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Efficacy of Lung Age and Cardiovascular Diseases Risk Screening Biofeedback on the Older Adults' Smoking Quit Rate: Randomized Controlled Study

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ABSTRACT

Background: The majority of smokers wish to stop smoking, but need effective support to succeed.

Purpose: To investigate the efficacy of informing the old adults' smokers their lungs' ages and the cardiovascular disease (CVD) risks on the smoking quit rate. Methods: 130 active cigarette smokers, aged 40-65 years were randomly allocated into group-I (study group; n=67) and group-II (control group; n=63). Initially, the lung age and the CVD risk were determined. The smoking quiet rate was evaluated pre-study (evaluation-1), after 12 interventional weeks (evaluation-2), and 8 weeks post-study cessation (follow-up; evaluation-3). Participants in both groups received a 10-minute motivational interview only at the beginning of the study and received nicotine replacement patches for 12 weeks. Participants in group-I were told their lung ages and their CVD risk' values at the beginning of the study.

Results: At evaluation-1, there were non-significant differences in the exhaled carbon oxide level (p=0.79), smoking duration (p=0.48), smoking intensity (p= 0.25), lung ages (p=0.61), and the CVD risks (p= 0.67) between group-I and II. At evaluation-2; there were significant differences in the smoking quit rates (26.87% versus 12.7%; P=0.04), and at evaluation-3 (22.39% and 7.94%; P=0.02) between groups-I and II respectively, in favor of the study group-I.

Conclusion: Lung age and CVD risk screening biofeedback is an effective approach to significantly increase the smoking quit rate in the smokers' older adults.

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INTRODUCTION

Tobacco smoking is a serious worldwide health challenge. The World Health Organization reported that more than one-fifth of the world population 15 years and older are active smokers, with 14.09% current smoking prevalence among the Saudi population.[1] Although the continuous smoking-prevention and quiet-supporting approaches; the smoking rate is still increasing to reach about 17.3% of the global population by 2025, with males (25.6%) being more affected than females (5.3%).[2]

Smoking contributes to massive deteriorating effects on the pulmonary and cardiovascular systems and general health.[3] Data are available regarding the effects of cigarette smoking on undergraduates,[4] adults, and older adults' smokers' health.[5] Tobacco smoking is the most contributing risk factor for early death and disability in males, the average tobacco-related death rate reached 50% of active tobacco consumers, with more than 8 million victims dying each year, from which 7 million died due to direct exposure while 1.3 million died because of the second-hand smoke. Most of the active smokers who are aware of the smoking harm want to stop smoking but need help and support.[6]

Cigarette smoking became a fast-spreading bad habit in both genders, resulting in an abnormally increased annual smoking-related disease death rate,[7] with the male cigarette smoking prevalence (32.5 %) is higher than the female prevalence (3.9%).[8] The smoking negative impacts on smoker's health appear clearly when considering that smoking contributes to the loss of about 60 million years of human life within the 2017-2037 period.[9]

The smoking harm is tightly correlated with the number of smoked cigarettes number. The peer pressure, the media, and the parents' smoking status are the most potent factors affecting smoking behavior.[10] The nature of the individual's occupation, and the workplace,[11] are also important contributors in increasing the smoking prevalence. The underestimation of the smoking-related health hazards,[12] and the "unwilling" status of the large proportion of current smokers to stop smoking after being informed about the massive health hazards necessitates increasing the efforts to clarify the impacts of cigarette smoking on different body systems as well as to support the smoking cessation and prevention strategies.[13]

Although the beneficial effect of smoking cessation on the CVD risk is well-documented,[14] still it is important to gain more data about the effects of available interventional approaches to augment the concept of smoking control. Quiet recently published reports emphasized the importance of quitting smoking to reduce the CVD risk and clarified that smoking cessation is the optimum method to reduce the CVD risk.[15]

Achievement of success in cigarette smoking cessation is best established via the combined application of pharmacotherapy (to alleviate the nicotine withdrawal symptoms) and behavioral counseling (to augment the motivation to quit smoking) options. Application of both procedures proved more effective in smoking cessation than the application of either of them alone,[16,17] with emphasis on the regular follow-up behavioral counseling and support that should be started as soon as possible after initiating the smoking quit program, most preferably to be from the first week.[18]

A recent study clarified the harmful impact of cigarette smoking on lung function, lung age, and functional performance in young adult smokers.[4] The same researchers recently reported that notifying young adult smokers about the harmful impacts of cigarette smoking on their lung health yielded significant effects in the form of increasing the smoking quit rate, both in the short term (by 23.61%) and long-term (by 19.4%) basis.[13] Although the availability of published reports regarding the effect of providing smokers with feedback about the effects of smoking on pulmonary function or other diseases risk; there is still little evidence about the effects of utilizing the biomedical risk assessment as an effective procedure to quit smoking.[19]

Up to our knowledge and recent updates, no published studies are available about the effectiveness of informing the smokers' older adults about their lung ages and the cardiovascular disease (CVD) risk to stop or control smoking, so the objective of this study was to investigate the efficacy of orienting the smokers' older adults about their lung age (in years), and CVD risk (using the Framingham risk score for estimation of the 10 years of CVD risk) on the smoking quit rate.

METHODS

Study Design

Randomized controlled study design.

Participant Recruitment

The active smokers' older adults were invited and voluntarily participated in the study. Non-probability, purposive, snowball (friends' invitations), face-to-face invitations, and announcements through social media communication programs were utilized to recruit the participants.

Sample Size Calculation

Considering the overall cigarette smoking prevalence is 14.09%.[1] The medium effect size (Cohen's f) = 0.7 to detect relevant results, the alpha error probability= 0.05, power=0.95, the G*Power3 (https://download.cnet.com/G Power/3000-2054_4-10647044.html) program was used and determined a suitable sample size of 110 participants to provide reliable results. An extra 20 participants were added to compensate for any suspected withdrawals, so the total number of participants was 130.

Inclusion and Exclusion Criteria

The active smokers' older adults, age 40-65 years, smoking 10 cigarettes or more per day, were included in this study. Exclusion criteria included pregnancy, smokers younger than 40 or older than 60 years, smokers with unstable angina, serious resting arrhythmias, recent myocardial infarction within the last 2 weeks, or those on regular exercise training within the last 3 months. Individuals who refused to sign the informed consent were initially excluded at the beginning of the study, before the group's allocation.

Randomization

Initially; all participants were recorded by an independent individual who had no other role in the study, and then the participants were randomly allocated into the study group (Group-I; n=67) and the control group (Group-II; n=63) through computer-generated random numbers using the online randomizer software (https://www.randomizer.org) (Figure-1; Participants' flowchart).

Outcome Measures

Initially, (Pre-study; evaluation-1); participants' demographic data were reported, the lung age was estimated (using a portable spirometer), the CVD risk was calculated (using the Framingham risk score for estimation of the 10-years of CVD risk), the exhaled Carbon Oxide (CO_{breath}) was measured to ensure the smoking status, and the pack year of smoked cigarettes was reported.

The smoking quit rate was the main study outcome, evaluated initially (Pre-study; evaluation-1) after 12-weeks (post-study; evaluation-2), and 8- weeks post-study termination (Follow-up, evaluation-3).

Evaluations

Participants' demographic characteristics

The participant's demographic characteristics including age (in years), height (in meters), weight (kg; by Detecto's scale, USA), body mass index (BMI; in kg/m^2), resting pulse rate (in pulse/min) and blood pressure (in mmHg; by BTL CardioPoint apparatus, USA) were evaluated using standardized procedures by the same independent assessor in all participants.

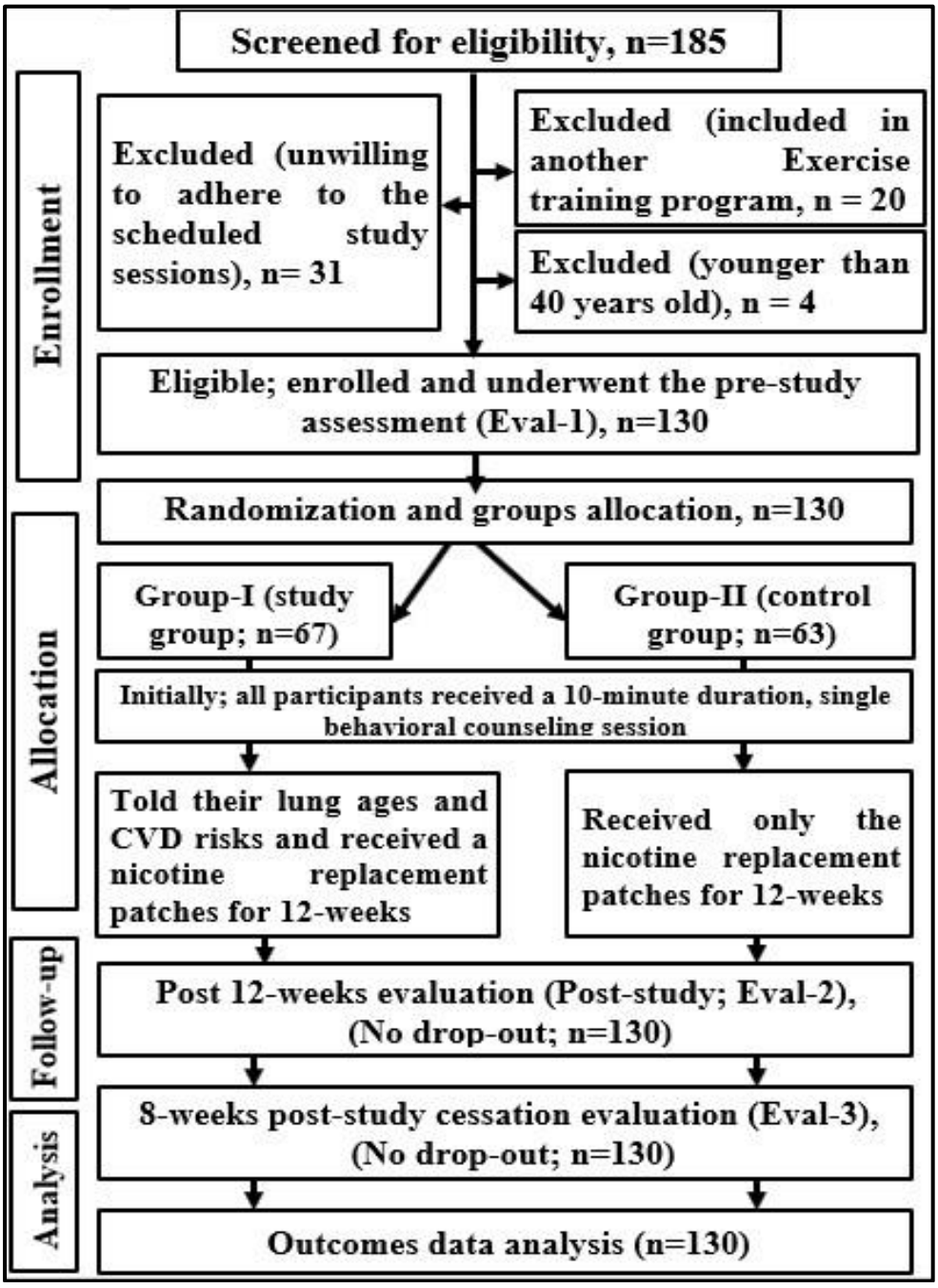

Fig 1. Patients flow chart, CVD: Cardiovascular disease.

The smoking status assessment (by measuring the exhaled carbon monoxide level)

Evaluating the exhaled carbon monoxide (CO_{breath}) level is a valid procedure to differentiate smokers from non-smokers. The CO_{breath} level of 11 ppm is the cut-off point between smokers and non-smokers.[20] The CO_{breath} level was measured using a Smokerlyzer instrument (Bedfont Scientific Ltd., Kent, UK) that was used and regularly calibrated according to the manufacturer's and published guidelines[21] to check the smoking status at the beginning of the study. While sitting in a well-ventilated room, each participant was directed to inhale deeply, hold his/ her breath for 15 seconds, and then exhale

slowly and fully through the mouthpiece tube attached to the hand-held Smokerlyzer device. The CO_{breath} value was reported on the device screen in parts per million (ppm).

Assessment of the smoking quiet status

The smoking quiet status was evaluated at the three evaluation time points (Pre-study, post-study "post 12-weeks", and 8-weeks post-study termination) by calculating the number of participants who stopped smoking compared to the total participants number in each group and was represented as a percentage.

The "lung age" assessment

Following recently published procedures;[4,13] the lung age value was assessed using a portable spirometer (Spiro ST 250 Analyzer, Japan). After a 10-minute rest; the participant assumed a standing position, breathed normally for multiple breaths, and then took deep inspiration, followed by forceful, fast, and prolonged expiration through the spirometer device disposable mouthpiece. The maneuver was repeated 3 times, and the best one was reported. The utilized spirometer device measured the lung age based on the value of the forced expiratory volume in one second.

The cardiovascular disease (CVD) risk assessment

The CVD was evaluated using the Framingham risk score (FRS) for the estimation of 10 years of the CVD risk. Six main risk factors formed the FRS, including the participant's age, gender, systolic blood pressure (SBP), high-density lipoprotein (HDL) cholesterol level, total cholesterol level, and smoking habits. Each of the six risk factor values was entered into the FRS sheet according to the provided numerical risk intervals which were then transformed into points on the FRS chart. The total points were then added together to calculate the ten-year CVD risk percentage. A score of (<10%) indicated a "low CVD risk", a score of (10-20%) indicated an intermediate CVD risk, and finally, a score of (>20%) indicated a high CVD risk.[22]

Interventions

Behavioral counseling intervention

All participants in both groups received a single, face-to-face, 10-minute duration, motivational and behavioral counseling session at the beginning of the study according to a previously published report.[13] The 10-minute motivational interview package followed the previously reported guidelines,[21] included verbal advice and guidelines empowering the participant's intent to effectively start the smoking cessation, behavioral support via clarifying the smoking negative impacts on the participant's health, listing the smoking-cessation associated health benefits, and providing printed materials including tips and steps to stop smoking. In addition to that; only the participants in study group-I were informed about their lungs' ages and their CVD risks' values at the beginning of the study.

Nicotine Replacement Therapy

Following the previous published guidelines,[23] and after exclusion of contraindications (severe psoriasis or eczema) by a physician, all participants in both groups received the nicotine replacement (NRT) patches (Niquitin® Clear Patch / 21mg) during the 1st 4-weeks, followed by (Niquitin® Clear Patch /

14mg) during the 2nd 4-weeks, and finally (Niquitin® Clear Patch/ 7mg) during the 3rd 4-weeks study duration. The NRT patches provided a steady nicotine replacement delivery for 24 hours, applied at the morning every day (A reminder was set on each participant's mobile phone at **7** O'clock for this purpose). To augment smoking abstinence; the NRT patches application was started one day before the actual smoking quit starting date.

Regarding the NRT patch application, participants were instructed to wash their hands with soap and water, peel the back off the patch, and firmly press on it for 10 seconds after putting it on the dry, hair-free area of the left or right upper arms alternatively every other day. Participants were notified about the expected minor and temporary burning, redness, or itching of the skin. Participants were also instructed to replace the NRT patch if dropped or became loose, and to remove the patch if the complaint or skin irritation was severe or persisted for more than 4 days. Adherence of the participants to the prescribed NRT program was ensured via a daily self-administered questionnaire that included questions regarding the daily time of patch application, and the site of application (right or left arm). The questionnaire allowed the participant to check a box corresponding to the selected answer easily. The questionnaire results were evaluated to ensure participant adherence. No serious side effects or abnormal findings were reported.

Statistical analysis

Statistical analysis was conducted using the SPSS-20 for Windows (SPSS, Chicago, USA). Descriptive analysis presented continuous variables' results as means ± standard deviations, while categorical variables were expressed as percentages and frequencies. The smoking quit rate was analyzed using the repeated measures ANOVA with two "within-subjects" factors; treatment (study group-I, control group-II) and time (Evaluation-1, evaluation-2, evaluation-3) to test the hypothesis within and between groups. The significance was accepted at $p < 0.05$.

RESULTS

Participants baseline characteristics

A total of 130 smokers' older adults completed this study. The overall participants' age was (49.93±3.71 years), weight (72.24±7.85 kg), height (1.65±0.06 meter), body mass index (26.63±3.22 kg/m^2). No drop-out or withdrawal was reported during the study.

Initially; there were non-significant differences between groups in the mean values of participants' age (P=0.62), height (P=0.3), weight (P=0.06), body mass index (P=0.13), resting heart rate (P=0.53), resting systolic blood pressure (P=0.34), diastolic blood pressure (P=0.22), gender "male: female ratio" (P=0.23), and the previous attempts to quiet (P=0.11) (Table 1).

Table 1: The demographic characteristics of participants in both groups (Mean ± SD).

Variables		Experimental group (n=67)	Control group (n=63)	P value☼
Age (year)		50.09 ± 3.83	49.76 ± 3.6	0.62 **
Height (m)		1.64 ± 0.055	1.65 ± 0.06	0.3**
Weight (kg)		70.99 ± 8.73	73.57 ± 6.6	0.06 **
BMI (Kg/m^2)		26.21 ± 3.58	27.07 ± 2.75	0.13 **
Pack year		30.2 ± 5.78	29.09 ± 5.16	0.25 **
Smoking duration (year)		25.25 ± 2.66	24.92 ± 2.68	0.48 **
Lung age (observed) (year)		62.05 ± 3.52	61.69 ± 4.43	0.61 **
Lung age difference (year)		11.96 ± 4.78	11.93 ± 4.09	0.97 **
CVD Risk (%)		24.09 ± 6.29	23.61 ± 5.95	0.67 **
The CO breath level (ppm)		17.13 ± 3.21	16.54±3.05	0.79 **
Resting heart rate (beat/min)		73.05 ± 4.48	73.52 ± 4.26	0.53**
SBP (mmHg)		142.45 ± 6.17	141.06 ± 5.99	0.34**
DBP (mmHg)		82.91 ± 4.07	81.94 ± 4.86	0.22**
Gender (Female: Male)		16 (23.6%): 51 (76.1%)	21 (33.3%): 42 (66.7%)	0.23 **
Previous attempts to quiet	0	29 (43.3%)	34 (54%)	0.11 **
	1	22 (32.8%)	22 (34.9%)	
	2	13 (19.4%)	5 (7.9%)	
	3	3 (4.5%)	2 (3.2%)	

☼= Level of significance at P<0.05, ** = non-significant, **BMI:** body mass index, **CVD**: Cardiovascular diseases risk, **CO breath:** The exhaled carbon monoxide level**, SBP:** Systolic blood pressure, **DBP:** Diastolic blood pressure.

Results initially revealed non-significant differences between groups in the observed lung age (P=0.61), lung age deficit (difference between the measured and chronological lung ages) (P=0.97), cardiovascular disease risk (CVD) (P=0.67), cigarette smoking duration (P=0.48), smoking intensity "pack/year" (P=0.25), the exhaled carbon monoxide (CO_{breath}) level (P=0.79), and the number of daily cigarette smoking (P=0.45).

The results of smoking quit rate

Results revealed significant differences in the smoking status between groups at evaluation-2 (P=0.04) and evaluation-3 (P=0.02), in favor of the study group-I. Results revealed significant increases in the smoking quit rate within study group-I at evaluation-2 (by 26.87%, P< 0.001) and evaluation-3 (by 22.39%, P< 0.001). Results revealed significant increases in the smoking quit rate within control group-II at evaluation-2 (by 12.7%, P=0.002), and evaluation-3 (by 7.94%, P=0.02) (Table 2).

Table 2. Between groups comparisons of the smoking status, cigarette smoking number, and the CO breath level (Mean ± SD).

Variables		Experimental group (n=67)	Control group (n=63)	P value☼
Smoking status (Eval-1)	Still Smoking	67 (100%)	63 (100%)	1.00 **
Smoking status (Eval-2)	Quit Smoking	18 (26.87%)	8 (12.7%)	0.04*
	Still Smoking	49 (73.13%)	55 (87.3%)	
Smoking status (Eval-3)	Quit Smoking	15 (22.39 %)	5 (7.94%)	0.02*
	Still Smoking	52 (77.61%)	58 (92.06%)	
Cigarette smoking number/day	Eval-1	23.88 ± 3.6	23.4 ± 3.59	0.45 **
	Eval-2	11.08 ± 6.92	15.83 ± 6.62	< 0.001*
	Eval-3	13.79 ± 7.8	19.00 ± 6.66	< 0.001*
The CO breath level (ppm)	Eval-1	17.13 ± 3.21	16.54 ± 3.05	0.28 **
	Eval-2	10.09 ± 4.98	12.1 ± 3.77	0.01 *
	Eval-3	11.82 ± 5.68	14.25 ± 3.94	0.01 *

☼= Level of significance at P<0.05, ** = non-significant, **Eval**: Evaluation, **CO** breath**:** The exhaled carbon monoxide level.

The results of the cigarette smoking number/day

Results revealed significant differences in the number of smoked cigarettes per day between study group-I and control group-II at evaluation-2 (P< 0.001) and evaluation-3 (P< 0.001), in favor of the study group-I.

Results revealed significant reduction in the number of smoked cigarettes per day within group-I at evaluation-2 (by – 54.66%; P< 0.001) and evaluation-3 (by – 43.66%; P< 0.001). Also, results revealed significant decreases in the number of smoked cigarettes per day within group-II at evaluation-2 (by – 31.48%; P< 0.001), and a significant decrease at evaluation-3 (by – 18.59%; P< 0.001) (Table 2).

The results of the CO breath level

Results revealed significant differences in the CO breath level (ppm) mean values between study group-I and control group-II at evaluation-2 (P=0.01) and evaluation-3 (P=0.01), in favor of study group-I. Results revealed significant reductions in the CO breath level (ppm) mean values within group I at evaluation-2 (by – 40.65%; P< 0.001) and evaluation 3 (by – 31.12%; P< 0.001). Also, results revealed significant decreases in the CO breath level (ppm) mean values within group-II at evaluation-2 (by – 25.71%; P< 0.001), and a significant decrease at evaluation-3 (by – 12.56%; P< 0.001) (Table 2).

DISCUSSION

This study examined the effectiveness of lung age, and CVD risk screening biofeedback on the older adults' smoking quit rate. Results revealed significant increases in the cigarette smoking quit rate after 12 interventional weeks and 8 weeks post-study cessation. The results clarified that motivational intervention through telling the smokers' older adults their lung ages and the CVD risks is effective in increasing the cigarette smoking quit rate in those populations.

It is not an easy process to gain significant success and increase the smoking quit rate among the smokers' older adults because of the long-term smoking dependency as well as the underestimation of the smoking danger by smokers, which made them unaware of being cigarette smoking-addicted until they initiated the smoking cessation process. The majority of smokers perceive the process of quitting smoking as a long-term exhausting process rather than being an achievable target.[24] Results of the current study regarding the effects of informing smokers about their lung age ran following results of previous reports that clarified the effectiveness of using the lung age concept in reducing the smoking rate among the healthy younger,[13] and older adult smokers, [25,26] and even in "difficult to treat" older adults' smokers affected with chronic pulmonary disorders.[27]

The danger of the continuously increasing prevalence of cigarette smoking necessitates the implementation of effective smoking-cessation motivational procedures. Quit smoking is the most effective factor in modulating the abnormally increased cardiopulmonary disorders and death rate.[28] Seeking new smoking-cessation supporting procedures and continuous motivation are important elements in the smoking control strategy because of their beneficial effects and cost-effective impacts.[29] The selected interview duration of 10 minutes in the present study was based on results of previous studies that reported that the 5-10 minutes motivational interview time is effective and even more advantageous than the longer interview duration (longer than 10 minutes) in motivating smokers to quit smoking.[17]

During this study, the impacts of smoking on the participants' pulmonary health and the CVD risk were provided in an easily understandable way (telling the participants in the study group-I the numerical values of the lung age, lung age deficits, and the CVD risk %), that in turn was reflected in the significantly increased smoking cessation rate among the study group-I participants. Parkes et al. previously reported comparable results.[26]

Although there is a tendency of a large smokers' proportion to quit smoking that can reach up to 70% of adult smokers, with more than 50% of smokers having previous attempts to quit smoking,[30] not all of them success in quitting smoking. The final reported rate of smoking cessation in the study group-I reached 22.39% (15 of 130) which exceeds the previously reported quit rate of 6%.[30] The relatively low success rate in the previous studies can be attributed to the dual challenge the smokers encountered during smoking cessation, presented as the nicotine withdrawal unpleasant symptoms and the unavoidable exposure to the smoking stimuli that trigger cravings in smoking.[31]

The significant differences between the 2 groups in the smoking quit rate during the present study can be attributed in part to the simplicity of provided information and the ease of its understanding by participants since success in modifying smoking behaviour depends on the way through which the smoking-related information is provided and the level of its understanding by the participant smokers.[32] The positive smokers' attitude, motivation, and decision to quit smoking can be related to their belief that it is not too late to stop smoking. Telling the participants in study group-I about their lung age and the CVD risk warned them about the magnitude of the encountered danger and encouraged them to quit smoking especially when considering that the lung function deterioration and the CDV risk are still within the "moderate zone" and have not yet reached the "sever affection level".[26]

On the other hand; the relapse rate encountered in the present study (factors contributed to the relapse were out of the current study scope) in both the study group (3 of 18) and the control group (3 of 8) is an expected event because it is well-known that even with the existence of pharmacological and non-pharmacological supportive measures, still that quit smoking is not an easy process, with expected multiple failure attempts,[33] so continuous motivation and support is essential to encourage smoking quit, maintain the smoking quit status and to prevent relapse,[34] especially when considering that relapsed smokers are exposed to a significantly higher CVD risk compared to those who maintained smoking cessation.[15] The relapse may raise a question about the need for further studies to examine the effects of more intensive, extended, and multiple supporting strategies to gain more pronounced success.

Although adherence of all participants to the prescribed treatments (free of charge NRT patches and behavioral treatment), the smoking quit rate in study group-I was 26.87% and 22.39% at evaluation-1 and 2 respectively, compared to 12.7% and 7.94% at evaluation-1 and 2 respectively in the control group. This may indicate that not all participants in either group were sufficiently motivated to start or maintain smoking cessation. Parkes et al. reported that the smoking-related deteriorated health aspects do not necessarily result in

modifying the smoker's behavior and decision towards smoking cessation.[26] According to that concept; and considering the underestimation status of the encountered health problems, it seems that more motivational procedures (in addition to the observed lung age and the CVD risk) are required to motivate the participants in the study group to quit smoking. For more significant results and relapse prevention, it is preferable to implement a multi-comprehensive program, with multiple smoking-quitting strategies.[33,34]

Although differences in studies duration, but results of the current and previous studies agreed that using the lung age as a motivational intervention to quit smoking is effective regardless of the program's length,[25] the results of the 8 interventional weeks followed by 8 follow-up weeks in the present study was comparable to the12-weeks results reported by Takagi et al.,[25] the 1-year results reported by Abdelaal & Mousa, [13] and the 1-year results reported by Parkes et al. [26], all reported significant results.

Although the exact mechanism behind the effects of the motivational interventions for quitting smoking remains unclear, the lung age feedback results can be considered as an educational opportunity for smokers about their pulmonary system health. Using the concept of the lung age is even more effective than utilizing the concept of full pulmonary function values, because of ease in understanding the meaning of the lung age, which directly draws the attention of smokers towards the risk of possible smoking-related lung diseases.[25]

The reported lung age deficit (11.96 years in the study group versus 11.93 years in the control group) defined as the difference between the measured lung age and the chronological age reflects the harmful impact of cigarette smoking on the smokers' pulmonary system health and function,[35] that predisposes the smokers to the development of serious pulmonary disorders.[36] The abnormally increased "observed participants' lung ages" compared to the "chronological ages" clarifies the harmful impact of cigarette smoking on lung health and function, and the magnitude of impairment in lung growth.[35]

The significantly increased smoking quit rate achieved in this study in response to the provided behavioral interventions agrees with the previous report stated that health professionals' advice and motivational support can effectively help smokers stop smoking.[17] Providing even brief advice by a health professional can significantly increase the smoking quit rate in the general population.[37]

Epidemiological studies agree that active cigarette smoking, or passive exposure is directly associated with increased cardiovascular morbidity and mortality.[38] Cigarette smoking is negatively impacting the lipid profile and is associated with abnormally reduced HDL cholesterol, and elevated total cholesterol levels,[39] which are among the important components during the CVD risk calculation.

The impact of cigarette smoking on the CVD risk was previously clarified. Cigarette smoking magnifies the CVD risk through two ways, the first one is through the direct effects of the cigarette consisting of nicotine, carbon monoxide, and other harmful chemicals that strongly contribute to the CVD events via inducing inflammation, endothelial damage, and blood clots, as well as disturbed lipid metabolism,[40] the second pathway is through the indirect effect through which the cigarette smoking is influencing other CVD risk factors as disturbing the lipid profile,[41] and increasing the type 2 diabetes risk.[42]

Quitting cigarette smoking can significantly disturb the smoking-related harmful health consequences. The improvements in endothelial function and blood clot risk (not evaluated in the present study) can contribute to improved cardiovascular system functions and controlled CVD risks after smoking cessation.[43]

Limitations

Despite the clinical importance of the study results in the field of quitting smoking; some limitations should be considered. Relatively short follow-up period, factors that contributed to the relapse process, as well as the family/relatives' contributions were not evaluated in the present study. Future studies are required to address these items.

Practical message

Introducing the CVD risk in addition to the lung age screening biofeedback can effectively magnify the benefits of the smoking cessation programs targeting the smoker's older adults. Based on the current study results and the previously published reports, it is empirical to implement the spirometric evaluations (including lung age) and the CVD risk screening within the routine assessment for every smoker older adult.

CONCLUSION

The lung age concept and the cardiovascular disease (CVD) risk are important contributing factors in augmenting the process of smoking cessation. The lung age and CVD risk screening biofeedback motivational approach proved significant effectiveness in increasing the older adults' smoking quit rate.

DATA AVAILABILITY

Data is available upon request.

Ethical Approval

This study procedures followed the Helsinki Declaration 1975, revised in 2008, and was approved by the Local Committee for Biological and Medical Ethics, Umm Al-Qura University, Saudi Arabia (Approval NO. HAPO-02-K-012-2023-01-1948), and was conducted at Umm Al-Qura University, Saudi Arabia.

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Conflict of interest

No potential conflicts of interest

Informed Consent

Each participant signed a written informed consent at the beginning of the study, agreeing for participation and approving

publication of the study results.

Authorship contributions

All authors contributed equally to the manuscript conception and design, acquisition, analysis and interpretation of data. All authors also equally participated in the drafting the article, revising it for important intellectual content; and finally approved the version to be published.

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