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DEVELOPMENT OF A NEW DYNAMOMETER FOR MEASURING THE ISOMETRIC FORCE OF THE PELVIC FLOOR MUSCULATURE

Aims of Study

Evaluation of the pelvic floor muscle (PFM) strength is an important parameter in clinical and scientific issues regarding PFM training in the treatment of urinary stress incontinence. So far, physiotherapists have relied on digital assessment, a subjective form of measurement that lacks sensitivity (1), or on indirect sources of measurements of the pelvic floor strength such as surface EMG and pressure measurements, which do not seem to offer adequate specificity (2). The aim of this study was to develop a new instrument capable of directly and accurately measuring PFM strength. This report describes the new dynamometer, presents its originality and documents its measuring accuracy and reliability.

Methods

The new dynamometer comprises a computerized central unit and one peripheral unit, a dynamometric speculum. The speculum comprises two stainless steel branches. While the upper branch of the speculum is fixed, the other, equipped with two pairs of strain gauges, can be moved by an adjustable screw allowing static forces to be measured at different vaginal openings. The forces exerted by the PFM against the speculum are measured using a cantilever principle. During PFM contraction, the lengthening or shortening of a strain gauge changes its electrical resistance which, in turn, is measured as a voltage variation. Voltage values from the strain-gauge amplifiers are then digitized and converted into units of force (N). A computer program presents the PFM force measurements in the form of written data and graphs.

The originality of this dynamometer is threefold. First, it is designed to take direct measurements of the PFM strength at different openings of the speculum, thereby allowing the strength to be measured at different muscle lengths. Second, the dynamometer is designed to take direct measurements of the pelvic floor passive strength at a given opening of the speculum, thus allowing for measurement of PFM tone and vaginal aperture. Third, the strain gauges on the lower branch of the speculum use a differential arrangement (3), ensuring that the force (F) is measured independently of the exact site of application to the lower branch of the speculum in the vagina. This feature is of primary importance in evaluating the maximum PFM strength, since the exact site of the resultant force applied to an intra-vaginal speculum is unknown. Thus a differential arrangement ensures the reliability of repeated measurements.

To establish the accuracy of the new device and determine possible sources of error in the results, a series of in-vitro calibration tests was undertaken. The strain gauges were calibrated for a range of forces from 0 to 15 N. The new instrument was assessed for linearity, reliability with repeated measures and the effects of hysteresis. Moreover, an appreciation study was conducted with 40 incontinent and continent subjects to evaluate the acceptability, comfort and fit of the new device.

Results The voltage output of the strain gauges during imposed force was observed to be highly linear. The results were then fitted with a first-order linear regression and the values of the regression coefficient were 0.999. The slopes and regression coefficients had identical values between trials ($p < .005$) indicating highly reliable measurements (4). Similarly the slopes and regressions obtained for calibrations at three different locations on the moving branch of the dynamometer showed that the same reading was obtained for the same force value ($p<.005$), confirming that the measurement is independent of the force location(4). Finally, the subjects' unanimous appreciation implies that the instrument is acceptable and the measuring procedure comfortable.

Conclusions

This study demonstrates that the dynamometer accurately measures forces applied to its instrumented branch and is deemed acceptable by continent and incontinent women. The new device thus appears to have conceptual and measurement advantages over conventional methods and seems to be a very promising instrument for measuring PFM strength, tone and vaginal apertures. It remains to be seen whether it will prove to be useful for evaluation and treatment of the PFM function in research laboratories and in clinical settings.

References:

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