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A quantitative approach to measure women's sexual function using electromyography: A preliminary study of the Kegel exercise

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Background: Currently, the reference standard used to clinically assess sexual function among women is a qualitative questionnaire. Hence, a generalised and quantitative measurement tool needs to be available as an alternative. This study investigated whether an electromyography (EMG) measurement technique could be used to help quantify women's sexual function.





Material/Methods: A preliminary intervention study was conducted on 12 female subjects, who were randomised into a control (n=6) and an intervention (n=6) group. Intervention involved a set regimen of pelvic floor muscle exercises (Kegel) and the control group did not have any treatment. All subjects were asked to answer a validated, self-rated Pelvic Organ Prolapse/Urinary Incontinence Sexual Function Questionnaire (PISQ). EMG measurements of the pelvic floor muscles (PFM) and the abdominal muscles were taken from all women at recruitment and 8 weeks after study commencement.

Results: After 8 weeks, most of the subjects in the control group did not display any noted positive difference in either PISQ score (4/6) or in their muscle strength (4/6). However, a noted progressive difference were observed in subjects who were placed in the Kegel group; PISQ score (5/6) and muscles strength (4/6).

Conclusions: The noted difference in the Kegel group subjects was that if progress is observed in the sexual function, improvement is also observed in the strength of at least 2 types of muscles (either abdominal or PFM muscles). Thus, EMG measurement is a potential technique to quantify the changes in female sexual function. Further work will be conducted to validate this assumption.

Key words: **women's sexual function • electromyography (EMG) measurement • Pelvic Organ Prolapse/Urinary Incontinence Sexual Function Questionnaire (PISQ) questionnaires • Kegel exercise**

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Background

An essential part of a loving relationship between married partners or couples is an adequate sexual expression which consequently enhances quality of life and provides a sense of physical, physiological, and social well-being [1]. However, it is ultimately challenging for the patient-physician relationship to find the correct way to put forward delicate and probing questions, to decode the answers on sexual health and illness, especially when dealing with women who are having sexual problems, due to the sensitive nature of this matter. The current approach is to gather information via standardized questionnaires or open-ended questionnaires [2].

A questionnaire called the Pelvic Organ Prolapse/Urinary Incontinence Sexual Function Questionnaire (PISQ) was developed to evaluate quality of life, sexual health, and to determine the effect of urine incontinence on sexual activity in women [3]. Although the PISQ is a common tool to evaluate sexual function in women [4], it is governed by the principles of psychometrics that cannot be quantified [5]. Moreover, older women, people aged 75 years and over, and those with poor physical or mental health have difficulty in answering questionnaires, and often require assistance [2,6,7]. This may introduce inconsistencies in the answers provided. In addition, each time the PISQ questionnaires needs to be used in a non-English speaking society, it has to be translated and validated [8]. Hence, a generalised and quantitative measurement tool needs to be available as an alternative to quantify women's sexual function.

Sexual dysfunction commonly results from more than 1 trait. Amid the multiple factors involved in sexual dysfunction, the pelvic floor muscle (PFM) appears to play an important role [9]; healthy PFM in women were found to be crucial for satisfactory genital arousal and attainment of orgasm [10], and weak muscles may provide inadequate stimulation and arousal, thus hindering orgasmic potential [11]. It has been reported that approximately 25–50% of women with PFM disorder have impaired sexual function [6]. Thus, it stands to reason that strengthening the PFM should help improve sexual function.

Studies have demonstrated that PFM exercises improved sexual function in women [12,13]. The Kegel exercise is a PFM exercise that can be done to strengthen the muscles that surround part of the vagina, rectum, and urethra. The benefit of this exercise is said to relieve symptoms from various problems that result from weakened PFM, such as urinary stress incontinence and pelvic organ prolapse, as well as to improve sexual response [14].

The strength of the PFMs (the muscles that surround part of the vagina, rectum, and urethra) can be measured using a

technique called electromyography (EMG), which involves testing the electrical activity of muscles. An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated [15]. The PFM activities can be directly measured using the intra-vaginal EMG measuring device called perineometry (a device that is inserted into vagina to capture EMG signal from PFM) [16]. However, this technique is invasive and can cause patient discomfort.

An alternative to measuring PFM directly with perineometry is to measure the EMG activity of the abdominal muscles using non-invasive surface electrodes. Incremental EMG readings above the baseline level were found during contractions of the PFM [17,18]. Neumann et al demonstrated that individual abdominal wall muscles such as the internal oblique muscles were recruited during maximal PFM contractions [7]. Similar studies have also shown the activation of abdominal muscles while performing PFM exercise movements [7,17,18]. However, to the best of our knowledge, no study has investigated the effects of the abdominal muscles activation on female sexual function after performing PFM exercises. Thus, the aim of this study was to examine the impact of Kegel exercise on female sexual function in relation to the PFM and the the abdominal muscles. The effectiveness of the Kegel exercise intervention was assessed by measuring both subjective and objective outcomes. Female sexual function was qualitatively measured using the PISQ questionnaire. The PFM and the abdominal muscles activity were quantitatively measured using the EMG.

Material and Methods

Subject recruitment

This study was a randomized control trial preliminary study. The target population for this study was married women who currently live in Kuala Lumpur, Malaysia or surrounding areas. The subjects were recruited from general gynecology and medical clinics at the University of Malaya Medical Centre (UMMC). Ethics approval was obtained from the UMMC Ethics Committee. Participants in this study were recruited via a community outreach strategy (e.g., placing posters with tear-off tabs in public locations and advertisements).

Interested participants were asked several screening questions to determine initial eligibility for the study. Screening inclusion criteria include: no diagnosis of bladder cancer or kidney disease, no prior treatment of urinary or bowel incontinence using biofeedback device or any other treatments, no urinary catheter, available to participate in the study for at least 2 months, and not currently pregnant. If these inclusion criteria were met, the participants were given a separate Saturday clinic appointment.

Table 1. PISQ-12 questionnaire [3].

PISQ-12 questions
1. How frequently do you feel sexual desire? This feeling may include waiting to have sex, planning to have sex, feeling frustrated due to lack of sex, etc.
2. Do you climax (have an orgasm) when having sexual intercourse with your partner?
3. Do you feel sexually excited (turned on) when having sexual activity with your partner?
4. How satisfied are you with the variety of sexual activities in your current sex life?
5. Do you feel pain during sexual intercourse?
6. Are you incontinent of urine (leak urine) with sexual activity?
7. Does fear of incontinence (either stool or urine) restrict your sexual activity?
8. Do you avoid sexual intercourse because of bulging in the vagina (the bladder, rectum or vagina falling out)?
9. When you have sex with your partner, do you have negative emotional reactions such as fear, disgust, shame or guilty?
10. Does your partner have a problem with erections that affects your sexual activity?
11. Does your partner have a problem with premature ejaculation that affects your sexual activity?
12. Compared to orgasms you have had in the past, how intense are the orgasms you have had in the past 6 months?

Twelve healthy married women aged 27–55 (mean 36) years were recruited for this preliminary study. Written informed consent was obtained from each subject stating that they agreed to take part in a 2-month intervention program. The 12 subjects were randomly divided into 2 groups; control and intervention groups.

PISQ questionnaires

The questionnaire used in the study was the PISQ-12 questionnaire, which contains 12 questions [3]. Questions 1–4 represent the behavioral-emotive factor, questions 5–9 represent the physical factors, and questions 10–12 represent the partner-related factors [19]. The questions are shown in Table 1.

Scores of the PISQ-12 questionnaire were calculated by totaling the scores for each question. The responses were graded on a 5-point scale from 'Never' to 'Always', but for items 1–4, reverse scoring was used [19]. The PISQ-12 is considered incomplete if the subject answered less than 10 questions [20]. Subjects answered the electronic form of PISQ-12 questionnaires that was translated using Visual Basic (2010) software.

Electromyography assessment

The EMG assessments were conducted while subjects performed the Kegel movement. The surface EMG electrodes were placed at 2 different abdominal muscles: (i) Channel 1 was placed at the left external oblique (OE) muscles which is located on the side and frontal parts of the abdomen, and (ii) Channel 2 was placed at the left internal oblique (IO) muscles over the tip of the eighth rib [7]. Surface EMG activities were recorded and monitored using the Noraxon Telemyo 2400 Wireless Transmission Acquisition System.

To ensure that the subjects performed the correct manoeuvre of the Kegel movement, the PFM activities were also taken

using the intra-vaginal EMG. The perineometry probe was inserted into the subject's vagina to capture the PFM's EMG signal. The measurements were recorded using a device called the FemiScan system [21].

Protocol for Kegel movement and Kegel exercise

Kegel exercises are a simple and inexpensive way to prepare for childbirth and improve muscle tone after delivery. Additionally, this exercise relieves symptoms of various problems that result from weakened PFM: urinary stress incontinence and prolapsed uterus, cystoceles, urethroceles, and rectoceles.

There are a variety of Kegel exercises but all use the same principle, which involves alternating contraction (tightening) and relaxation (releasing) the PFM. These muscles are the same ones recruited to stop the flow of urine when sitting with the legs spread apart [14].

In this study, instruction for Kegel exercise was given by a trained physiotherapist who taught each individual subject in the intervention group. Subjects were asked to contract the PFM muscles while in the supine position. They were asked to perform the maximal contraction for 5 s and the released the contraction for 10 s. One complete cycle of Kegel movement (Figure 1) generally takes about 30 s. Kegel exercise is performed for 30 min per day, which equates to 1 session consisting of 60 cycles. This exercise session is repeated 3 times a week, which is approximately 90 minutes [22].

Study procedure

The study procedure is shown in Figure 2. During clinic visits (the first visit and the second visit, which was 8 weeks after the first visit), the subjects were asked to answer the PISQ questionnaires. At the same time, the muscle activities at the

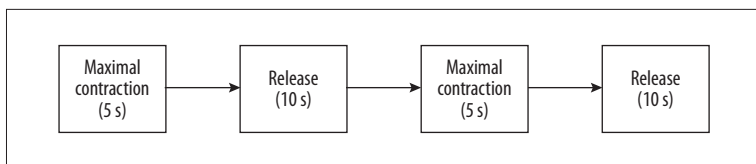


Figure 1. One cycle of Kegel movement.

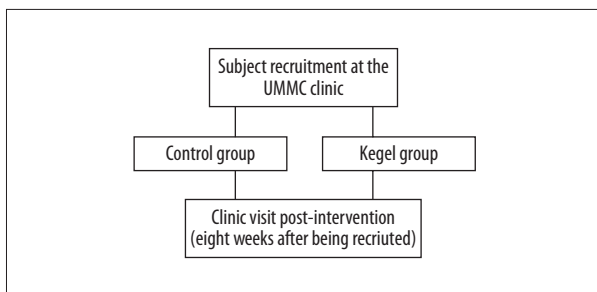


Figure 2. The study procedure flowchart.

PFM and the abdominal muscles were recorded while the subjects performed 1 cycle of the Kegel movements. The subjects performed the movement in a supine position with hips and knees bended. The measurements were taken by a physiotherapist or a nurse.

The subjects in the intervention group were requested to perform the Kegel exercise, while the control subjects were asked to return after 8 weeks without further intervention. Subjects in the Kegel intervention group were given a daily diary card for as a self-reporting instrument and to help discipline themselves to do the exercise.

Table 2. Subject's information.

Control group					
No	Age	Body Mass Index (BMI)	Number of child	Delivery method (in at least one of the delivery)	Menopous
1	36	23	2	Self-voluntary	No
2	36	30	0	—	No
3	29	25	2	Self-voluntary	No
4	49	26	3	Self-voluntary	Yes
5	45	27	1	Caesarean	No
6	43	19	5	Self-voluntary	No
Kegel Group					
1	27	26	1	Caesarean	No
2	36	19	1	Self-voluntary	No
3	33	23	3	Caesarean	No
4	34	19	2	Self-voluntary	No
5	55	32	1	Self-voluntary	Yes
6	28	22	1	Caesarean	No

Data analysis

EMG data collected from the abdominal muscles and the PFM muscles were averaged. Root mean square (RMS) values of the EMG data were calculated across all contractions using sequential 50 ms sliding windows. Then the data was analysed to obtain the raw data of the RMS values. The raw data obtained were viewed offline to detect and cut the different onsets of activity of OE and IO for each contraction depending on the PFM maximal contractions. The mean contraction values were calculated for each patient. MyoResearch XP Master Edition software was used for all data processing.

Results and Discussions

The 12 subjects who participated in the study were randomly divided into 2 groups: Kegel (n=6) and control (n=6) groups.

Table 2 shows the information of each subject in the control and Kegel groups. The oldest subject in the control group was a 49 years old and the oldest subject in the Kegel group was a 55-year-old; both subjects were postmenopausal. Only

Figure 3. Electronic PISQ assessment form.

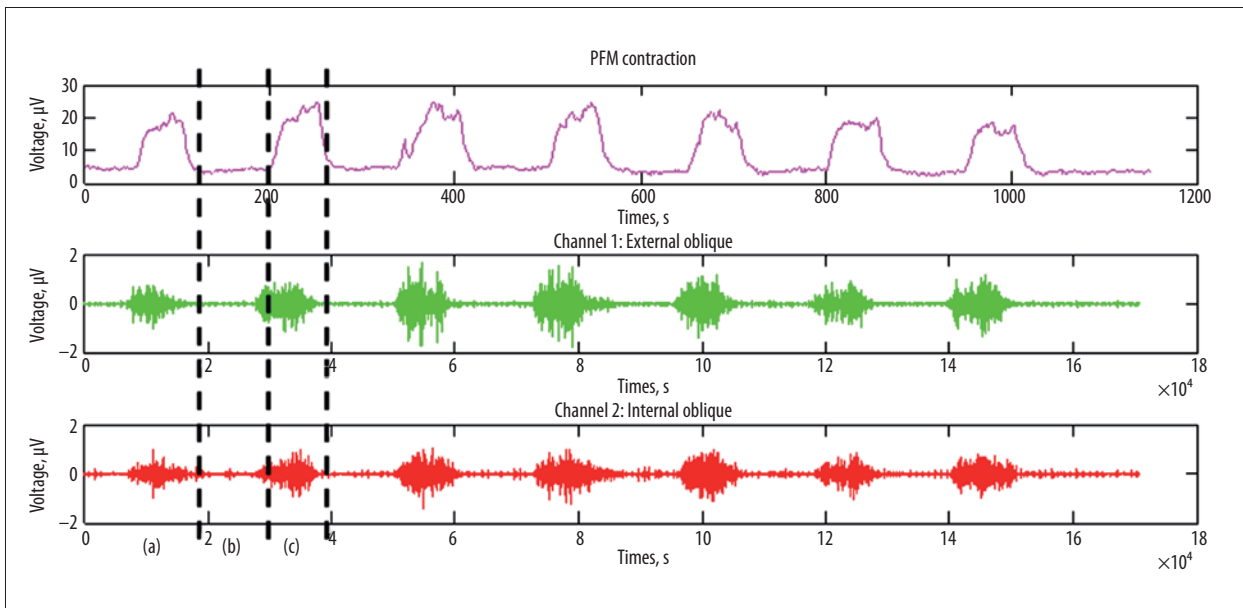


Figure 4. Graph of PFM and individual abdominal muscles contraction.

1 subject in the control group had a previous caesarean section (Subject 5), while 3 subjects in the Kegel group had undergone at least 1 caesarean section. One subject (Subject 2) in the control group was overweight and 1 subject (Subject 5) in the intervention group was moderately obese.

All subjects answered the PISQ questionnaires via an electronic PISQ assessment form (Figure 3). According to the muscles signals in the graph in Figure 4, OE and IO muscles have high relative activation levels, suggesting that both muscles are more closely tied synergistically to the PFM. This signifies that the abdominal muscles and PFM muscles contract simultaneously.

The changes of the PISQ scores and the percentage changes of the muscle strength for each subject in the control and Kegel groups after the intervention period are shown in Figure 5. Table 3A and 3B summarizes the changes.

Based on Figure 5 and Table 3, there are no obvious trends seen in the control group. Most of the subjects showed a decrease in either PISQ score or in their muscles strength. Only 2 subjects in the control group showed a slight improvement in the PISQ score: a 2-unit score increase for Subject 3 and a 3-unit score increase for Subject 6. Four out of 6 subjects showed a marked decrement in their muscle strength (either for OE or IO or PFM muscles).

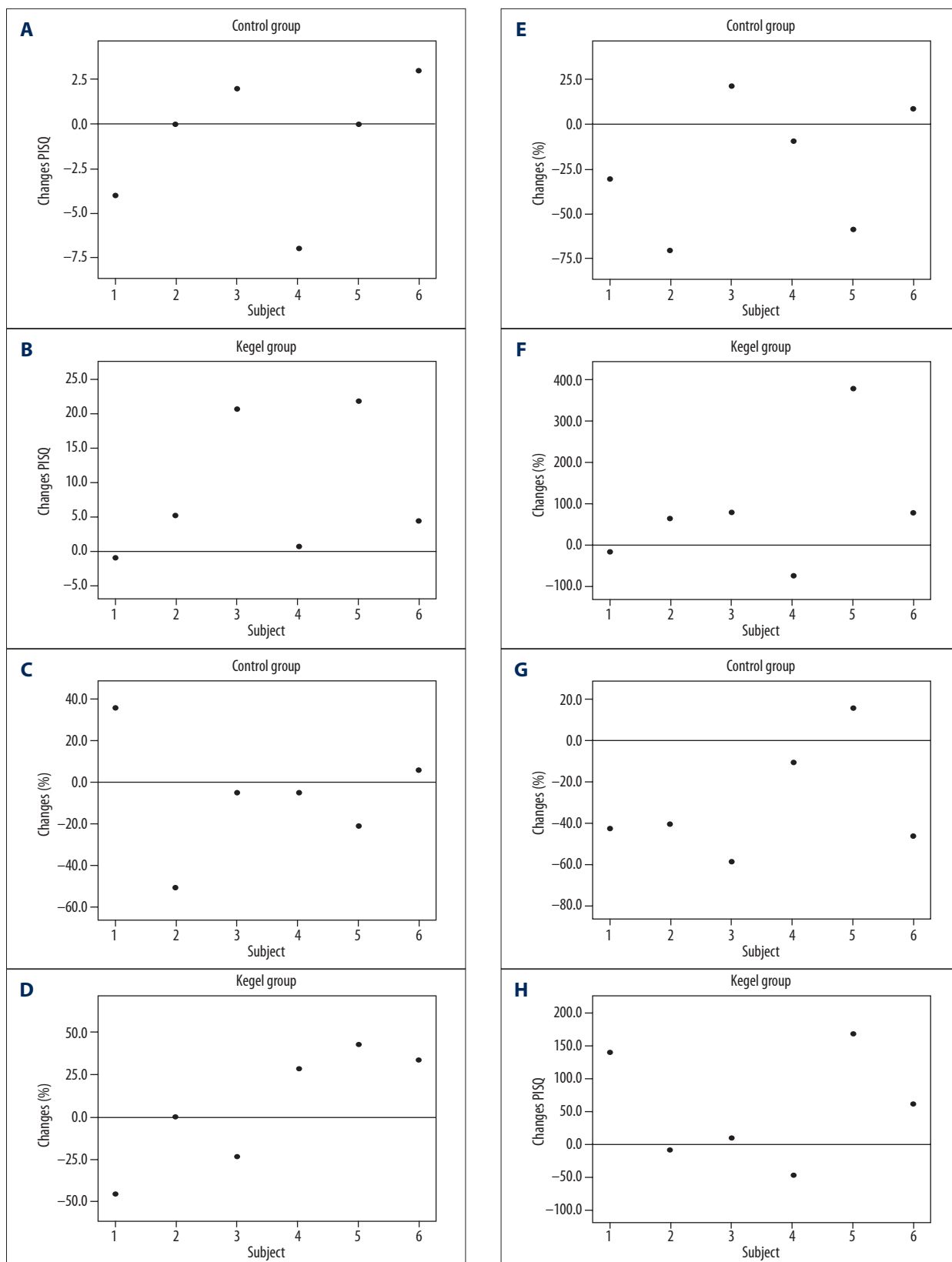


Figure 5. Changes of the PISQ scores and the percentage changes of the muscle strength for each subject in the control and Kegel groups after the intervention period.

Table 3A. Changes of the PISQ scores and the percentage changes of the muscle strength for each subject in the control group.

Subject	PISQ Score changes	OE muscles strength percentage changes	IO muscles strength percentage changes	PFM muscles strength percentage changes
1	-ve	+ve	-ve	-ve
2	=	-ve	-ve	-ve
3	+ve	-ve	+ve	-ve
4	-ve	-ve	-ve	-ve
5	=	-ve	-ve	+ve
6	+ve	+ve	+ve	-ve

Table 3B. Changes of the PISQ scores and the percentage changes of the muscle strength for each subject in Kegel group.

Subject	PISQ Score changes	OE muscles strength percentage changes	IO muscles strength percentage changes	PFM muscles strength percentage changes
1	-ve	-ve	-ve	+ve
2	+ve	+ve	+ve	-ve
3	+ve	-ve	+ve	+ve
4	+ve	+ve	-ve	-ve
5	+ve	+ve	+ve	+ve
6	+ve	+ve	+ve	+ve

However, 5 out of 6 subjects in the Kegel group exhibited an improvement in their PISQ score. An improvement of the muscle strength for either OE or IO or PFM muscles were observed in at least 4 out of 6 subjects. The minor decrease of 1 unit in PISQ score for Subject 1 is most probably due to the inconsistency of performing Kegel exercise during the intervention period; this assumption is based on the daily diary as self-recorded by the subject.

A trend was observed in the Kegel group subjects, where if progress is observed in the sexual function (an increase in PISQ score after Kegel intervention), improvements are also observed in the strength of at least 2 types of muscles; conversely, if a decrement of PISQ is observed, decline in muscle strength is also observed in at least 2 types of muscles. These observations were consistent except for Subject 4. She revealed that she had previously undergone surgery involving the abdominal muscle after commencement of this study. This may have an affect on the performance of the IO muscles and the PFM [23].

The most encouraging progress was observed in Subject 5 (a 55-year-old menopausal woman). She displayed an improvement in both qualitative and quantitative assessments after performing an 8-week Kegel exercise intervention. The

improvement in sexual function may be due to the improvement in the PFM strength, which consequently affected the anatomical position of the clitoral erectile tissue, which in turn is directly related to sexual stimulation [24,25].

While this study has explored the ability of using EMG measurement techniques as a possible quantitative assessment of women sexual function, there is another technique that is more specific – duplex Doppler ultrasonography, also known as vaginal photoplethysmography. Measurements using these devices can be used to assess the hemodynamic status of clitoral erectile tissues (a parameter to study genital circulation for sexual stimulation) [26]. Nevertheless, EMG measurement is more cost-effective than the Doppler ultrasonography [27].

In this study, we only used basic signal-processing techniques in handling the EMG signals. There are several factors that should be considered for enhancement. Movement artifacts while the subject is performing the Kegel movement should be removed; this could be done by using adaptive filtering method in preprocessing the EMG signals [28]. In addition, since the surface EMG electrode could have possibly picked up the EMG activity from all the active muscles in its surrounding area (not only the intended muscles), a more advance processing

technique, such as the autoregressive time series model, is needed to improve the analysis [29]. Both enhancements will be considered in our future research work.

Our future studies will be longer than 12 weeks and subject sample size will be increased to look for further improvement in both PFM and abdominal muscles [30]. Also, several exclusion criteria will be introduced for subjects recruitment: (a) a skinfold thickness of >2.5 cm because the subcutaneous tissue layer could affect the surface EMG signal measurement [31]; (b) urinary and vaginal infection in order (to avoid the risk of spreading infection to other patients; and (c) no previous history of surgery on the abdomen or lower limbs.

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Conclusions

Currently, the validated self-rated PISQ questionnaires is the reference standard used to clinically assess sexual function among women. In this study, we propose use of EMG measurement as a quantitative way to observe the improvement of female sexual function after performing Kegel exercises.

Based on the finding of this preliminary study, we conclude that female sexual function can be enhanced with Kegel exercise if the strength of 2 or more of her abdominal or PFM muscles (measured using the EMG technique) display improvement. Further research with a larger sample size is required to confirm or refute our findings.