ผลของโปรแกรมการออกกำลังกายต่อความจุปอด และภาวะซึมเศร้าในวัยรุ่นหญิงที่มีภาวะซึมเศร้า
Effects of Exercise Program on Lung Capacity and Depression among Female Adolescents with Depressive Symptoms

นิพนธ์ต้นฉบับ

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Original Article

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บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาผลของโปรแกรมการออกกำลังกายต่อความจุปอดและภาวะซึมเศร้าในวัยรุ่นหญิงที่มีภาวะซึมเศร้า **วิธีการศึกษา:** กลุ่มตัวอย่าง คือ วัยรุ่นหญิงอายุ 15 - 17 ปี ที่มีภาวะซึมเศร้า ในโรงเรียนมัธยมศึกษาแห่งหนึ่งในภาคตะวันออกจำนวน 66 คนที่ผ่านเกณฑ์คัดเข้า สุ่มตัวอย่างอย่างง่ายเข้ากลุ่มทดลองและกลุ่มควบคุมกลุ่มละ 33 คน กลุ่มทดลองได้รับโปรแกรมการออกกำลังกายแบบแอโรบิค 5 ครั้ง/สัปดาห์ ครั้งละ 50 นาที นาน 8 สัปดาห์ กลุ่มควบคุมได้รับการดูแลตามปกติของโรงเรียน รวบรวมข้อมูลโดยใช้การวัดความจุปอด และแบบประเมินภาวะซึมเศร้า Children's Depression Inventory (CDI) ที่ก่อนการทดลอง หลังการทดลองเสร็จสิ้นทันที และติดตามผล 1 เดือน ทดสอบความแตกต่างระหว่างสองกลุ่มที่เวลาต่าง ๆ ด้วยการวิเคราะห์ความแปรปรวนสองทางแบบวัดซ้ำ **ผลการศึกษา:** ที่หลังการทดลอง และระยะติดตามผล กลุ่มทดลองมีค่าเฉลี่ยความจุปอดเพิ่มขึ้นและคะแนนเฉลี่ยภาวะซึมเศร้าต่ำลงจากก่อนทดลองอย่างชัดเจนในขณะที่กลุ่มควบคุมมีการเปลี่ยนแปลงดังกล่าวค่อนข้างน้อย และกลุ่มทดลองมีค่าเฉลี่ยความจุปอดและคะแนนเฉลี่ยภาวะซึมเศร้าแตกต่างกับกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ (*P*-value < 0.05) และกลุ่มทดลองมีค่าเฉลี่ยความจุปอดและคะแนนเฉลี่ยภาวะซึมเศร้าในระยะก่อนและหลังการทดลอง และระยะติดตามผล แตกต่างกันอย่างมีนัยสำคัญทางสถิติ (*P*-value < 0.05) **สรุป:** โปรแกรมการออกกำลังกายสามารถลดภาวะซึมเศร้าและเพิ่มสมรรถภาพการทำงานของปอดให้กับวัยรุ่นหญิงในโรงเรียนที่มีภาวะซึมเศร้าได้

คำสำคัญ : โปรแกมการออกกำลังกาย, ความจุปอด, ภาวะซึมเศร้า, วัยรุ่นหญิง

Abstract

Objective: To examine the effects of exercise program on lung capacity and depression in female adolescents with depressive symptoms. **Method:** Sixty-six high school students in the eastern region of Thailand who met the inclusion criteria were recruited and were randomly assigned to the experiment (test group) and usual care (control group), n = 33 each. The test group was trained with 5-times weekly 50-minute sessions for 8 weeks. Those in the control group received only routine care. The measurements of lung capacity and depression using the Children's Depression Inventory questionnaire were carried out before, right after and one-month after the program. Repeated measure ANOVA was used to compare lung capacity and depressions score over the three time points. **Results:** Right after and one-month after the program, lung capacity increased and depression scores decreased overtly in the test group and slightly in the control group. Over time, participants in the test group had lung capacity higher and depression scores lower than those in the control group (*P*-value < 0.05). In the test group, lung capacity and depressions scores over the three time points were significantly different (*P*-value < 0.05). **Conclusion:** The exercise program improved lung capacity and decreased depression in depressed female adolescents.

Keywords: exercise program, lung capacity, depression, female adolescents

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Introduction

Depression in adolescents has been more prevalent and posed more psychological, physical, emotional, and social burden among adolescents. Depression has been the second most cause of the disability adjusted life year (DALY) in adolescents worldwide.[1] Depression is also associated with suicidal tendency, self-harm, and substance abuse among adolescents. Depression in adolescents leads to physical and psychological health problems and ultimately clinical depression their adulthood.[2] Studies reveal prevalence of depression among adolescents worldwide has increased by 25.2%.[3] Prevalence of depression was 15.7% in American adolescents[4], 4 – 11% in adolescents in Europeans such as England and France[5], 40.4% in Asian adolescents such as Nepal[6], and 64.8% in adolescents in China.[7] In Thailand, depression prevalence has been increased among adolescents aged 15 – 18 years. Most of them are in senior high school years. A study reported that depression was 63.2% and 69.1% in Thai male and female adolescents, respectively.[8] In Thai male and female senior high school

students, prevalence was 7.6% and 18.8%, respectively.[9] Another study in Thai adolescents revealed prevalence of 40.5% and 43.6% in male and female adolescents, respectively.[10] It is evident that a high prevalence of depression among senior high school students could put an immense burden on health system.

Depression is a abnormality in emotion, thinking, and behavior manifested as feeling sad, bored, depressed, despaired, and hopeless, insomnia, loss of concentration and memory, poor relationship with others, loss of self-efficacy, desperation, and ultimately self-harm and suicide.[11] Depression in school-aged adolescents is prevalent especially among those in senior high school years which is the critical age of the passage to early adulthood. With the critical turn of life, adolescents face dramatic physical, psychological, cognitive, emotional, and social changes which could lead to adjustment problems toward changing situations. The change of emotion in particular could be immense and presented as severe, fluctuating, everchanging, uncontrollable, and responding improperly.[12] Depressed adolescents are sad, depressed, lonely, unhappy, mood swing, having negative thinking of self, worthless, and hopeless. They sometimes have changes in behavior such as indifference, isolation, nonresponsive to surrounding, and refraining from activities with peers.[11] Depression also impacts physical changes such as fatigue, tiredness, loos of energy, insomnia, impaired immunity, decreased lung function, vasoconstriction, and an increased risk of cardiovascular diseases.[13-16]

Depression in adolescents is caused by stress.[17] The stress could cause imbalance in central nervous system which connects to endocrinological system especially the hypothalamic-pituitary-adrenal (HPA) axis. The hyperactivity of HPA axis could cause a higher level of cortisol[15,18] which could cause depression. Depression is associated with physical capabilities such as decreased lung function and lung capacity, and decreased circulatory function. The decrease in these two systems leads to the reduction in heart, blood vessels, and oxygen circulation to the muscle cells.[14,16,19] Studies show that exercise is a modality to alleviate depression. Aerobic exercise allows for a release of endorphin which is anti-depressive, promoting physical performance, and reducing cortisol[20,21] which is an indicator of stress and a biological index of depression among adolescents.[20-22] Aerobic exercise could also improve respiratory system, circulatory system, vital signs at rest, body refreshing, physical performance, lung performance, lung capacity, and mental health, and alleviate depression.[21-23] Aerobic exercise allows for relaxation, direct physical experience, improved self-efficacy, more motivation to actual action, more self-regulation, and more positive thoughts and behavior.[24] With a concern on the rising prevalence of depression among adolescents and the benefit of aerobic exercise on depression and physical function specifically lung function, this present study aimed to determine effects of aerobic exercise on depression and lung capacity among depressed female adolescents. Specifically, the study aimed to compare depression scores and lung capacity between those who attended the exercise program (test group) and those who did not (control group), at the end of the program and at one-month follow-up. In addition, it aimed to compare depression scores and lung capacity in the test group at before and after the program, and at one-month follow-up. It was hypothesized that in the test group, depression scores were lower and lung capacity was higher than those in the test group over time. In the test group, it was hypothesized that depression scores decreased and lung capacity increased over time.

The study was conceptually framed based on the social cognitive theory of Bandura[24] which proposes that a human behavior consists of three components of Behavior, Person, and Environment which influences each other. Bandura proposes three mechanisms for behavior modification including observational learning (or modeling), self-regulation, and self-efficacy. Self-regulation and self-efficacy could be developed through practice and training. Training could be done through imitating role model and enhancing motivation. These measures have been proved to change human behavior. Self-regulation and self-efficacy are crucial for the success of performing behavior. The aerobic exercise program developed in this present study could help female adolescents relax, interact with others, and develop self-regulation and self-efficacy in their own way. Ultimately, they could be motivated to practice or perform the exercise behavior. The regular exercise could ultimately improve depression and lung capacity.

Methods

In this quasi-experimental research, it used a two group pre-post-test and follow-up design. Outcome measurement

was done at before, right after, and one-month after the intervention.

The study population was female students in a senior high school in Muang district, Rayong province. They were in their 15 – 17 years of age. To be eligible for participation, they had to have depression score of at least 15 points as measured by the Children's Depression Inventory (CDI), have no any illnesses unsafe or contraindicated for exercise, have no diagnosed psychiatric illness, not participated in any exercise program, and be able to attend the scheduled exercise program. However, those who were unable to participate the exercise program at least 80% of all the scheduled sessions were excluded.

The sample size was estimated based on the experimental study.[25] With a minimum requirement, a sample size of 60 participants for parallel design were required. To compensate for a 10% attrition rate[26], a total of 66 participants were required. The researcher selected participants using simple random sampling without replacement where numbers 1 – 33 were assigned to the experimental (test) group and 34 - 66 to the control group.

Research instruments

Research instruments were a set of questionnaires for data collection, spirometer for lung capacity evaluation, and an exercise program. For the questionnaire, the **first part** collected demographic characteristics including age, monthly allowance, and cumulative grade point average (GPA). The **second part** of the questionnaire was the Thai version of Children's Depression Inventory (CDI). It was found to have a high internal consistency reliability with a Cronbach's alpha coefficient of 0.83.[27] The self-reported questionnaire consists of 27 items with five domains specifically depressive symptoms overtly expressed (5 items), physical symptoms (3 items), cognitive changes (13 items), interpersonal relationship (5 items), and suicidal ideation (1 item) within the last two weeks. The response was a 3-point rating scale ranging from 0-not at all, 1-occasionally, and 2-all the time. With the total score of 0 – 54 points, high scores indicate higher tendency of depression with a cut-off of 15 points or higher indicating the depression. In this present study, Cronbach's alpha coefficient was 0.85.

The lung capacity was defined as vital capacity (VC) which is volume of air expelled by the maximal expiratory effort after a maximum inhalation.[28] VC reflects the performance of respiratory muscle and lungs where individuals with high VC could perform a long exercise, have a healthy body, and less chance of illness. In this study, VC was measured by the standardized spirometer as liter (L).

Exercise program

The exercise program was developed by the researcher based on the program to help alleviate depression in the first year nursing students.[21] The jogging was replaced with an aerobic dance to suit the senior high school female adolescents preference. However, the level of strenuousness and duration of the activities was equivalent to the original program. The exercise program consisted of 3 steps starting from warm-up for 10 minutes, followed by a 30-minute aerobic exercise with an intensity of 50% of the highest pulse rate, and the last step of 10-minute cool-down. Each exercise bout took about 50 minutes. The exercise was scheduled 5 times per weeks for 8 weeks. The program was examined for content validity by three experts, specifically on in sport science, one in mental health and psychiatric nursing, and one in pediatric and child nursing. Revision was made according to the advice and critique. The revised program was pilot tested in 3 individuals with characteristics comparable to the participants. Feasibility was observed and the program was slightly adjusted for better implementation.

Participant ethical protection

This study was approved by the Ethics Committee for Human Study of Burapha University (approval number: 0528.023/0098). The researcher (CN) requested the director of the study school in Rayong province for experiment permission. Once permitted, the researcher approached teacher assigned by the school director to be responsible for study coordination and the prospective participants. The researcher provided students with objectives, process, and voluntary nature of the study. Students were informed that they could withdraw from the study at any time without any consequences. All information was secured and the results were presented as summary not individual participant's information. Once the written informed assent was obtained, the researcher provided the informed consent form for the student to ask for consent from their parents. Once signed informed consent form Once the experiment in the test group was completed, the researcher conducted the exercise program for participants in the control group for their benefits.

The participation in the exercise program in the control was voluntary.

The experiment and data collection procedure

The researcher made appointment date, time, and place for exercise sessions for the participants. A researcher assistant which was a high school teacher on health education was trained to understand the exercise program. The researcher assistant was experienced with aerobic exercise and had been working with health education for more than one year.

Before the exercise program, participants in **both groups** were asked to complete the depression questionnaire and tested for lung capacity. The participants in the **test group** attended the exercise session 5 times a week, from Monday to Friday, at 4.00 – 4.50 PM for 8 weeks. At each session, it was stated with a 10-minute warm-up, followed by a 30-minute aerobic exercise with an intensity of 50% of the highest pulse rate, and a 10-minute cool-down step. The researcher and research assistant monitored the exercise intensity to be in the required range for all activities. Participants also participated in regular classes, extracurricular activities, and consultations with school advisors. Depression and lung capacity were assessed right after the end of the experiment and at a one-month follow-up. In the **control group**, participants participated in regular classes, extracurricular activities, and consultations with school advisors. Like those in the test group, participants in the control group were also assessed for depression and lung capacity right after the end of the experiment and at a one-month follow-up.

Data analysis

Descriptive statistics including frequency with percentage and mean with standard deviation were used to summarize demographic characteristics. Differences of these characteristics between the two groups were tested using independent t test or chi-square test as indicated. Differences of depression scores and lung capacity between the two groups before the program (i.e., pre-test) were tested using independent t test. Repeated measure analysis of variance was used to compare differences of depression scores and lung capacity between the two groups at the three time points (i.e., pre-test, post-test, and one-month follow-up). If overall change over time was found, pairwise comparisons with Bonferroni adjustment were done. Statistical significance was set a type I error of 5%. All statistical analyses were carried out using the software program SPSS version 25.0.

Results

Of the 66 female adolescents, 33 in each group, there were no differences regarding age, GPA or monthly allowance between the two groups (Table 1).

Table 1 Demographic characteristics of participants in the two groups (N = 66).

Characteristics	Test group (n = 33)		Control group (n = 33)		*P*-value
	N	%	N	%	
Gender					
Female	33	50	33	50	
Age (years)					
15	15	45.5	16	48.5	0.597†
16 - 17	18	54.5	17	51.5	
Mean ± SD	15.6 ± 0.56		15.5 ± 0.50		
GPA					
< 2.50	3	9.1	6	18.2	0.406*
≥ 2.50	30	90.9	27	81.8	
Mean ± SD	2.82 ± 0.35		2.76 ± 0.33		
Monthly allowance (Baht)					
≤ 2,500	14	42.4	17	51.5	0.655*
> 2,500	19	57.6	16	48.5	
Mean ± SD	2,824.3 ± 813.56		2,727.3 ± 935.17		

* Independent t test.
† Chi-square test.

Depression scores in the test group overtly decreased from 21.51 points at pre-test, to 14. 18 and 11.97 points, at post-test and one-month follow-up, respectively; while those in the control group slightly decreased from 20.69 points, to 18. 93 and 18.18 points, respectively (Table 2). At pre-test, depression scores of the test and control groups were not different (21.51 and 20.69 points, respectively, *P*-value = 0.541)

Regardless of time points, depression scores between the two groups were significantly different ($F_{1,64}$= 7.74, *P*-value = 0.007). With the lower depression scores over time in the test group (21.51, 14.18, and 11.97 points at pre-test, post-test, and one-month follow-up, respectively) compared with those in the control group (20.69, 18.93, and 18.18 points at pre-test, post-test, and one-month follow-up, respectively), it could be simply concluded that by average depression score in the test group was significantly lower than that in the control group. With a sizable decrease in the depression scores over time in the test group but a slight decrease over time in the control group, changes in depression scores over time in the two groups were statistically significant ($F_{2,128}$= 13.46, *P*-value

< 0.001). It was also found that depression scores within the test group at three time points were significantly different ($F_{2,97}$ = 40.09, P-value < 0.001) (Table 2).

Since changes in depression scores over time in the test group were significantly different from those in the control group, pairwise comparisons of depression scores at the three time points in the test group were carried out. The increases from 21.51 points at pre-test both to 14.18 points at post-test (a mean decrease of 7.33 points) and to 11.97 points at one-month follow-up (a mean decrease of 9.54 points) were statistically significant (*P*-value < 0.001 for both). No statistical significance was found for the decrease from post-test (14.18 points) to one-month follow-up (11.97 points).

Table 2 Scores of study variables at pre-test, post-test and follow-up of participants in the two groups (N = 66).

Study variables	Test group (n = 33)		Control group (n = 33)		*P*-value*
	mean	*SD*	mean	*SD*	
Depression					
Pre-test	21.51	6.03	20.69	4.69	0.541
Post-test	14.18	7.60	18.93	4.96	
Follow-up	11.97	7.25	18.18	4.42	
	Repeated measures ANOVA:				
	Between group: $F_{1,64}$ = 7.74, *P*-value = 0.007				
	Between time point: $F_{2,128}$ = 38.60, *P*-value < 0.001.				
	Group x time point: $F_{2,128}$ = 13.46, *P*-value < 0.001.				
	Within the test group over time:				
	$F_{2,97}$ = 40.09, *P*-value < 0.001.				
Lung capacity (L)					
Pre-test	1.65	0.31	1.63	0.35	0.769
Post-test	1.88	0.32	1.64	0.29	
Follow-up	1.91	0.33	1.67	0.27	
	Repeated measures ANOVA:				
	Between group: $F_{1,64}$ = 6.06, *P*-value = 0.017.				
	Between time point: $F_{2,128}$ = 14.46, *P*-value < 0.001.				
	Group x time point: $F_{2,128}$ = 9.09, *P*-value < 0.001.				
	Within the test group over time:				
	$F_{2,97}$ = 31.51, *P*-value < 0.001.				

* Independent t test.

For **lung capacity**, the volume overtly increased from 1.65 L at pre-test, to 1.88 and 1.91 at post-test and one-month follow-up, respectively (Table 2). On the other hand, the volume in the control group slightly increased from 1.63 L at pre-test, to 1.64 and 1.67 at post-test and one-month follow-up, respectively. At pre-test, lung capacity volumes of the test and control groups were not different (1.65 and 1.63 L, respectively, *P*-value = 0.769).

Regardless of time points, lung capacity between the two groups were significantly different ($F_{1,64}$= 6.06, *P*-value = 0.017). With the higher volumes of lung capacity over time in the test group (1.65, 1.88, and 1.91 L at pre-test, post-test, and one-month follow-up, respectively) compared with those in the control group (1.63, 1.64, and 1.67 L at pre-test, post-test, and one-month follow-up, respectively), it could be simply concluded that by average lung capacity in the test group was significantly higher than that in the control group. With a sizable increase in the lung capacity over time in the test group but a slight increase over time in the control group, changes in lung capacity over time in the two groups were statistically significant ($F_{2,128}$= 9.09, *P*-value < 0.001). It was also found that lung capacity volumes within the test group at three time points were significantly different ($F_{2,97}$ = 31.51, *P*-value < 0.001) (Table 2).

Since changes in lung capacity over time in the test group were significantly different from those in the control group, pairwise comparisons of lung capacity at the three time points in the test group were carried out. The increases from 1.65 L at pre-test both to 1.88 L at post-test (a mean increase of 0.23 L) and to 1.91 L at one-month follow-up (a mean increase of 0.26 L) were statistically significant (*P*-value < 0.001 for both). No statistical significance was found for the increase from post-test (1.88 L) to one-month follow-up (1.91 L).

Discussions and Conclusion

In this study, depressed female students in senior high school participating the exercise program had decreasing depression scores and increasing lung capacity at the end of the program and one-month follow-up which were significantly different than those before the program. These overt decrease in depression scores and increase in lung capacity with the exercise program were significantly different from a slight decrease in depression scores and minimal increase in lung capacity with no exercise program. Such improvement in depression scores and lung capacity with exercise program could be explained as follows.

This aerobic exercise program helped improve lung capacity and respiratory performance for depressed female adolescents. The program was developed by the research as guided by various literature. The 8-week aerobic exercise set the intensity of 50% of maximal pulse rate[21] to prevent physical and psychological stress and allow relaxation and interpersonal interaction. Participants attended at least 80% of the sessions. Consistent training is enhancing depressed adolescents their self-efficacy and motivation to successfully continue the exercise.[24] Depressed adolescents usually are sad, enjoying things less, having less energy and more fatigue, and having less physical performance and respiratory

function.[16,29] Aerobic exercise improve systemic circulation which could enhance the performance of the heart, blood vessels, lungs so oxygen could be effectively supplied to the muscles.[14,15] This further offers less fatigue, stronger muscles, enhanced physical performance, and better lung function which could increase lung capacity in depressed female adolescents. Our finding is consistent with the previous works revealing that exercise improves lung function and mental health and reduces depression.[21-23,30]

We found that lung capacity at one-month follow-up slightly increased from the post-test with no statistical significance. This could mean that the exercise offered a sustained short-term benefit after the program. This sustained benefit could be because the participants attended at least 80% of the sessions. With no intervention after the program, they could apply knowledge and experience from the substantial training in their daily life.

The exercise program could also alleviate depression in depressed female adolescents which is mostly caused by stress.[11,17] Exercise could allow for endorphin secretion which is anti-depressive.[20] Consistent exercise helps reduce hormones responsible for stress. Stress stimulates the release of adrenocorticotropic hormone (ACTH) which further stimulates the adrenal cortex to secrete cortisol, the hormone responsible for prompting the body for any stimuli. However, excessive cortisol release causes negative effects which could lead to depression. Excessive cortisol could also cause atrophy and death of the hippocampal cells which lead to cognitive impairment and memory loss.[15] Regular exercise revitalize the body and mind with the promotion of serotonin and inhibition of cortisol as a biological marker of depression.[15,21] With participants attending at least 80% of the 8-week training, these depressed adolescents could have perceived more self-efficacy[24], motivation and reinforcement allowing them to adjust their thought and behaviors more positive. In addition, with more self-esteem developed, depressed female adolescents with the exercise had their depression scores decreased significantly at the end of the program and at one-month follow-up. Our finding is consistent with previous works revealing that exercise alleviated depression.[20-22] The sustainability of alleviating depression was obvious at the one-month follow-up could be due to the knowledge and skills acquired from the intense training as the participants attended at least 80% of the sessions.

Based on our findings and study conduct, nurses, healthcare providers, teachers and school administrators could apply the exercise program to alleviate depression and improve lung capacity for depressed female adolescents in other academic settings. In terms of limitations, since this was a quasi-experimental study, certain bias could be expected. A full randomized control trial should be conducted. This study was done in female senior high school students, broader demographic groups with depression such as male high school students, early adolescents, and other groups should be studied. In addition, outcomes other than depression and lung capacity such as heart and lung performance, change in body mass index, hormones related to stress, and mental health should be determined.

In conclusion, 8-week aerobic exercise program could improve lung capacity and alleviate depression scores in female high school adolescents. The exercise could be applied to promote mental and physical health among female adolescents with depression.

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