Effect of cardiac patients' perceived benefits from and perceived self-efficacy and performance accuracy in the use of an incentive spirometer on spirometric values after coronary artery bypass graft surgery

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Objective
The primary aim of this work was to study the relationships between cardiac patients' spirometric values after coronary artery bypass graft (CABG) surgery and each of the following three variables: patients' perceived benefits from and perceived self-efficacy and performance accuracy in the use of an incentive spirometer. The secondary aim was to study the relationships between the three variables.

Method
Incentive spirometers were introduced to patients who had undergone elective CABG. The patients were advised to use the incentive spirometers for breathing exercises 10 times per hour during waking hours after the surgery, according to the American Association for Respiratory Care clinical practice guidelines. The spirometric values were measured preoperatively and on the first postoperative day. Two numeric scales were used to record the patients' perceived benefits from the incentive spirometer in enhancing the recovery of spirometric values following CABG and the patients' perceived self-efficacy in using the incentive spirometer accurately. The researcher observed the patients while they exercised with the incentive spirometer and used 10 items on a 3-point scale to rate their incentive spirometer performance accuracy. Two-tailed Pearson's correlation tests were used to study the predetermined relationships.

Results
There were significant positive relationships between most spirometric values on the first day postoperatively and each of the following: patients' perceived benefits from the incentive spirometer, patients' perceived self-efficacy, and patients' accuracy of performance. Results also showed significant positive relationships between the patients' perceived benefits from the incentive spirometer, patients' perceived self-efficacy in using the spirometer, and their accuracy of performance.

Conclusion
Cardiac patients' spirometric values after CABG surgery were significantly positively related to each of the following: patients' perceived benefits from the incentive spirometer, patients' perceived self-efficacy, and their performance accuracy in the use of the incentive spirometer.

Keywords:
accuracy of incentive spirometer performance, coronary artery bypass graft surgery, incentive spirometer, perceived benefits of incentive spirometer, perceived self-efficacy, spirometer

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Introduction

Coronary artery disease is a common health problem in the Saudi Arabian population [1,2]. Coronary artery bypass graft (CABG) surgery is adopted for heart revascularization. During this surgery, the patient is subjected to general anesthesia, the heart is exposed through a median sternotomy, and its metabolism is reduced using a solution called cardioplegia solution. The blood circulating in the body is circulated through a cardiopulmonary bypass machine for the duration of the operation. The saphenous vein, internal mammary artery, or radial artery is harvested and connected to the aorta, and the occluded coronary branches are bypassed [3]. Although CABG surgery provides the heart with new vascularization, it is associated with postoperative pulmonary complications in the form of ventilatory dysfunction and reduced spirometric values [4–9].

Cardiac rehabilitation is a usual practice after CABG [10] and it is composed of three phases, I, II, and III [11]. Phase-I cardiac rehabilitation is the acute phase, which takes place during the 3–5 days immediately after surgery when the patient's condition is stable, as decided by his/her surgeon. During phase-I, care is taken to manage the pulmonary complications and reduced spirometric values [12]. An incentive spirometer (IS) is a simple and inexpensive breathing exercise device that is commonly used as a part of the protocol to correct reduced spirometric values [13–15]. Performing breathing exercise using an IS has many benefits, including facilitation of deep and prolonged inspiratory efforts, filling of deflated alveoli, enhancement of pulmonary compliance, fostering the re-expansion of the lung, and diminishing the regional ventilation–perfusion mismatch [16]. Because the benefits of performing breathing exercises with an IS are highly dependent on the patient's effort and accurate use of the device [17], it is customary to offer cardiac patients a preoperative educational session [18]. During this session the physiotherapist instructs the patient on the benefits of performing breathing exercises using an IS and demonstrates its correct usage [19]. According to the health belief model, which is the most commonly used theory in health education, health behavior is determined by personal belief [20]. Perceived benefits and self-efficacy are two main constructs of this theory. Perceived benefit is the person's opinion of the value or usefulness of a health behavior and self-efficacy is the belief in one's own ability to do something [20].

The primary aim of the current work was to study the relationships between cardiac patients' spirometric values after CABG and each of the following three variables: patients' perceived benefits from the use of the IS; patients' perceived self-efficacy; and their performance accuracy in the use of the IS. The secondary aim was to study the relationships between the three variables.

Method

The study proposal was approved by the college council in its 11th meeting on 16 May 2012 (letter number 198-566/12/3). The study was conducted over a period of 14 months from July 2012 to September 2013. The location of this study was King Abdul-Aziz Cardiac Center, King Abdul-Aziz Medical City, Riyadh, Saudi Arabia. A convenient study design was used to recruit Saudi Arabian cardiac patients who were listed for elective CABG surgery. The study inclusion criteria were as follows: being a Saudi Arabian cardiac patient aged 45–69 years, having been diagnosed with coronary artery disease; having undergone elective CABG for the first time; having a BMI of up to 35%; being a lifelong nonsmoker or having had quit smoking at least 8 weeks before surgery; not having respiratory dysfunction; having been weaned from mechanical ventilation less than 24 h postoperatively; and being at least 80% committed to the use of the IS. Preoperatively, each patient was introduced to an IS and instructed to use it 10 times every hour during waking hours postoperatively. The patient was also provided with an IS diary and instructed to mark on the diary every time he/she used the IS. The researchers checked the patient's diary and calculated the percentage of his/her commitment to the use of IS. The 26 eligible patients who agreed to participate in the study signed a consent form. Preoperatively, the researchers met with the patients. They explained the study aim to the patients and assured them that there would be no adverse consequences from refusing to participate in the study and also that the treatment and rehabilitation processes that would be implemented would be the traditional plan followed by the center. In addition, one of the researchers instructed the patients about the effect and importance of breathing exercises using an IS for their pulmonary care and spirometric recovery after the surgery and demonstrated to them how to use the IS accurately according to the American Association for Respiratory Care clinical practice guidelines [21]. The other researcher measured the following outcomes: (i) spirometric values with a desktop spirometer (COSMED Pony FX, COSMED The Metabolic Company, USA), including vital capacity (VC), forced VC (FVC), forced expiratory volume in the first second (FEV_1), ratio of FEV_1/FVC, and maximum voluntary ventilation: spirometric values were measured just 1 day preoperatively and on the first postoperative day when the patients were weaned from mechanical ventilation and with the permission of the surgeon in charge. Standardized instructions of the American Thoracic Society for spirometric measurements were followed [22]. (ii) The patient's perceived benefits from IS in enhancing the recovery of spirometric values following CABG and the patient's perceived self-efficacy in using the IS accurately: a literature-based [23,24] scale sheet was designed and used to record the patient's perceived benefits from the IS and their perceived self-efficacy. The scale ranges from 1 to 10, where '1' indicates least perception and '10' indicates maximum perception (Appendix). (iii) The patient's performance accuracy in the use of the IS: the rating scale was designed to measure the patient's percentage of accurate performance in using the IS. It was a 3-point rating scale consisting of 10 items that were the same criteria as set forth in the American Association for Respiratory Care clinical practice guidelines to judge whether the patient was using the IS accurately [21]. The 3-point rating scale ranked the performance as satisfactory, somewhat satisfactory, and dissatisfactory. The researcher observed the patient while he or she exercised with the IS on the first postoperative day and scored each item on the scale. When the patient performed the exercise accurately as per the instructions he/she was rated satisfactory. When the patient performed less accurately, he or she was rated somewhat satisfactory. The patient was rated dissatisfactory when the exercise was performed inaccurately. The three rates were scored as follows: satisfactory=3, somewhat satisfactory=2, and dissatisfactory=1. The scale's maximum score was 30 (10 items×3 for satisfactory). The patient's performance was calculated using the following equation: patient's performance (%)=patient's total marks/scale maximum marks × 100.

Data analysis

The collected data were analyzed statistically using SPSS, version 13 (SPSS Inc., Chicago, Illinois, USA). Demographics of the patients are expressed as mean and SD for continuous variables and as frequency for categorical variables. Dependent *t*-tests were used to compare between the spirometric values on the preoperative day and those on the first postoperative day. Two-tailed Pearson's correlation tests were used to study the relationships between the spirometric values of the first postoperative day and each of the following: patients' perceived benefits from IS, patients' perceived self-efficacy in using the IS, and patients' observed performance accuracy in using the IS. Two-tailed Pearson's correlation tests were also used to study the relationships between the patients' perceived benefits, self-efficacy, and performance accuracy.

Results

Twenty-six cardiac patients at King Abdul-Aziz Cardiac Center met the study inclusion criteria. Their average age was 58.9 ± 6.9 years (Table 1). Their spirometric values showed reduction during the first day postoperatively compared with the preoperative values (Fig. 1). There were significant positive relationships between most of the spirometric values of the first postoperative day and each of the following: the patients' perceived benefits from the IS, the patients' perceived self-efficacy in using the IS, and the patients' accuracy of performance (Table 2). Results also showed significant positive relationships between the patients' perceived benefits from the IS, the patients' perceived self-efficacy in using the IS, and the patients' accuracy of performance (Table 3).

Table 1 Demographic characteristics of the Saudi Arabian cardiac patients who participated in this study

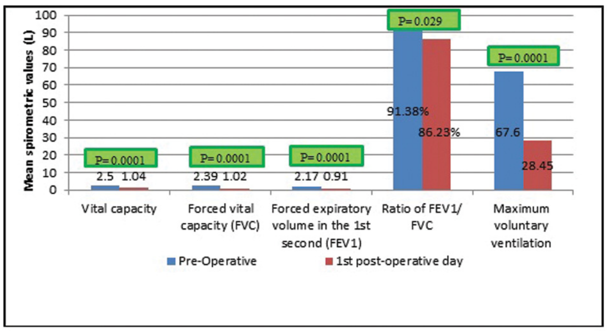
Variables	*N*	Mean	SD
Age (years)		58.9	6.9
Weight (kg)	26	80.4	12.7
Height (cm)		165.7	8.0
BMI (%)		29.2	3.9
Sex [*n* (%)]			
Male	23 (88.5)		
Female	3 (11.5)		
Total	26 (100)		
Smoking habit [*n* (%)]			
Lifelong nonsmokers	18 (69.2)		
Quit smoking	8 (30.8)		
Total	26 (100)		

Discussion

Reduction in postoperative spirometric values

Coronary artery disease is a common health problem among Saudi Arabians. CABG surgery is commonly performed to bypass diseased coronaries and provide the hearts with blood supply. CABG surgery saves the lives of many patients, but it leaves them with pulmonary complications, mainly with decreased spirometric values. The current study findings address the escalating pulmonary complications after CABG. All of the studied cardiac patients showed a decrease in spirometric values after CABG compared with their values before CABG. This spirometric reduction was significant for all measured values: VC, FVC, FEV_1, FEV_1/FVC, and maximum voluntary ventilation.

Figure 1



Comparison between preoperative spirometeric values and those obtained 1 day postoperatively (*N* = 26).

Table 2 Relationships between the spirometric values and cardiac patients' perceived benefits from, and perceived self-efficacy and performance accuracy in the use of the incentive spirometer after coronary artery bypass graft surgery ($N=26$)

Spirometric values	Perceived benefits	Perceived self-efficacy	Performance accuracy
Vital capacity			
r	0.493*	0.435*	0.432*
P	0.010	0.027	0.028
Forced vital capacity (FVC)			
r	0.507**	0.498**	0.422*
P	0.008	0.010	0.032
Forced expiratory volume in the first second (FEV_1)			
r	0.519**	0.516**	0.410*
P	0.007	0.007	0.038
Ratio of FEV_1/FVC			
r	0.339	0.389*	0.290
P	0.090	0.050	0.151
Maximum voluntary ventilation			
r	0.507**	0.505**	0.388
P	0.008	0.008	0.050

*Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed).

Table 3 Relationships between the patients' perceived benefits from and their perceived self-efficacy and performance accuracy in the use of the incentive spirometer after coronary artery bypass graft surgery ($N=26$)

	Perceived benefits	Perceived self-efficacy	Performance accuracy
Perceived benefits			
r	1	0.849**	0.678**
P		0.000	0.000
Perceived self-efficacy			
r	0.849**	1	0.751**
P	0.000		0.000
Performance accuracy			
r	0.678**	0.751**	1
P	0.000	0.000	

*Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed).

Relationship between spirometric values and accuracy of incentive spirometer performance

During phase-I cardiac rehabilitation, the physiotherapist implements a protocol for pulmonary care to overcome postoperative pulmonary complications and improve spirometric values. This protocol includes breathing exercises to inflate the alveoli, improve lung compliance, and increase spirometric values. Once the alveoli are inflated, they remain inflated for 1 h [16]. The physiotherapist offers the patient the IS to perform breathing exercises about 10 times during waking hours. Usually, this is preceded by a preoperative educational session. In the current study, the researcher informed the patients about the benefits of exercising with the IS and demonstrated the accurate way of using it. This was particularly important because the positive impact of IS on spirometric values is markedly dependent on the patient's performance [17]. The results of the current study support this claim. There was a significant positive relationship between most of the spirometric values and the patient's performance accuracy. The more accurate the patient's performance in exercising with the IS, the higher the spirometric values, as measured on the first day postoperatively. Accurate performance implies strict adherence to the standardized instructions [21]. This would ensure that patients are adopting a deep and long breathing pattern, which improves their spirometric values. Careful observation to rate the patient's performance added to the validity of the current study results. Observation offers a more direct measurement, as it involves viewing the patient's actual behavior in natural settings [25]. In addition, rating scales, such as the one used in this study, are well-known tools for assessing the performance of tasks [26]. One of the advantages of rating scales is that they indicate the degree of accomplishment rather than merely giving yes or no answers [26]. They provide quantifiable information, provide systematically organized information, and are easy to complete and score [27]. A 3-point rating scale is more efficient at making decisions versus a 5-point or 7-point rating scale [28]. That is why the researchers used the 3-point rating scale, which rated the patient performance as satisfactory, somewhat satisfactory, and dissatisfactory.

Relationship between spirometric values and both perceived benefits and perceived self-efficacy of the patients

Patients with high perceived benefits from the IS showed higher spirometric values. This positive relationship between patients' perceived benefits from the IS and spirometric values was significant for all measured spirometric values except for the FEV_1/FVC ratio. The same applied to the patients' perceived self-efficacy. All measured spirometric values showed a significant positive relationship with the patients' perceived self-efficacy. These findings could be attributed to the fact that patients with high self-efficacy have high confidence in their ability to perform and overcome barriers. Moreover, it was found that self-efficacy is correlated with compliance and a sense of competence. In contrast, perceived benefits are beliefs about the effectiveness of taking action, which encourages the patient to perform [29]. As mentioned earlier, the IS is dependent on a patient's accuracy in performance as well as his/her compliance and adherence to exercising 10 times a day. It was reported by Glanz *et al.* [20] that both perceived benefits and self-efficacy are associated with adherence. When patients have faith in the benefits that accrue from use of the IS and in their ability to follow the instructions on its use and use it accurately, they will perform better and be more adherent to the exercise frequency. The logical consequence would be better spirometric values.

Relationships between patients' perceived benefits, their perceived self-efficacy, and their performance accuracy

The performance accuracy in the use of the IS was significantly positively related to both patients' perceived benefits and their perceived self-efficacy. Furthermore, patients' perceived benefits and perceived self-efficacy were significantly positively related. This triple-positive relationship raised a very interesting query. Correlation tests indicate the relationship between variables but they do not show the causation. In other words, did patients' high perceived benefits cause patients' high perceived self-efficacy or vice versa? The question is repeated with performance accuracy: did the patients' perceived benefits or their self-efficacy influence the accuracy of performance or vice versa? Different answers for these two questions could be possible. Patients may believe in the benefits from IS and this could increase their self-efficacy and result in accurate performance. In addition, patients may believe in their ability to use IS and this improves their perceived benefits and performance. Accurate performance on the other hand may improve the patients' perceived benefits and self-efficacy. This study limits the use of the regression test, which examines the causality of each of the studied variables. Regression analysis introduces a regression equation in which a predictive weight is offered for each studied variable (performance accuracy, perceived benefit, and perceived self-efficacy) on the outcome variable (spirometric variables).

Conclusion

Cardiac patients' spirometric values after CABG had significant positive relationships with each of the following: patients' perceived benefits from the IS, and their perceived self-efficacy and performance accuracy in using the IS.

Clinical implication and recommendation

This study indicates that the benefits from the use of the IS as a part of pulmonary care during phase I of cardiac rehabilitation after CABG can be increased through patients' accurate performance, increased patient perceived benefits, and increased patient perceived self-efficacy. A preoperative education session should introduce the patient to the benefits accruing from the use of the IS and give clear instructions on accurate performance. This study emphasizes the importance of preoperative patient education. The physiotherapist should give more attention to preoperative patient education. Patient education should be treated as an integral part of cardiac rehabilitation after CABG.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Appendix

Do you think that you are able to use the IS device accurately?

Do you think that the use of an IS would enhance the recovery of your spirometric values after CABG?

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