The output variable was the "fuzzy PFM activity index" created by the authors to indicate the activity of the PFMs in the proposed squatting exercise. The minimum and maximum values of this variable ranged from 1 to 5, with 1 indicating poor activity and 5 indicating excellent activity.

After these steps, fuzzy logic models were elaborated using the Fuzzy Logic Toolbox. In this fuzzy model, the type of inference used was of the type Mamdani and centroid defuzzification.

Models with the trapezoidal, triangular, and Gaussian functions and different amounts of fuzzy rules were elaborated. A function was created in the MATLAB environment to optimize data analysis and generate the output variable of the fuzzy models more quickly. The function was designated "calcfuz". This function read the input variables, processed these variables in the created fuzzy model, and generated the fuzzy output variable.

Figure 1 - Radiofrequency Tonederm® G2 Spectra

Results

A total of 76 women were invited to participate, but only 37 subjects were included in the analysis. Eight fuzzy models were developed, and a fuzzy Mamdani model was selected. In addition, three input variables, one output variable, trapezoidal and triangular functions, "and" logic connectors, and centroid defuzzification were used. The mean PFM activity using the fuzzy logic was 2.45 ± 0.72 in the symptomatic group and 3.26 ± 0.78 in the asymptomatic group ($p = 0.03$). The output language variables were "poor," "good," and "excellent." The fuzzy model quantified the activity of PFM muscles during squatting. There was a significant moderate correlation of the fuzzy model (I-MAP fuzzy) with the International Consultation on Incontinence Questionnaire–Short Form (ICIQ-SF) and smallest knee angle during squatting in the groups with and without symptoms of urinary incontinence.

The adopted model was Mamdani with "and" logic connectors and centroid defuzzification

Concluding message

The model adequately provided indicators of the activity of the PFMs during squatting. A lower fuzzy value indicated a lower ability to squat and higher rate of incontinence symptoms among the study participants. This model may be used as a reference for developing tools for clinical applications.

CATERISANO, A. et al. The effect of back squat depth on the EMG activity of 4 superficial hip and thigh muscles. **Journal of strength and conditioning research / National Strength & Conditioning Association**, v. 16, n. 3, p. 428–432, 2002.

CORREA, C. S.; COSTA, R.; PINTO, R. S. Utilização de Diferentes Técnicas para o Controle do Posicionamento dos Eletrodos de Superfície na Coleta do sinal Eletromiográfico. **Rev. Acta Brasileira do Movimento Humano –**, v. 2, n. 2, p. 5–13, 2012.