CHAPTER IV
RESULTS

This chapter composed of two studies which were served to examine the effects of acute different exercise intensity and the effects of aerobic exercise training combined with vitamin C supplement on general physiological characteristics, clinical symptoms and cytokine level in allergic rhinitis patients. These two studies were listed as followed:-

Study I: The effect of acute exhaustive and moderate intensity exercise on physiological changes and symptoms in allergic rhinitis patients.

Part 1 The comparison of physiological characteristics and blood chemical data variables between the control group (CON) and the allergic rhinitis patients group (AR).

Part 2 The comparison of cytokines determination variables between pre- and post acute exhaustive and moderate intensity exercise and between the control group (CON) and the allergic rhinitis patients group (AR).

Study II: The effects of moderate exercise training combined with vitamin C supplementation on physiological changes and symptoms in allergic rhinitis patients.

Part 1 The comparison of physiological characteristics variables between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Part 2 The comparison of blood chemical variables between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Part 3 The comparison of cytokine levels in nasal secretion between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Part 4 The comparison of rhinitis symptoms variables between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Study I: The effect of acute exhaustive and moderate intensity exercise on physiological changes and symptoms in allergic rhinitis patients.

Part 1 The comparison of physiological characteristics and blood chemical data variables between the control group (CON) and the allergic rhinitis patients group (AR).

Physiological characteristics and blood chemical data of the subjects are summarized in Table 4.1. Body fat, cholesterol, and low density lipoprotein in the AR group were significantly lower than the C group ($p<0.05$). Moreover, the AR group exhibited a significantly higher total IgE than C groups ($p<0.05$). There were no significant differences ($p<0.05$) in heart rate, systolic blood pressure, diastolic blood pressure, maximal oxygen consumption (VO_2max), forced vital capacity (FVC), forced expiratory volume at 1 second (FEV1), hemoglobin, hematocrit, triglyceride, and high density lipoprotein cholesterol between the CON and AR groups.

Table 4.1 The comparison of physiological characteristics and blood chemical data variables between the control group (CON) and the allergic rhinitis patients group (AR).

Variables	CON (n=14)	AR (n=13)	t	P-value
Age (years)	28.93 ± 1.40	26.30 ± 2.28	-1.00	0.32
Weight (kg.)	60.24 ± 4.18	58.16 ± 3.97	-0.35	0.59
BMI (kg/m^2)	21.46 ± 1.05	21.50 ± 1.24	0.02	0.88
Body fat (%)	24.42 ± 2.01	22.60 ± 3.37*	-0.47	0.03
Resting heart rate (b/min)	82.66 ± 3.28	80.53 ± 2.12	-0.52	0.11
Systolic BP (mmHg)	120.73 ± 4.11	111.69 ± 2.43	-1.81	0.13
Diastolic BP (mmHg)	71.13 ± 2.15	68.46 ± 2.95	-0.74	0.64
Vo_2max (ml/kg./min)	32.6 ± 2.36	33.30 ± 2.35	0.21	0.87
FVC (Liter)	2.85 ± 0.15	2.97 ± 0.22	0.46	0.08
FEV1 (Liter)	2.60 ± 0.14	2.38 ± 0.19	-0.91	0.45
Hemoglobin (g/dl)	14.01 ± 0.58	13.82 ± 0.37	-0.26	0.34
Hematocrit (%)	46.00 ± 1.77	41.54 ± 1.28	-1.97	0.16
Cholesterol (mg/dl)	218.67 ± 10.38	182.92 ± 4.06*	-3.02	0.00
Triglyceride (mg/dl)	117.93 ± 20.40	67.38 ± 7.67	-2.18	0.34
HDL-C (mg/dl)	67.47 ± 2.81	66.69 ± 3.68	-0.16	0.38
LDL-C (mg/dl)	129.87 ± 9.27	104.23 ± 3.96*	-2.40	0.00
Total IgE (IU/ml)	77.07 ± 13.44	416.50 ± 95.43*	2.85	0.00

Values are means ± SEM.

* $p < 0.05$, significant different from the CON group.

BMI=Body mass index, BP=Blood pressure, VO_2max=Maximal oxygen consumption, FVC=Forced vital capacity, FEV1= Forced expiratory volume in 1 second, HDL-C=High density lipoprotein Cholesterol, LDL-C=low density lipoprotein Cholesterol, IgE=Immunoglobulin E

Part 2 The comparison of cytokines determination variables between pre- and post acute exhaustive and moderate intensity exercise and between the control group (CON) and the allergic rhinitis patients group (AR).

The cytokines level of IL-2, IL-4, IL-13, and TNF-α measured in serum and nasal secretions were shown in Table 4.2. The concentrations of the cytokines level were expressed as pg/ml. The cytokines concentration in nasal secretions contained significantly higher ($p<0.05$) levels than serum in both groups. Moreover, all cytokines levels at baseline in AR group were significantly higher than CON group ($p<0.05$). The percent difference of IL-2, IL-4, IL-13, and TNF-α after exhaustive exercise in the AR group were 35.25, -2.46, 1.49 and -15.42, respectively. The percent difference of IL-2, IL-4, IL-13, and TNF-α after moderate exercise in the CON group were 58.36, - 11.74, -1.26 and -27.23, respectively.

Table 4.2 Cytokine in serum and nasal secretion.

Cytokine (pg/ml)	CON (n=10)		t	P	AR (n=10)		t	P
	Serum	Nasal secretion			Serum	Nasal secretion		
IL-2	6.85 ± 3.62	68.79 ± 8.11*	-6.56	0.00	16.81 ± 4.86	104.25 ± 12.49*†	-6.51	0.00
IL-4	0.00 ± 0.00	6.93 ± 2.66*	-3.93	0.00	2.38 ± 2.16	23.36 ± 5.08*†	-4.59	0.00
IL-5	0.00 ± 0.00	1.41 ± 0.74*	-3.22	0.00	0.00 ± 0.00	14.30 ± 5.32*†	-4.12	0.00
IL-13	42.13 ± 10.55	100.24 ± 2.20*	5.80	0.00	76.17 ± 6.14†	116.62 ± 4.98*†	-6.78	0.00
TNF-α	1.53 ± 0.38	8.07 ± 1.13*	-2.25	0.03	3.68 ± 0.97	15.78 ± 2.24*†	-6.26	0.00

Values are means ± SEM.

*$p < 0.05$, significant different between serum and nasal secretion in the same group.

†$p < 0.05$, significant different from CON group.

IL-2 = Interleukin 2, IL-4 = Interleukin 4, IL-13 = Interleukin 13, TNF-α = Tumor necrosis factor-alpha

The percent difference of cytokine levels in nasal secretion of the C and AR groups are shown in Figure 4.1. The data demonstrate that there are no significant difference ($p>0.05$) in the percent difference of nasal secretion cytokines when compared between exhaustive exercise and moderate exercise in both the C and AR groups. It was found that both the CON and AR groups had relatively lower percent

difference in IL-4, IL-13, and TNF-α and relatively higher percent difference in anti-inflammatory cytokine (IL-2) after moderate exercise but not significant difference. However, the ratio of IL-2 and IL-4 (IL-2/IL-4) after moderate exercise was significantly higher than exhaustive exercise in both the C and AR groups ($p<0.05$) (Figure 4.2.). The IL-2/IL-4 of the CON and AR groups after moderate exercise were 0.5 and 0.7, respectively. The IL-2/IL-4 of the CON and AR groups after exhaustive exercise were 6.32 and 2.18, respectively.

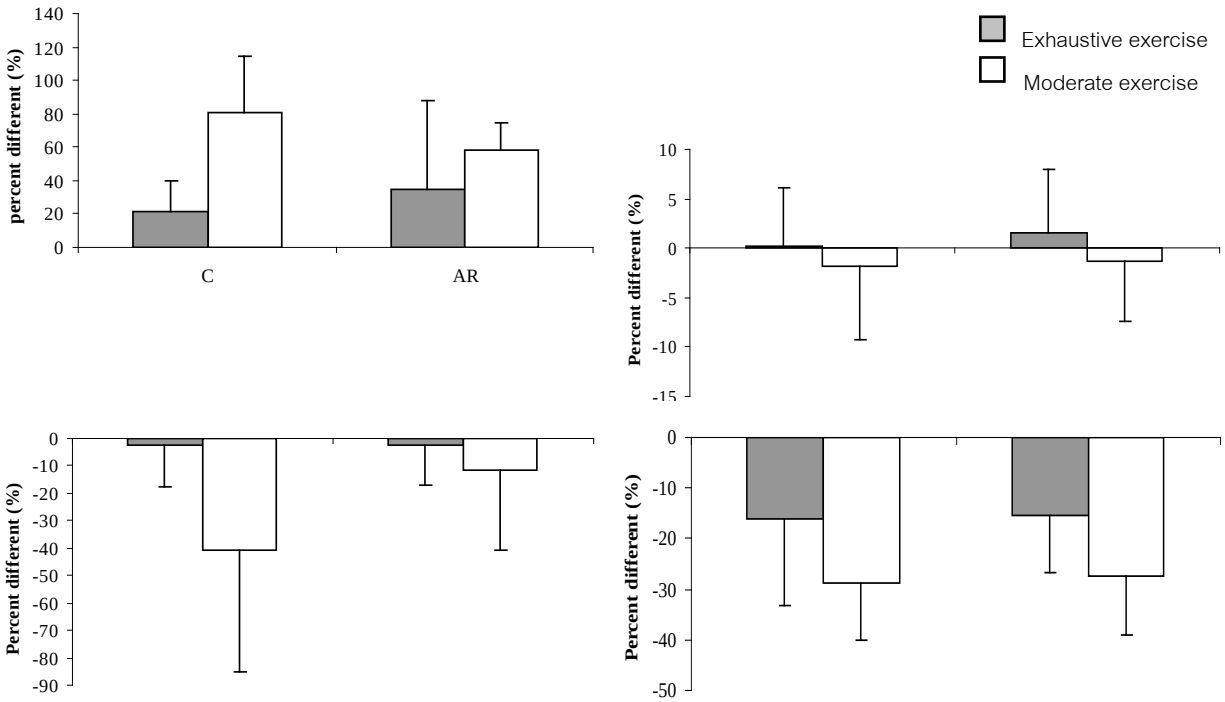
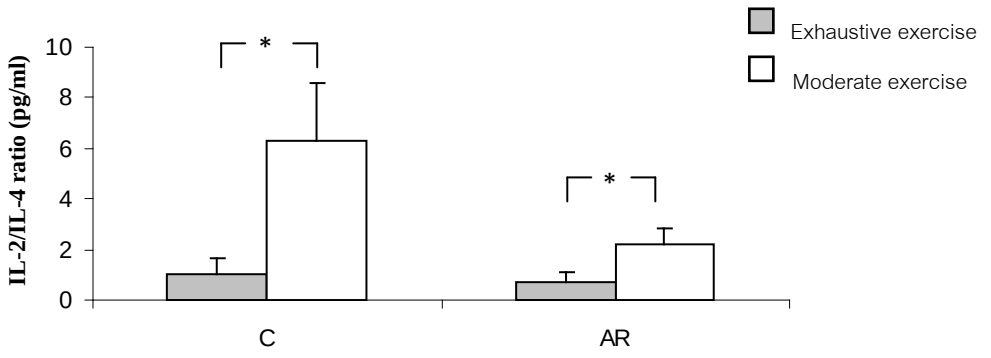


Figure 4.1 The percent different between pre and post of exhaustive and moderate exercise in cytokine levels: IL-2, IL-4, IL-13, and TNF-α (pg/ml) in healthy (CON) and allergic rhinitis patient (AR) groups.



*P<.05, Different between exhaustive and moderate exercise in the same group.

Figure 4.2 The ratio of IL-2 and IL-4 (IL-2/IL-4) compared between exhaustive and moderate exercise in healthy (CON) and allergic rhinitis patient (AR) groups.

Study II: The effects of moderate exercise training combined with vitamin C supplementation on physiological changes and symptoms in allergic rhinitis patients.

Part 1 The comparison of physiological characteristics variables between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

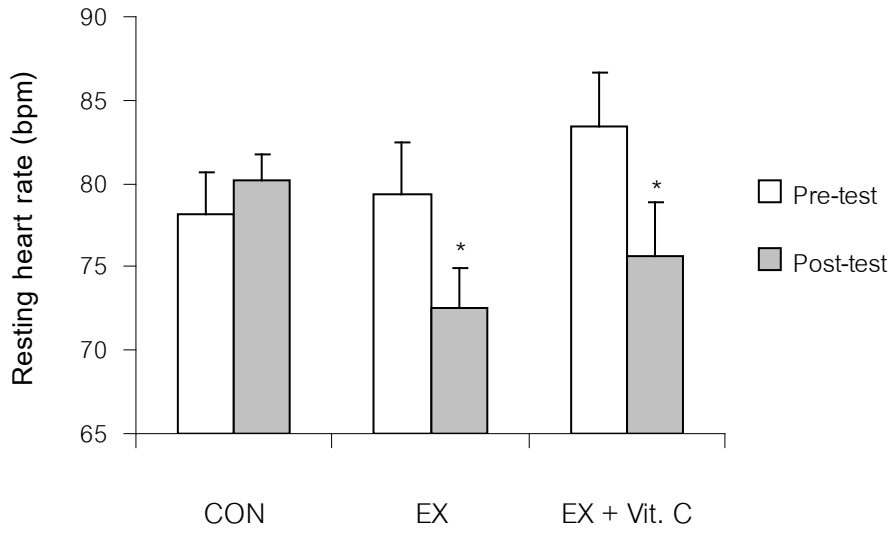
Values of resting heart rate were shown in Table 4.1 and Figure 4.1. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) resting heart rate when compared to pre-test.

Table 4.1 The comparison of resting heart rate (bpm) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Resting heart rate (bpm)		t	P-value
	Pre-test	Post-test		
CON (n=8)	78.12 ± 2.52	80.25 ± 1.46	-1.52	0.17
EX (n=9)	79.33 ± 3.17	72.55 ± 2.43*	3.21	0.01
EX + Vit. C (n=10)	83.40 ± 3.28	75.60 ± 3.26*	3.33	0.00

Values are means ± SEM.

*p < 0.05, significant different from pre-test.



*p < 0.05, significant different from pre-test.

Figure 4.1 The comparison of resting heart rate (bpm) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of systolic blood pressure were shown in Table 4.2 and Figure 4.2.There were no significant difference in systolic blood pressure between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.2 The comparison of systolic blood pressure (mmHg) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Systolic blood pressure (mmHg)		t	P-value
	Pre-test	Post-test		
CON (n=8)	115.89 ± 3.22	114.11 ± 3.64	-1.47	0.18
EX (n=9)	113.16 ± 4.23	113.00 ± 5.44	0.98	0.35
EX + Vit. C (n=10)	112.10 ± 3.88	108.10 ± 3.53	1.68	0.12

Values are means ± SEM.

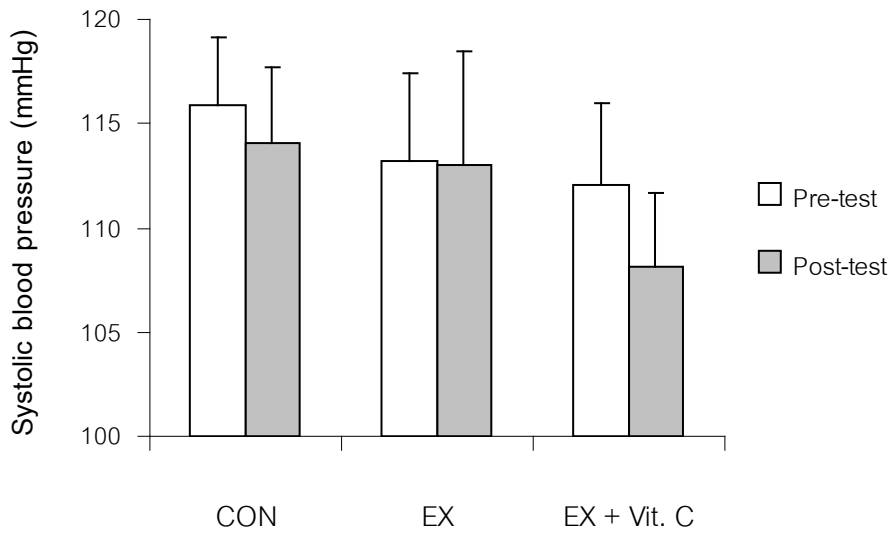


Figure 4.2 The comparison of systolic blood pressure (mmHg) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of diastolic blood pressure were shown in Table 4.3 and Figure 4.3.There were no significant difference in diastolic blood pressure between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.3 The comparison of diastolic blood pressure (mmHg) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Diastolic blood pressure (mmHg)		t	P-value
	Pre-test	Post-test		
CON (n=8)	74.12 ± 2.78	74.12 ± 2.74	0.00	1.00
EX (n=9)	73.11 ± 4.53	69.22 ± 3.86	1.11	0.29
EX + Vit. C (n=10)	70.10 ± 3.59	65.50 ± 2.24	1.43	0.18

Values are means ± SEM.

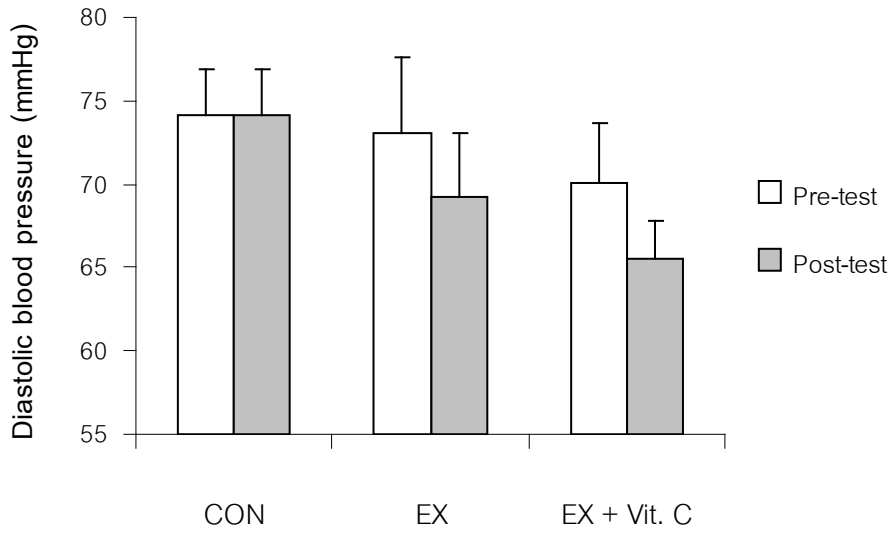


Figure 4.3 The comparison of diastolic blood pressure (mmHg) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of body weight were shown in Table 4.4 and Figure 4.4.There were no significant difference in body weight between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.4 The comparison of body weight (kg) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Body weight (kg)		t	P-value
	Pre-test	Post-test		
CON (n=8)	61.32 ± 4.22	61.97 ± 4.24	-1.77	2.12
EX (n=9)	61.75 ± 5.28	61.13 ± 4.95	1.11	0.29
EX + Vit. C (n=10)	52.58 ± 2.71	52.47 ± 2.65	0.39	0.70

Values are means ± SEM.

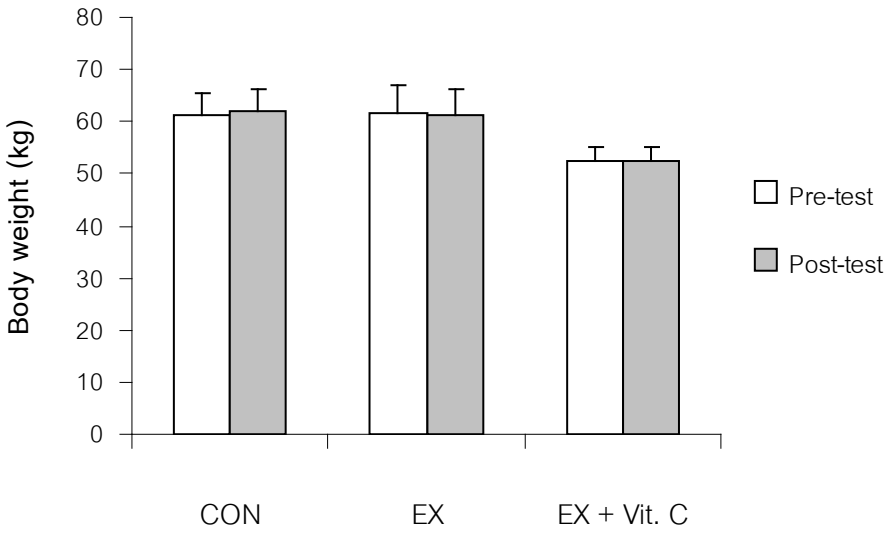


Figure 4.4 The comparison of body weight (kg) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of body mass index were shown in Table 4.5 and Figure 4.5. There were no significant difference in body mass index between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.5 The comparison of body mass index (kg/m^2) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	BMI (kg/m^2)		t	P-value
	Pre-test	Post-test		
CON (n=8)	21.61 ± 1.27	21.76 ± 1.25	-1.02	0.34
EX (n=9)	23.36 ± 1.83	23.10 ± 1.70	1.25	0.24
EX + Vit. C (n=10)	20.08 ± 0.92	19.99 ± 0.88	0.75	0.47

Values are means ± SEM.

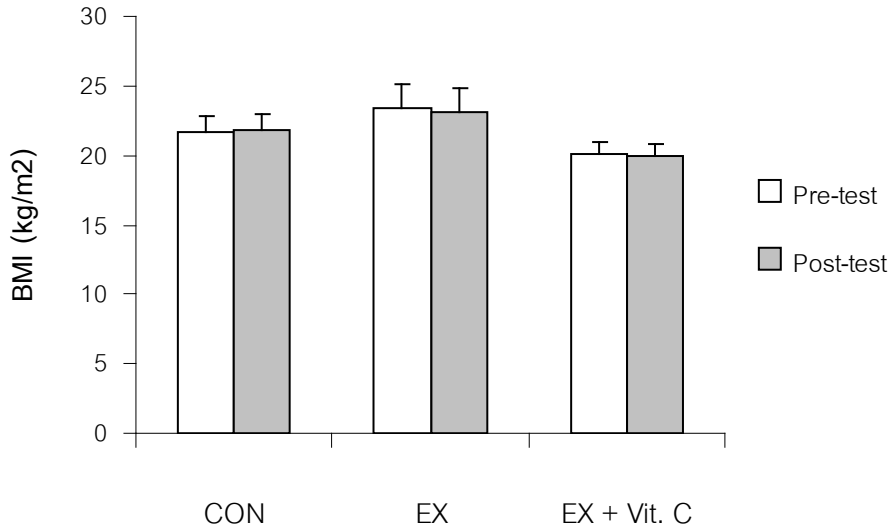


Figure 4.5 The comparison of body mass index (kg/m^2) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of body fat were shown in Table 4.6 and Figure 4.6. There were no significant difference in body fat between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.6 The comparison of body fat (%) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Body fat (%)		t	P-value
	Pre-test	Post-test		
CON (n=8)	21.30 ± 3.59	21.35 ± 3.52	-0.15	0.88
EX (n=9)	26.55 ± 4.26	26.07 ± 3.90	0.77	0.46
EX + Vit. C (n=10)	21.52 ± 3.21	20.64 ± 2.97	1.41	0.18

Values are means ± SEM.

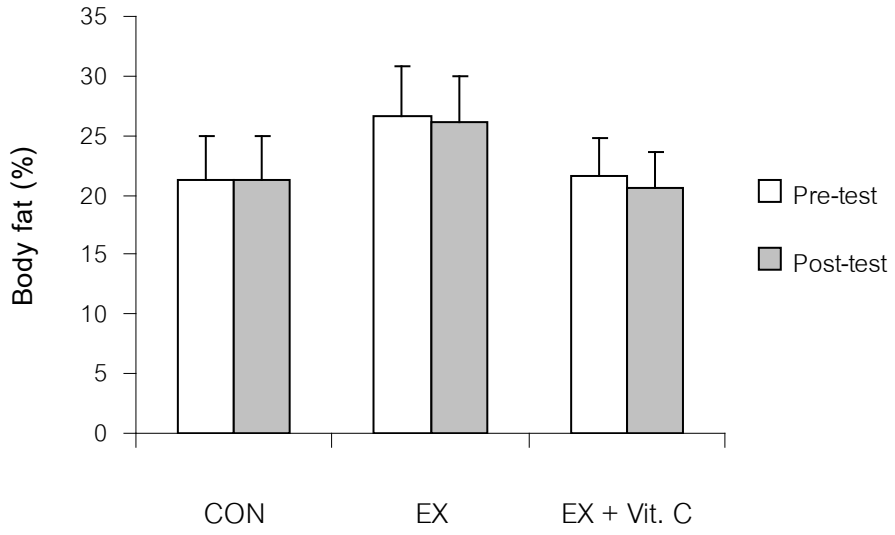


Figure 4.6 The comparison of body fat (%) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

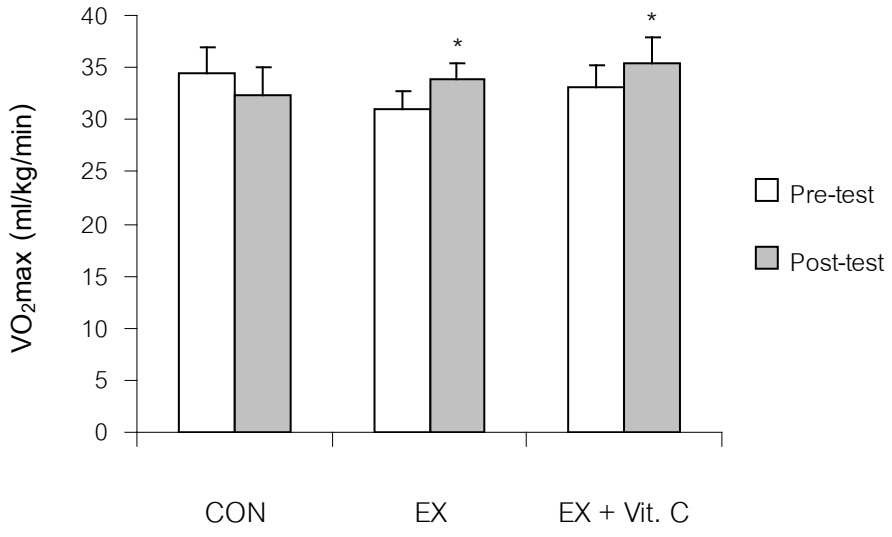
Values of VO_2max were shown in Table 4.7 and Figure 4.7. After 8 weeks of training, EX and EX + Vit. C groups had a significantly higher ($p < 0.05$) VO_2max when compared to pre-test.

Table 4.7 The comparison of maximum oxygen consumption; VO_2max (ml/kg/min) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	VO_2max (ml/kg/min)		t	P-value
	Pre-test	Post-test		
CON (n=8)	34.50 ± 2.44	32.28 ± 2.72	1.68	0.12
EX (n=9)	31.00 ± 1.76	33.88 ± 1.46*	-2.63	0.03
EX + Vit. C (n=10)	33.11 ± 2.13	35.44 ± 2.52*	-2.60	0.03

Values are means ± SEM.

*$p < 0.05$, significant different from pre-test.



*$p < 0.05$, significant different from pre-test.

Figure 4.7 The comparison of maximum oxygen consumption; VO_2max (ml/kg/min) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of FVC were shown in Table 4.8 and Figure 4.8. There were no significant difference in FVC between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.8 The comparison of forced vital capacity; FVC (liters) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	FVC (liters)		t	P-value
	Pre-test	Post-test		
CON (n=8)	3.08 ± 0.25	2.93 ± 0.27	1.89	0.10
EX (n=9)	2.56 ± 0.20	2.64 ± 0.20	-1.17	0.27
EX + Vit. C (n=10)	2.63 ± 0.23	2.71 ± 0.23	-1.80	0.10

Values are means ± SEM.

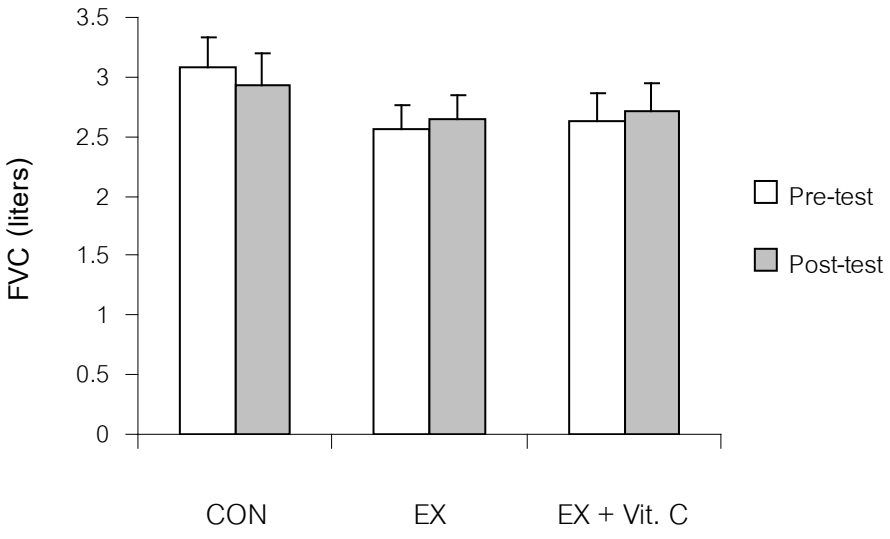


Figure 4.8 The comparison of forced vital capacity forced vital capacity; FVC (liters) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of FEV1 were shown in Table 4.9 and Figure 4.9. There were no significant difference in FEV1 between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.9 The comparison of forced expiratory volume at 1 second; FEV1 (liters) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	FEV1 (liters)		t	P-value
	Pre-test	Post-test		
CON (n=8)	2.69 ± 0.25	2.70 ± 0.24	-0.07	0.94
EX (n=9)	2.50 ± 0.17	2.59 ± 0.16	-1.62	0.14
EX + Vit. C (n=10)	2.16 ± 0.28	2.52 ± 0.23	-1.87	0.09

Values are means ± SEM.

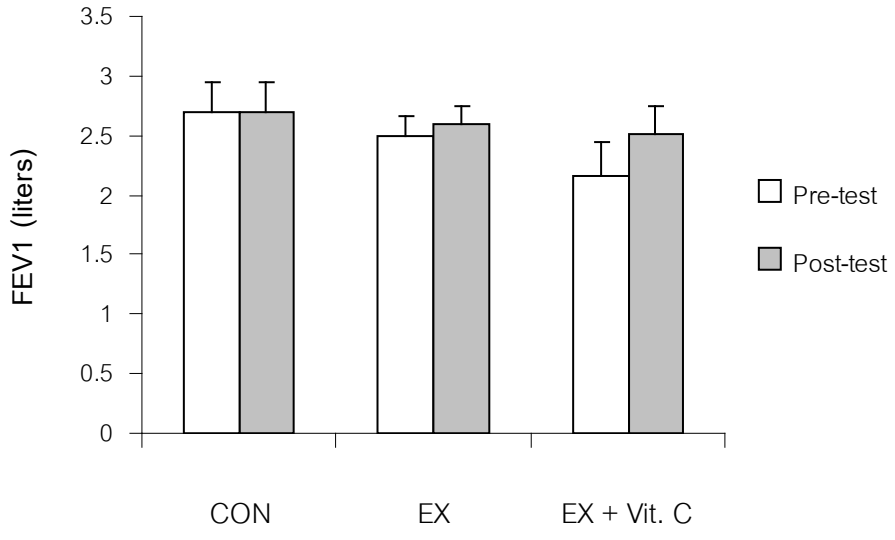


Figure 4.9 The comparison of forced expiratory volume at 1 second; FEV1 (liters) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of SVC were shown in Table 4.10 and Figure 4.10. There were no significant difference in SVC between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.10 The comparison of slow vital capacity; SVC (liters) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	SVC (liters)		t	P-value
	Pre-test	Post-test		
CON (n=8)	3.02 ± 0.27	2.97 ± 0.25	0.84	0.42
EX (n=9)	2.86 ± 0.20	3.00 ± 0.22	-1.99	0.08
EX + Vit. C (n=10)	2.76 ± 0.17	2.88 ± 0.22	-1.18	0.26

Values are means ± SEM.

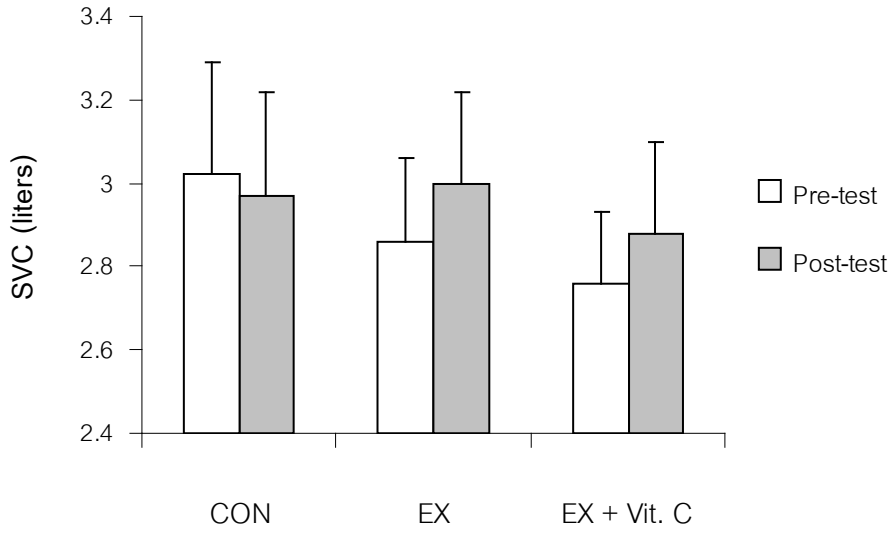


Figure 4.10 The comparison of slow vital capacity; SVC (liters) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of MVV were shown in Table 4.11 and Figure 4.11. There were no significant difference in MVV between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.11 The comparison of maximum voluntary ventilation; MVV (liters/min) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	MVV (liters/min)		t	P-value
	Pre-test	Post-test		
CON (n=8)	76.62 ± 13.88	78.70 ± 12.38	-0.45	0.66
EX (n=9)	74.33 ± 6.86	76.77 ± 7.38	-0.85	0.41
EX + Vit. C (n=10)	75.00 ± 9.21	80.80 ± 9.49	-1.39	0.19

Values are means ± SEM.

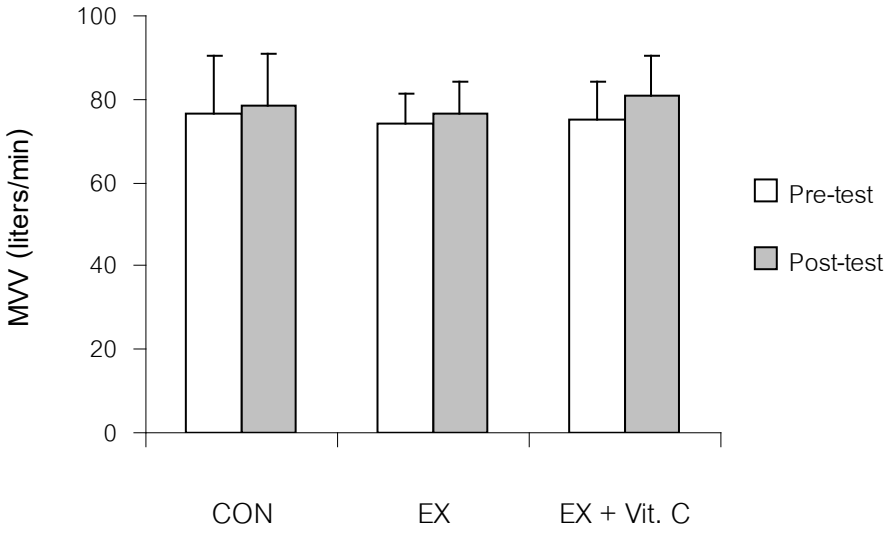


Figure 4.11 The comparative between pre-test and post-test of maximum voluntary ventilation; MVV (liters/min) in control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.12 The comparison of percent difference of the physiological characteristics variables among in control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Variables	CON (n=8)			EX (n=9)			EX + Vit. C (n=10)			F	P-value
	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff		
Resting heart rate (b/min.)	78.12 ± 2.52	80.25 ± 1.46	3.09	79.33 ± 3.17	72.55 ± 2.43*	-8.10†	83.40 ± 3.28	75.60 ± 3.26*	-9.11†	7.78	0.00
Systolic BP (mmHg)	115.89 ± 3.22	114.11 ± 3.64	5.90	113.16 ± 4.23	113.00 ± 5.44	-1.53	112.10 ± 3.88	108.10 ± 3.53	-3.26	3.35	0.05
Diastolic BP (mmHg)	74.12 ± 2.78	74.12 ± 2.74	0.19	73.11 ± 4.53	69.22 ± 3.86	-4.07	70.10 ± 3.59	65.50 ± 2.24	-4.69	0.35	0.70
Body weight (kg.)	61.32 ± 4.22	61.97 ± 4.24	1.08	61.75 ± 5.28	61.13 ± 4.95	--0.70	52.58 ± 2.71	52.47 ± 2.65	-0.17	1.76	0.19
BMI (kg./m^2)	21.61 ± 1.27	21.76 ± 1.25	0.72	23.36 ± 1.83	23.10 ± 1.70	-0.84	20.08 ± 0.92	19.99 ± 0.88	-0.34	1.22	0.31
Body fat (%)	21.30 ± 3.59	21.35 ± 3.52	0.71	26.55 ± 4.26	26.07 ± 3.90	0.43	21.52 ± 3.21	20.64 ± 2.97	-2.61	0.60	0.55
Vo_2max (ml./kg./min.)	34.50 ± 2.44	32.28 ± 2.72	-6.31	31.00 ± 1.76	33.88 ± 1.46*	10.49†	33.11 ± 2.13	35.44 ± 2.52*	6.31†	7.53	0.00
FVC (Liters)	3.08 ± 0.25	2.93 ± 0.27	-2.76	2.56 ± 0.20	2.64 ± 0.20	3.45	2.63 ± 0.23	2.71 ± 0.23	3.73	3.31	0.05
FEV1 (Liters)	2.69 ± 0.25	2.70 ± 0.24	1.65	2.50 ± 0.17	2.59 ± 0.16	3.90	2.16 ± 0.28	2.52 ± 0.23	11.79	1.88	0.17
SVC (Liters)	3.02 ± 0.27	2.97 ± 0.25	-1.14	2.86 ± 0.20	3.00 ± 0.22	4.75	2.76 ± 0.17	2.88 ± 0.22	3.70	1.18	3.32
MVV (Liters/min)	76.62 ± 13.88	78.70 ± 12.38	8.53	74.33 ± 6.86	76.77 ± 7.38	3.41	75.00 ± 9.21	80.80 ± 9.49	10.11	0.30	0.73

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same group. †$p < 0.05$, significant difference from CON group.

The percent difference of the physiological characteristics variables of control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C) are shown in Table 4.12. The data demonstrate that the percent difference of resting heart rate in both EX and EX + Vit. C groups were significantly lower than CON group ($p < 0.05$) and the percent difference of maximum oxygen consumption (VO_2max) in both EX and EX + Vit. C groups were significantly higher than CON group ($p < 0.05$). However, there are no significant difference ($p>0.05$) in the percent difference of systolic blood pressure, diastolic blood pressure, body weight, body mass index, body fat, FVC, FEV1, SVC and MVV when compared among in CON group, EX group and EX + Vit. C group.

Part 2 The comparison of blood chemical variables between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of white blood cell were shown in Table 4.13 and Figure 4.12. There were no significant difference in white blood cell between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.13 The comparison of white blood cell (cells/mm^3) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	White blood cell (cells/mm^3)		t	P-value
	Pre-test	Post-test		
CON (n=8)	6902.50 ± 536.78	6793.75 ± 411.44	0.34	0.74
EX (n=9)	6373.33 ± 448.98	6721.13 ± 405.33	-0.68	0.51
EX + Vit. C (n=10)	6117.03 ± 401.06	5762.03 ± 283.01	1.45	0.18

Values are means ± SEM.

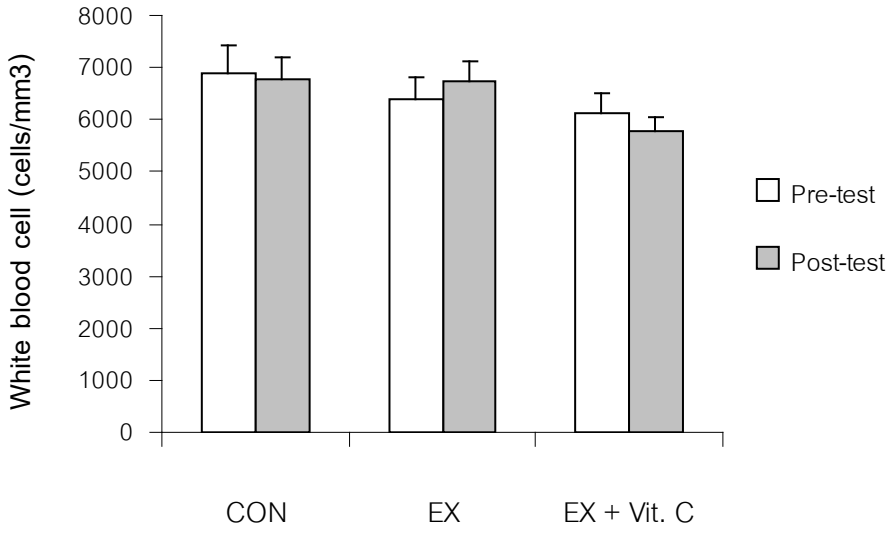


Figure 4.12 The comparison of white blood cell (cells/mm^3) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of red blood cell were shown in Table 4.14 and Figure 4.13. There were no significant difference in red blood cell between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.14 The comparison of red blood cell (mcells/mm^3) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Red blood cell (Mcells/mm^3)		t	P-value
	Pre-test	Post-test		
CON (n=8)	5.27 ± 0.24	5.27 ± 0.27	0.00	1.00
EX (n=9)	4.80 ± 0.23	4.71 ± 0.30	-0.38	0.71
EX + Vit. C (n=10)	4.63 ± 0.23	4.75 ± 0.24	0.45	0.66

Values are means ± SEM.

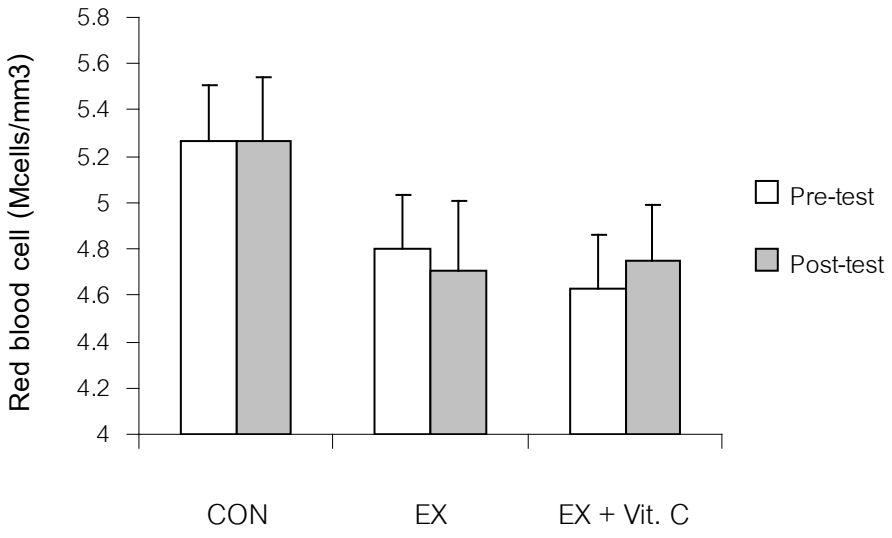


Figure 4.13 The comparison of red blood cell (mcells/mm^3) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of hemoglobin were shown in Table 4.15 and Figure 4.14. There were no significant difference in hemoglobin between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.15 The comparison of hemoglobin (g/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Hemoglobin (g/dl)		t	P-value
	Pre-test	Post-test		
CON (n=8)	14.50 ± 0.44	14.46 ± 0.51	0.18	0.85
EX (n=9)	13.24 ± 0.37	13.13 ± 0.49	0.37	0.71
EX + Vit. C (n=10)	13.45 ± 0.49	13.42 ± 0.52	0.11	0.91

Values are means ± SEM.

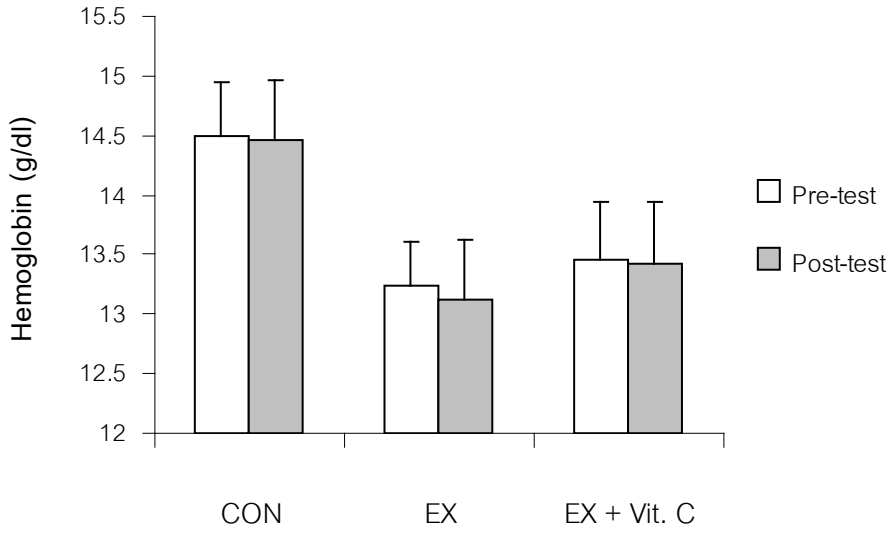


Figure 4.14 The comparison of hemoglobin (g/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of hematocrit were shown in Table 4.16 and Figure 4.15. There were no significant difference in hematocrit between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.16 The comparison of hematocrit (%) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Hematocrit (%)		t	P-value
	Pre-test	Post-test		
CON (n=8)	45.12 ± 1.65	42.75 ± 1.23	2.42	0.05
EX (n=9)	40.22 ± 1.43	39.44 ± 1.48	0.93	0.37
EX + Vit. C (n=10)	40.60 ± 1.53	40.20 ± 1.48	0.40	0.69

Values are means ± SEM.

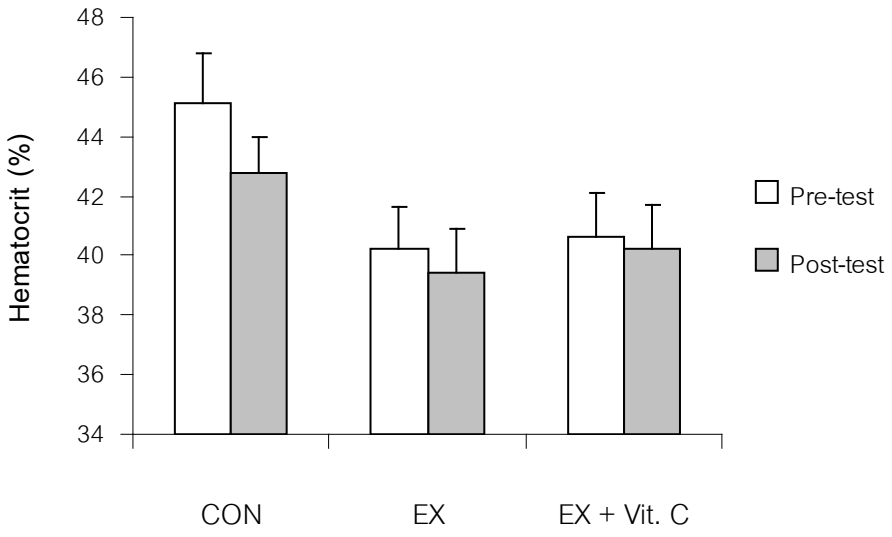


Figure 4.15 The comparison of hematocrit (%) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of cholesterol were shown in Table 4.17 and Figure 4.16. There were no significant difference in cholesterol between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.17 The comparison of cholesterol (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Cholesterol (mg/dl)		t	P-value
	Pre-test	Post-test		
CON (n=8)	197.38 ± 10.73	200.62 ± 11.67	-0.45	0.66
EX (n=9)	197.00 ± 8.17	198.67 ± 9.09	-0.25	0.80
EX + Vit. C (n=10)	188.10 ± 5.42	194.00 ± 4.13	-1.29	0.22

Values are means ± SEM.

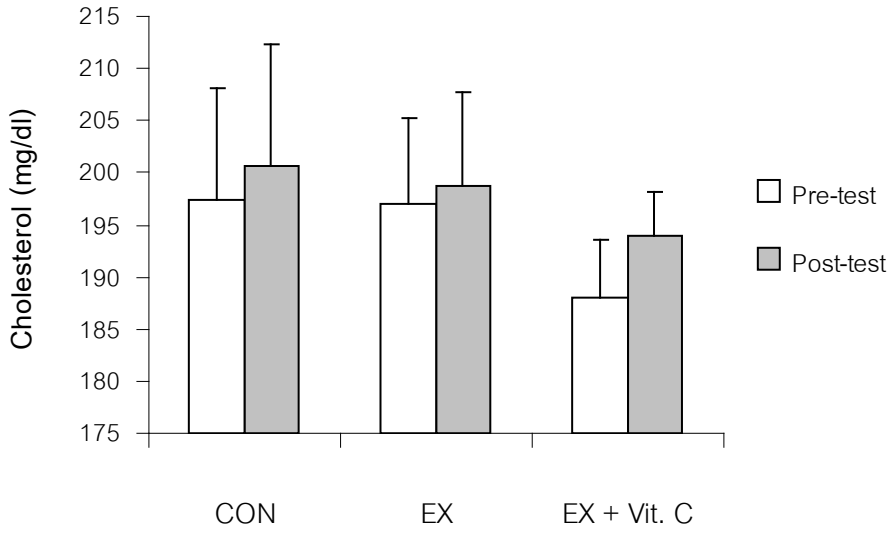


Figure 4.16 The comparison of cholesterol (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of triglyceride were shown in Table 4.18 and Figure 4.17. There were no significant difference in triglyceride between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.18 The comparison of triglyceride (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Triglyceride (mg/dl)		t	P-value
	Pre-test	Post-test		
CON (n=8)	93.37 ± 20.06	87.87 ± 14.51	0.75	0.47
EX (n=9)	70.22 ± 7.69	94.66 ± 14.89	-1.53	0.16
EX + Vit. C (n=10)	57.60 ± 8.82	69.50 ± 8.58	-1.38	0.20

Values are means ± SEM.

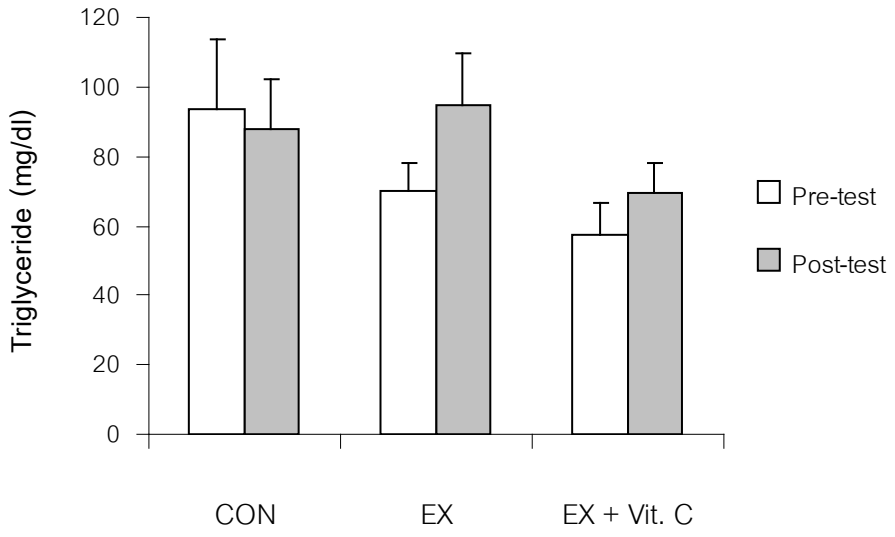


Figure 4.17 The comparison of triglyceride (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of HDL-C were shown in Table 4.19 and Figure 4.18. There were no significant difference in HDL-C between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.19 The comparison of high density lipoprotein cholesterol; HDL-C (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	HDL-C (mg/dl)		t	P-value
	Pre-test	Post-test		
CON (n=8)	62.25 ± 5.88	56.50 ± 6.30	1.84	0.17
EX (n=9)	59.00 ± 3.91	54.11 ± 3.53	2.06	0.07
EX + Vit. C (n=10)	66.90 ± 4.57	64.70 ± 4.43	0.75	0.47

Values are means ± SEM.

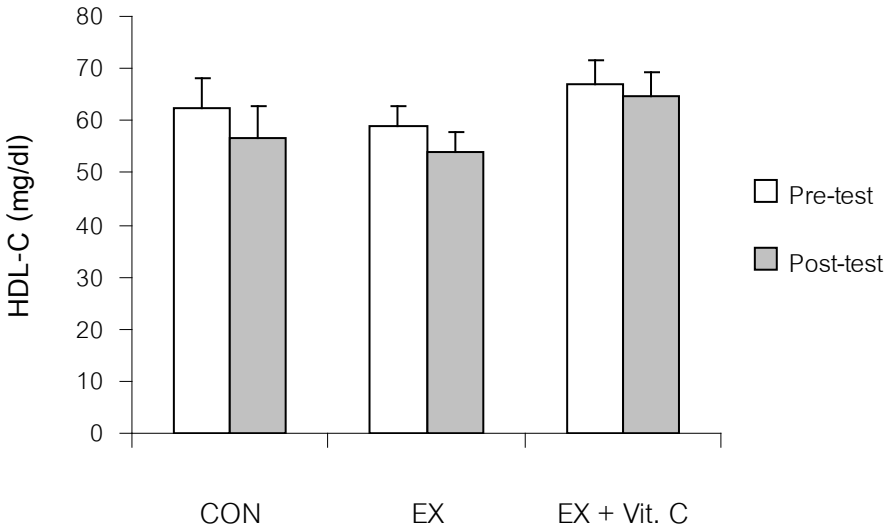


Figure 4.18 The comparison of high density lipoprotein cholesterol; HDL-C (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of LDL-C were shown in Table 4.20 and Figure 4.19. There were no significant difference in LDL-C between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.20 The comparison of low density lipoprotein cholesterol; LDL-C (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	LDL-C (mg/dl)		t	P-value
	Pre-test	Post-test		
CON (n=8)	118.38 ± 10.69	128.75 ± 10.40	-2.23	0.06
EX (n=9)	125.89 ± 9.27	129.67 ± 8.99	-0.70	0.49
EX + Vit. C (n=10)	108.80 ± 4.57	118.80 ± 4.84	-2.28	0.05

Values are means ± SEM.

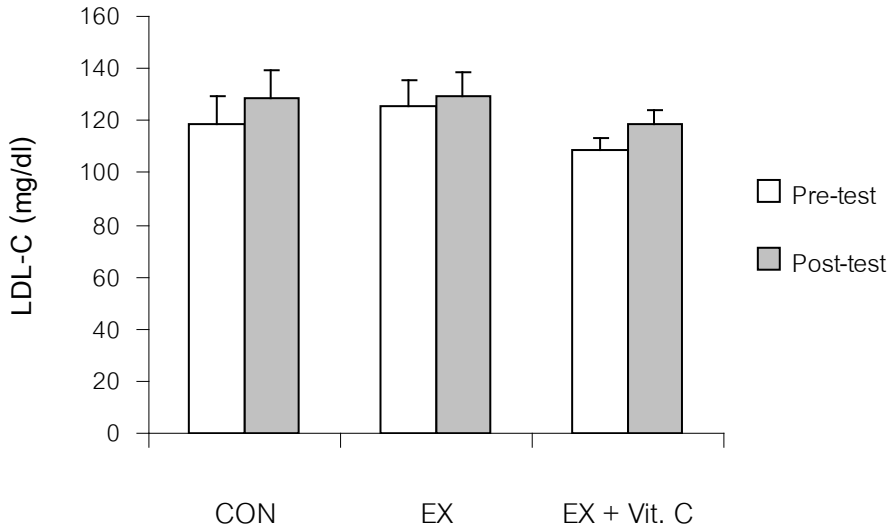


Figure 4.19 The comparison of low density lipoprotein cholesterol; LDL-C (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of Total IgE were shown in Table 4.21 and Figure 4.20. There were no significant difference in total IgE between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.21 The comparison of total Immunoglobulin E; Total IgE (IU/ml) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Total IgE (IU/ml)		t	P-value
	Pre-test	Post-test		
CON (n=8)	283.12 ± 89.36	302.62 ± 85.67	-1.12	0.29
EX (n=9)	340.33 ± 106.81	321.11 ± 90.20	0.80	0.44
EX + Vit. C (n=10)	289.90 ± 97.78	229.80 ± 66.93	1.85	0.09

Values are means ± SEM.

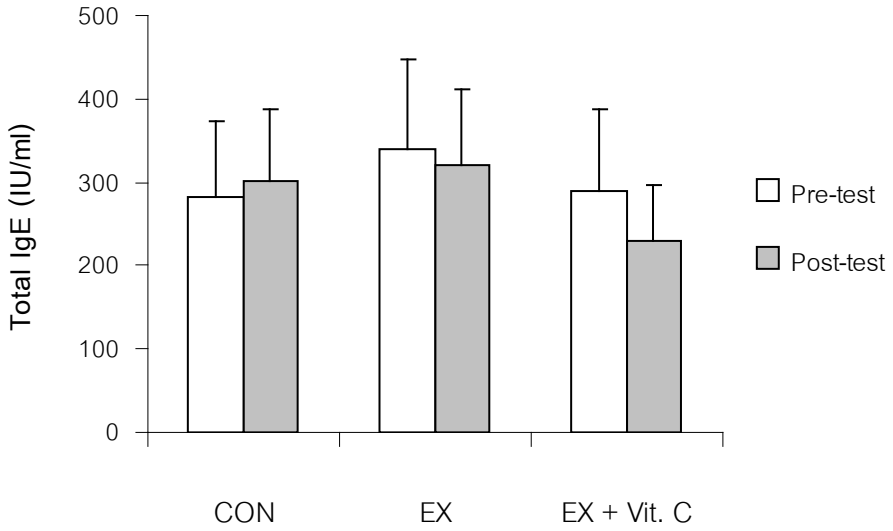


Figure 4.20 The comparison of total Immunoglobulin E; Total IgE (IU/ml) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of specific IgE were shown in Table 4.22 and Figure 4.21. There were no significant difference in specific IgE between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.22 The comparison of specific immunoglobulin E; specific IgE (*D.pteronyssinus*) (kUA/L) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Specific IgE (kUA/L)		t	P-value
	Pre-test	Post-test		
CON (n=6)	18.17 ± 16.43	17.94 ± 16.45	0.98	0.36
EX (n=6)	30.85 ± 15.64	35.88 ± 17.04	-0.79	0.46
EX + Vit. C (n=7)	24.58 ± 13.93	29.86 ± 16.07	-0.88	0.40

Values are means ± SEM.

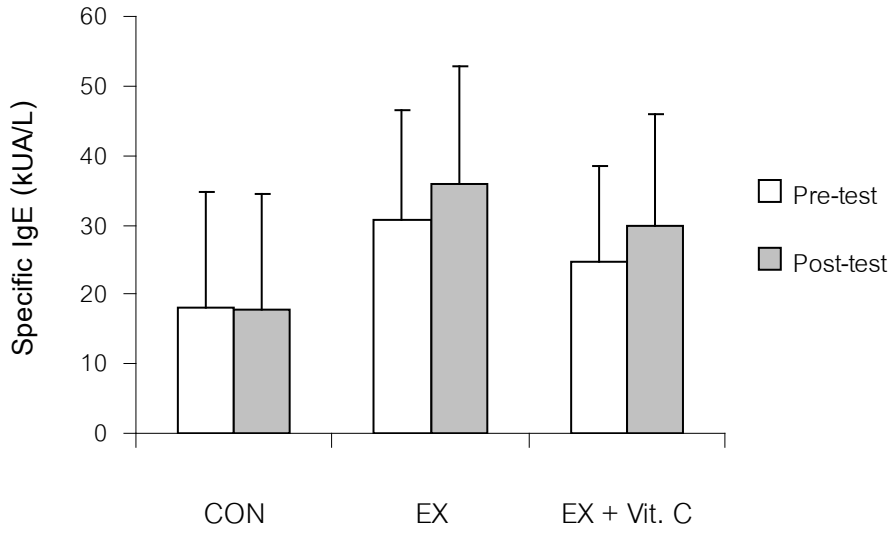


Figure 4.21 The comparison of specific immunoglobulin E; Specific IgE (*D.pteronyssinus*) (kUA/L) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

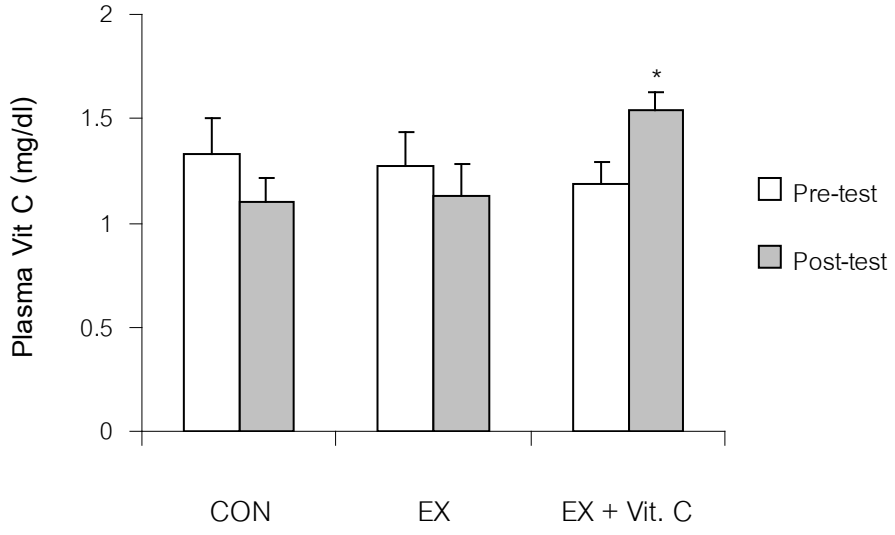
Values of plasma Vit C were shown in Table 4.23 and Figure 4.22. After 8 weeks of training, EX + Vit. C groups had a significantly higher ($p < 0.05$) plasma Vit C when compared to pre-test.

Table 4.23 The comparison of plasma Vit C (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Plasma Vit C (mg/dl)		t	P-value
	Pre-test	Post-test		
CON (n=8)	1.33 ± 0.17	1.10 ± 0.12	1.70	0.13
EX (n=9)	1.27 ± 0.17	1.13 ± 0.15	1.00	0.34
EX + Vit. C (n=10)	1.19 ± 0.10	1.54 ± 0.09*	-2.55	0.03

Values are means ± SEM.

*p < 0.05, significant different from pre-test.



*p < 0.05, significant different from pre-test.

Figure 4.22 The comparison of plasma Vit C (mg/dl) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

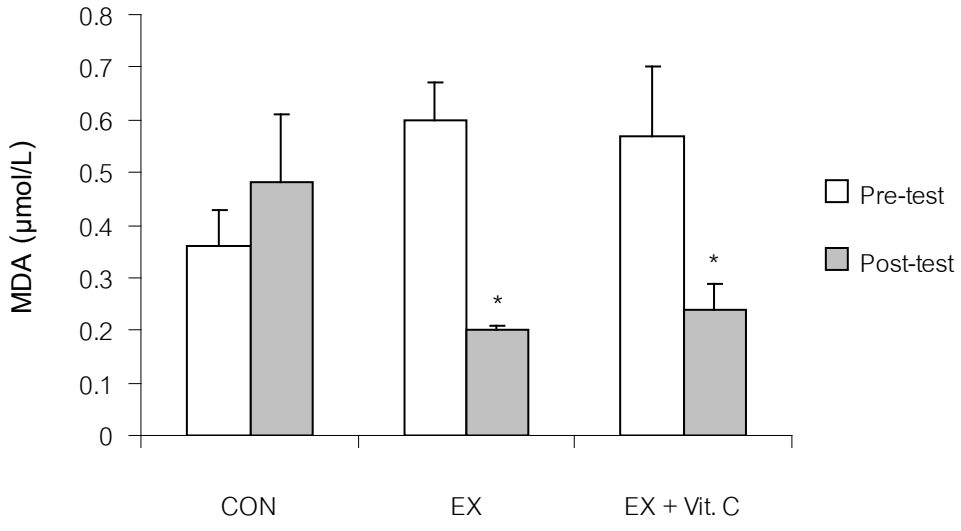
Values of MDA were shown in Table 4.24 and Figure 4.23. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) MDA when compared to pre-test.

Table 4.24 The comparison of malondialdehyde; MDA (μmol/L) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	MDA (μmol/L)		t	P-value
	Pre-test	Post-test		
CON (n=6)	0.36 ± 0.07	0.48 ± 0.13	-0.79	0.46
EX (n=6)	0.60 ± 0.07	0.20 ± 0.01*	4.63	0.00
EX + Vit. C (n=7)	0.57 ± 0.13	0.24 ± 0.05*	3.08	0.02

Values are means ± SEM.

*$p < 0.05$, significant different from pre-test.



*$p < 0.05$, significant different from pre-test.

Figure 4.23 The comparison of malondialdehyde; MDA (μmol/L) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.25 The comparison of percent difference of the blood chemical variables among in control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Variables	CON (n=8)			EX (n=9)			EX + Vit. C (n=10)			F	P-value
	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff		
WBC (cells/mm^3)	6902.50 ± 536.78	6793.75 ± 411.44	-2.00	6373.33 ± 448.98	6721.13 ± 405.33	5.45	6117.03 ± 401.06	5762.03 ± 283.01	-5.80	1.14	0.33
RBC (mcells/mm^3)	5.27 ± 0.24	5.27 ± 0.27	0.00	4.80 ± 0.23	4.71 ± 0.30	-1.87	4.63 ± 0.23	4.75 ± 0.24	2.59	0.19	0.82
Hemoglobin (g/dl)	14.50 ± 0.44	14.46 ± 0.51	-0.28	13.24 ± 0.37	13.13 ± 0.49	0.83	13.45 ± 0.49	13.42 ± 0.52	-0.22	0.03	0.96
Hematocrit (%)	45.12 ± 1.65	42.75 ± 1.23	-5.25	40.22 ± 1.43	39.44 ± 1.48	-1.94	40.60 ± 1.53	40.20 ± 1.48	-0.99	0.95	0.39
Cholesterol (mg/dl)	197.38 ± 10.73	200.62 ± 11.67	1.64	197.00 ± 8.17	198.67 ± 9.09	0.85	188.10 ± 5.42	194.00 ± 4.13	3.14	0.17	0.84
Triglyceride (mg/dl)	93.37 ± 20.06	87.87 ± 14.51	-5.89	70.22 ± 7.69	94.66 ± 14.89	34.80	57.60 ± 8.82	69.50 ± 8.58	20.66	1.33	0.28
HDL-C (mg/dl)	62.25 ± 5.88	56.50 ± 6.30	-9.24	59.00 ± 3.91	54.11 ± 3.53	-0.29	66.90 ± 4.57	64.70 ± 4.43	-3.29	0.80	0.45
LDL-C (mg/dl)	118.38 ± 10.69	128.75 ± 10.40	8.76	125.89 ± 9.27	129.67 ± 8.99	3.00	108.80 ± 4.57	118.80 ± 4.84	9.19	0.60	0.55
Total IgE (IU/ml)	283.12 ± 89.36	302.62 ± 85.67	6.89	340.33 ± 106.81	321.11 ± 90.20	-5.65	289.90 ± 97.78	229.80 ± 66.93	-20.73	3.07	0.06
Specific IgE (kUA/L)	18.17 ± 16.43	17.94 ± 16.45	-1.27	30.85 ± 15.64	35.88 ± 17.04	16.30	24.58 ± 13.93	29.86 ± 16.07	21.48	0.39	0.68
Plasma Vit C (mg/dl)	1.33 ± 0.17	1.10 ± 0.12	-1.73[¥]	1.27 ± 0.17	1.13 ± 0.15	-11.02[¥]	1.19 ± 0.10	1.54 ± 0.09*	29.41	5.74	0.00
MDA (µmol/L)	0.36 ± 0.07	0.48 ± 0.13	33.33	0.60 ± 0.07	0.20 ± 0.01*	-66.67[†]	0.57 ± 0.13	0.24 ± 0.05*	-57.89[†]	7.72	0.00

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same group. [†]$p < 0.05$, significant difference from CON group. [¥]$p < 0.05$, significant difference from EX + Vit. C group.

The percent difference of the blood chemical variables of control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C) are shown in Table 4.25. The data demonstrate that the percent difference of plasma Vit C in EX + Vit. C group was significantly higher than both CON and EX group ($p < 0.05$) and the percent difference of MDA in both EX and EX + Vit. C groups were significantly lower than CON group ($p < 0.05$). However, there are no significant difference ($p>0.05$) in the percent difference of WBC, RBC, Hemoglobin, Hematocrit, Cholesterol, Triglyceride, HDL-C, LDL-C, total IgE and specific IgE when compared among in CON group, EX group and EX + Vit. C group.

Part 3 The comparison of cytokine levels in nasal secretion between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of interleukin-2 were shown in Table 4.26 and Figure 4.24. There were no significant difference in interleukin-2 between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.26 The comparison of interleukin-2 (pg/ml) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Interleukin-2 (pg/ml)		t	P-value
	Pre-test	Post-test		
CON (n=8)	74.88 ± 18.86	66.53 ± 22.23	0.58	0.57
EX (n=9)	73.01 ± 13.12	87.93 ± 15.08	-1.28	0.23
EX + Vit. C (n=10)	77.50 ± 13.80	99.12 ± 10.95	-2.26	0.05

Values are means ± SEM.

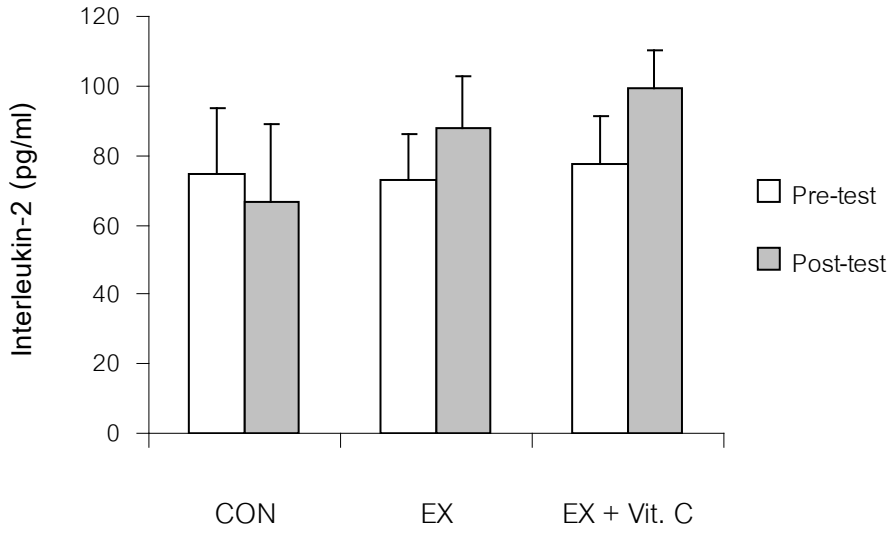


Figure 4.24 The comparison of interleukin-2 (pg/ml) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.27 The comparison of percent difference of interleukin-2 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Interleukin-2 (pg/ml)										%Diff	
	Pre-test					Post-test					t	P-value
	Baseline	After challenge	t	P-value	%Diff	Baseline	After challenge	t	P-value	%Diff		
CON (n=8)	74.88 ± 18.86	80.98 ± 18.52	-0.43	0.67	8.14	66.53 ± 22.23	65.87 ± 23.72	0.04	0.96	-0.99	0.26	0.79
EX (n=9)	73.01 ± 13.12	102.87 ± 14.33	-1.57	0.15	40.89	87.93 ± 15.08	121.38 ± 14.39*	-3.07	0.01	38.04	0.36	0.72
EX + Vit. C (n=10)	77.50 ± 13.80	97.79 ± 17.19*	-2.99	0.01	26.18	99.12 ± 10.95	113.46 ± 21.80	-0.77	0.45	14.46	-0.28	0.78

Values are means ± SEM.

* $p < 0.05$, significant difference from baseline.

Values of interleukin-2 after nasal challenge were shown in Table 4.27 and Figure 4.25, 4.26 and 4.27. After nasal challenge in pre-test, interleukin-2 in EX + Vit. C group was significantly higher ($p < 0.05$) than baseline. In addition, After nasal challenge in post-test, interleukin-2 in EX group was significantly higher ($p < 0.05$) than baseline.

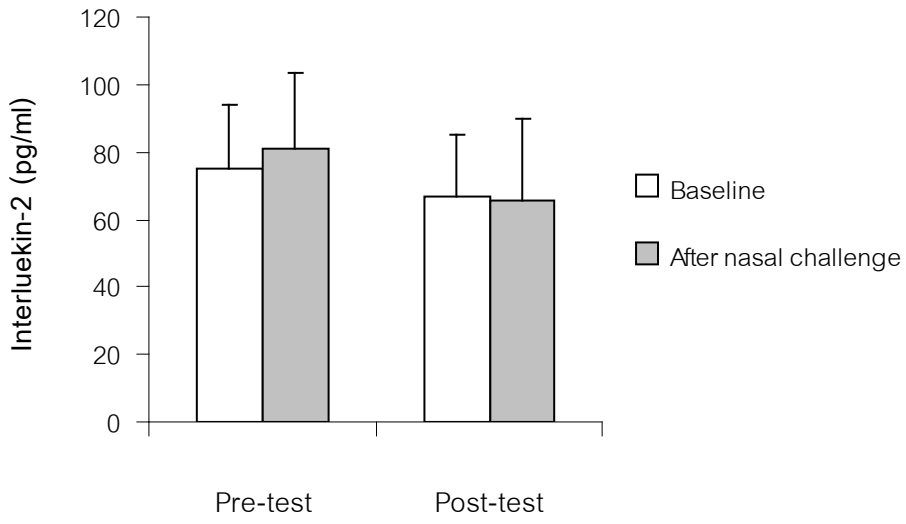
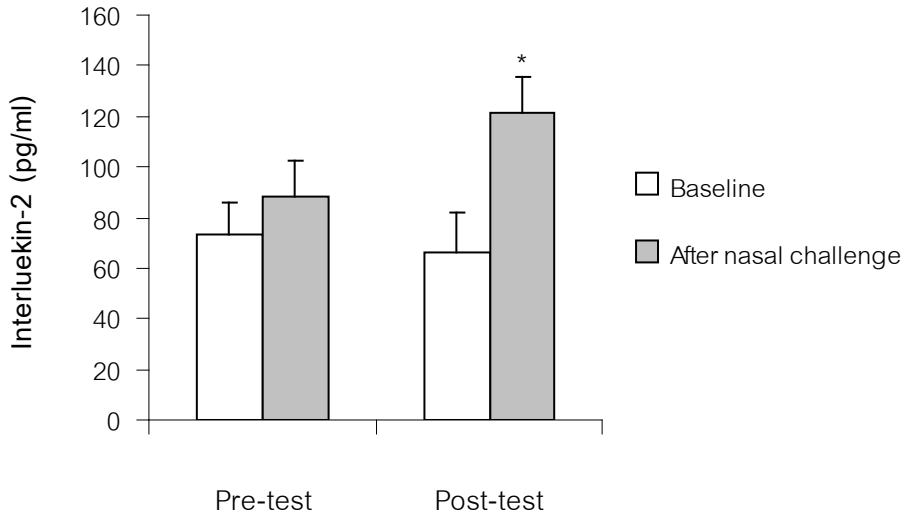
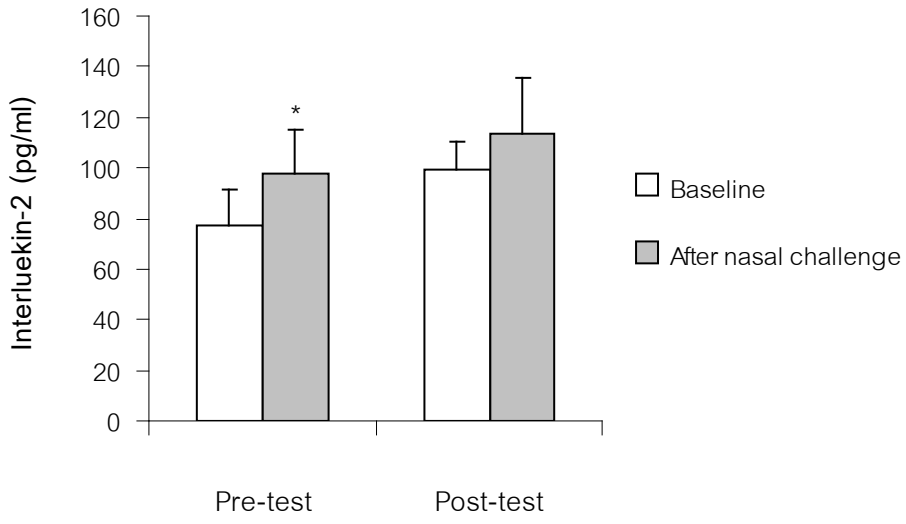


Figure 4.25 The comparison of interleukin-2 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in control group (CON).



* $p < 0.05$, significant difference from baseline.

Figure 4.26 The comparison of interleukin-2 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in exercise group (EX).



* $p < 0.05$, significant difference from baseline.

Figure 4.27 The comparison of interleukin-2 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in exercise combined vitamin C supplementation group (EX + Vit. C).

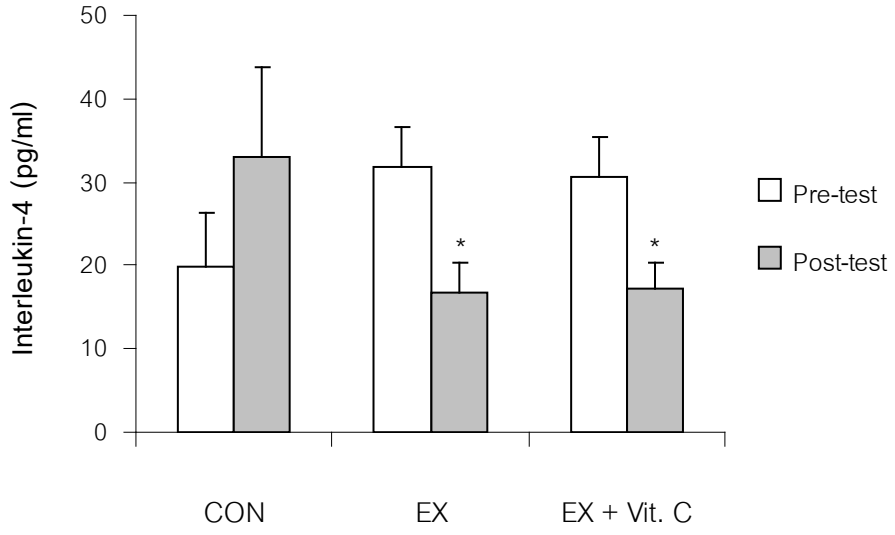
Values of interleukin-4 were shown in Table 4.28 and Figure 4.28. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) interleukin-4 when compared to pre-test.

Table 4.28 The comparison of interleukin-4 (pg/ml) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Interleukin-4 (pg/ml)		t	P-value
	Pre-test	Post-test		
CON (n=8)	19.77 ± 6.54	32.94 ± 10.79	-2.09	0.07
EX (n=9)	31.89 ± 4.83	16.77 ± 3.60*	5.44	0.00
EX + Vit. C (n=10)	30.71 ± 4.71	17.15 ± 3.21*	3.41	0.00

Values are means ± SEM.

*$p < 0.05$, significant different from pre-test.



*$p < 0.05$, significant different from pre-test.

Figure 4.28 The comparison of interleukin-4 (pg/ml) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.29 The comparison of percent difference of interleukin-4 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Interleukin-4 (pg/ml)										%Diff	
	Pre-test					Post-test					t	P-value
	Baseline	After challenge	t	P-value	%Diff	Baseline	After challenge	t	P-value	%Diff		
CON (n=8)	19.77 ± 6.54	24.44 ± 8.61	-2.04	0.08	23.62	32.94 ± 10.79	41.13 ± 12.86	-2.15	0.06	24.86	-0.48	0.63
EX (n=9)	31.89 ± 4.83	33.04 ± 6.66	-0.10	0.91	3.88	16.77 ± 3.60	27.21 ± 8.43	-1.09	0.30	62.25	-0.72	0.47
EX + Vit. C (n=10)	30.71 ± 4.71	39.66 ± 9.64	-1.10	0.29	29.14	17.15 ± 3.21	25.21 ± 7.89	-1.46	0.17	46.99	0.13	0.89

Values are means ± SEM.

Values of interleukin-4 after nasal challenge were shown in Table 4.29 and Figure 4.29, 4.30 and 4.31. There were no significant difference in interleukin-4 between baseline and after nasal challenge in all three groups; CON group, EX group and EX + Vit. C group.

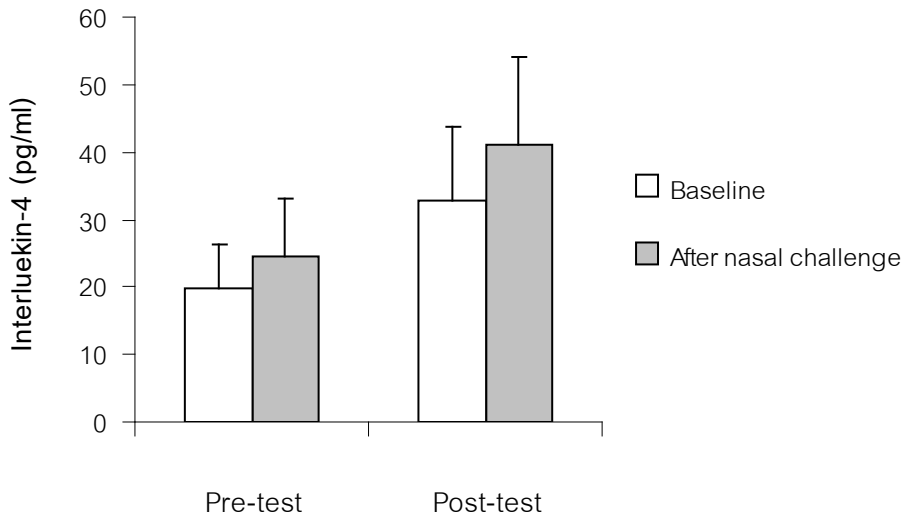


Figure 4.29 The comparison of interleukin-4 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in control group (CON).

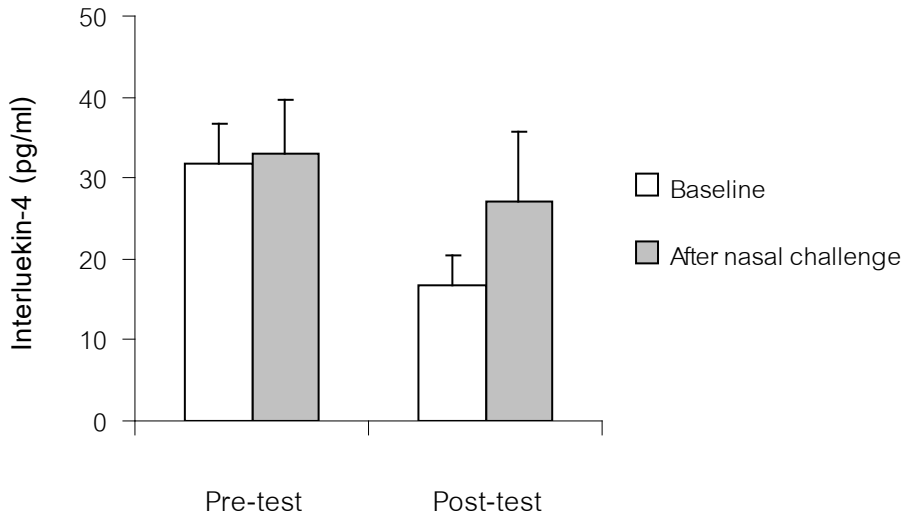


Figure 4.30 The comparison of interleukin-4 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in exercise group (EX).

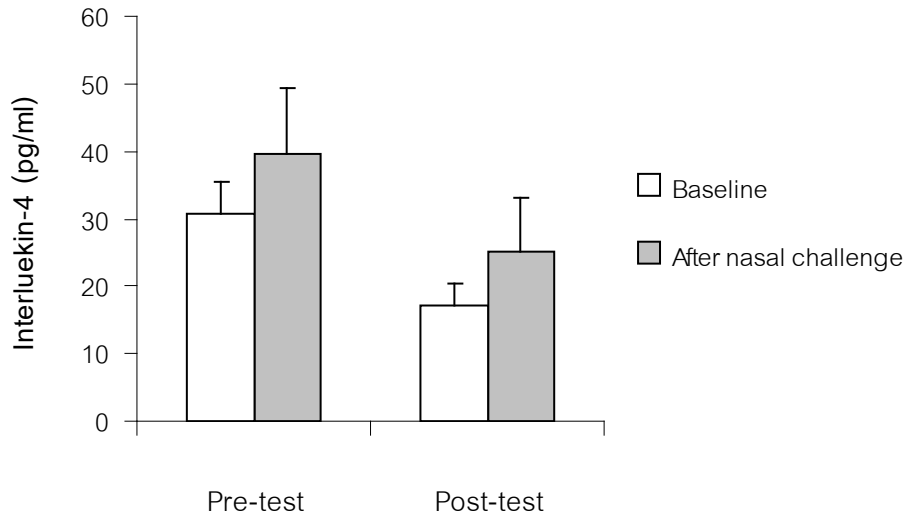


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Figure 4.31 The comparison of interleukin-4 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in exercise combined vitamin C supplementation group (EX + Vit. C).

Values of interleukin-13 were shown in Table 4.30 and Figure 4.32. There were no significant difference in interleukin-13 between pre- and post-test in all three groups; CON group, EX group and EX + Vit. C group.

Table 4.30 The comparison of interleukin-13 (pg/ml) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Interleukin-13 (pg/ml)		t	P-value
	Pre-test	Post-test		
CON (n=8)	103.59 ± 8.21	111.22 ± 21.53	-0.40	0.70
EX (n=9)	119.59 ± 11.18	99.08 ± 9.31	1.99	0.08
EX + Vit. C (n=10)	107.11 ± 6.86	96.65 ± 6.47	2.14	0.06

Values are means ± SEM.

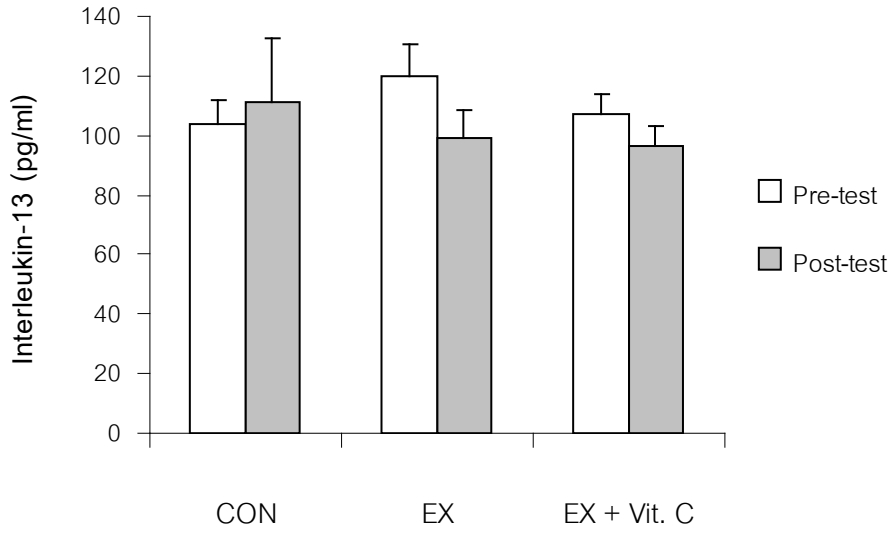


Figure 4.32 The comparison of interleukin-13 (pg/ml) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

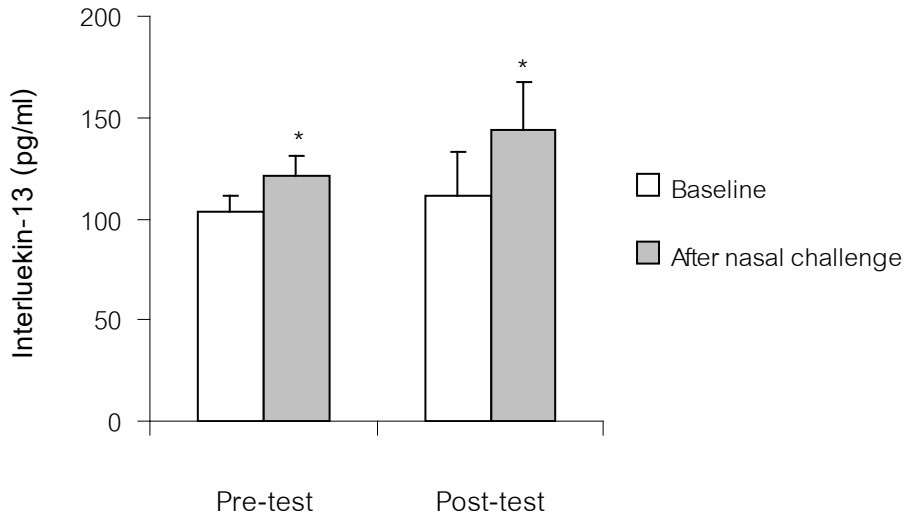
Table 4.31 The comparison of percent difference of interleukin-13 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Interleukin-13 (pg/ml)										%Diff	
	Pre-test					Post-test					t	P-value
	Baseline	After challenge	t	P-value	%Diff	Baseline	After challenge	t	P-value	%Diff		
CON (n=8)	103.59 ± 8.21	121.36 ± 9.92*	-2.51	0.04	17.15	111.22 ± 21.53	143.90 ± 23.70*	-2.48	0.04	29.38	0.30	0.76
EX (n=9)	119.59 ± 11.18	130.52 ± 8.88	-0.68	0.51	9.20	99.08 ± 9.31	111.06 ± 7.02†	-1.16	0.27	12.09	-0.17	0.86
EX + Vit. C (n=10)	107.11 ± 6.86	132.94 ± 20.68	-1.41	0.19	24.11	96.65 ± 6.47	99.45 ± 46.44†	-0.18	0.85	2.89	0.91	0.37

Values are means ± SEM.

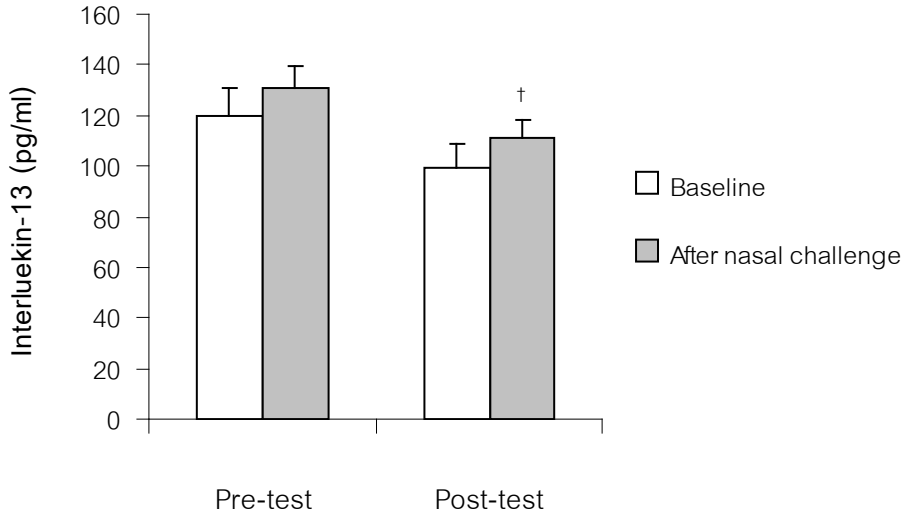
* $p < 0.05$, significant difference from baseline. † $p < 0.05$, significant difference from pre-test.

Values of interleukin-13 after nasal challenge were shown in Table 4.31 and Figure 4.33, 4.34 and 4.35. After nasal challenge, interleukin-13 in CON group were significantly higher ($p < 0.05$) than baseline in both pre and post-test. Moreover, after nasal challenge in post-test, interleukin-13 in both EX and EX + Vit. C groups were significantly higher ($p < 0.05$) than pre-test.



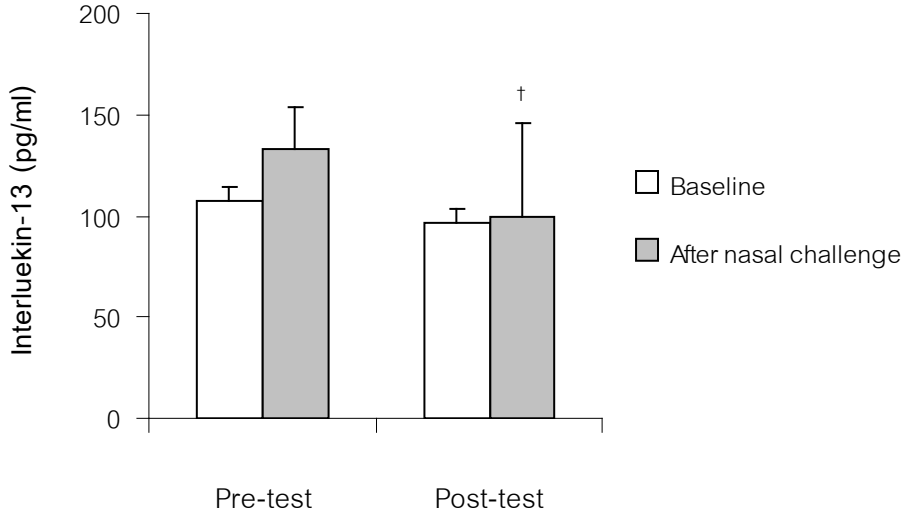
*$p < 0.05$, significant different from baseline.

Figure 4.33 The comparison of interleukin-13 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in control group (CON).



†p < 0.05, significant different from pre-test.

Figure 4.34 The comparison of interleukin-13 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in exercise group (EX).



†p < 0.05, significant different from pre-test.

Figure 4.35 The comparison of interleukin-13 after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training in exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.32 The comparison of percent difference of cytokine levels in nasal secretion after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Variables		CON (n=8)			EX (n=9)			EX + Vit. C (n=10)			F	P-value
		Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff		
IL-2	Baseline	74.88 ± 18.86	66.53 ± 22.23	-11.15	73.01 ± 13.12	87.93 ± 15.08	20.43*	77.50 ± 13.80	99.12 ± 10.95	27.89*	3.78	0.03
	Challenge	80.98 ± 18.52	65.87 ± 23.72	-18.65	102.87 ± 14.33	121.38 ± 14.39	17.99*	97.79 ± 17.19	113.46 ± 21.80	16.02*	3.25	0.04
	%Diff	(8.14)	(-0.99)		(40.89)	(38.04)		(26.18)	(14.46)			
IL-4	Baseline	19.77 ± 6.54	32.94 ± 10.79	66.61	31.89 ± 4.83	16.77 ± 3.60	-47.14*	30.71 ± 4.71	17.15 ± 3.21	-44.15*	22.05	0.00
	Challenge	24.44 ± 8.61	41.13 ± 12.86	68.28	33.04 ± 6.66	27.21 ± 8.43	-17.64*	39.66 ± 9.64	25.21 ± 7.89	-36.43*	35.48	0.00
	%Diff	(23.62)	(24.86)		(3.88)	(62.25)		(29.14)	(46.99)			
IL-13	Baseline	103.59 ± 8.21	111.22 ± 21.53	7.36	119.59 ± 11.18	99.08 ± 9.31	-17.15	107.11 ± 6.86	96.65 ± 6.47	-9.76	1.28	0.29
	Challenge	121.36 ± 9.92	143.90 ± 23.70	18.57	130.52 ± 8.88	111.06 ± 7.02	-14.90*	132.94 ± 20.68	99.45 ± 46.44	-25.19*	4.17	0.02
	%Diff	(17.15)	(29.38)		(9.20)	(12.09)		(24.11)	(2.89)			

Values are means ± SEM.

* $p < 0.05$, significant difference from CON group.

The percent difference of the cytokine levels in nasal secretion after 5 minutes nasal challenge by house dust mite (*D.pteronyssinus*) of control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C) are shown in Table 4.32. The data demonstrate that the percent difference of interleukin-2 in baseline and after nasal challenge of the both in EX and EX + Vit. C groups were significantly ($p < 0.05$) higher than CON group. The percent difference of interleukin-4 in baseline and after nasal challenge of the both in EX and EX + Vit. C groups were significantly ($p < 0.05$) lower than CON group. Moreover, The percent difference of interleukin-13 after nasal challenge of the both in EX and EX + Vit. C groups were significantly ($p < 0.05$) lower than CON group.

Part 4 The comparison of rhinitis symptoms variables between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

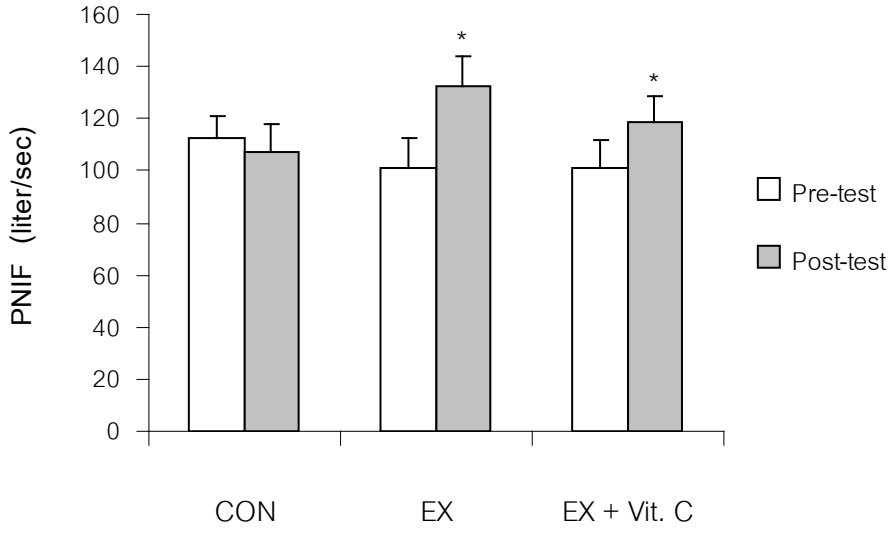
Values of PNIF were shown in Table 4.33 and Figure 4.36. After 8 weeks of training, EX and EX + Vit. C groups had a significantly higher ($p < 0.05$) PNIF when compared to pre-test.

Table 4.33 The comparison of peak nasal inspiratory flow; PNIF (liter/sec) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	PNIF (liter/sec)		t	P-value
	Pre-test	Post-test		
CON (n=8)	112.50 ± 8.60	106.88 ± 10.97	1.09	0.30
EX (n=9)	101.11± 11.35	132.78 ± 10.90*	-3.16	0.01
EX + Vit. C (n=10)	101.00 ± 10.58	119.00 ± 9.93*	-3.13	0.01

Values are means ± SEM.

*p < 0.05, significant different from pre-test.



*p < 0.05, significant different from pre-test.

Figure 4.36 The comparison of peak nasal inspiratory flow; PNIF (liter/sec) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.34 The comparison of PNIF after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	PNIF (liters/sec)											
	Pre-test						Post-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	112.50 ± 8.60	108.12 ± 12.88	76.25 ± 20.26	66.25 ± 16.79	60.00 ± 16.90	68.75 ± 19.86	106.88 ± 10.97	95.00 ± 21.63	76.25 ± 21.78	65.00 ± 21.71	58.75 ± 19.58	62.50 ± 20.06
(% Diff)		(-3.89)	(-32.22)	(-41.11)	(-46.67)	(-38.89)		(-11.12)	(-28.66)	(-39.18)	(-45.03)	(-41.52)
EX	101.11± 11.35	93.33 ± 11.54	60.00 ± 14.81	48.88 ± 11.35	57.22 ± 11..27	52.77 ± 12.10	132.78 ± 10.90	84.44 ± 10.68	71.66 ± 11.11	57.22 ± 13.61	81.11 ± 9.92	87.77 ± 13.82*
(% Diff)		(-7.69)	(-40.66)	(-51.66)	(-43.41)	(-47.81)		(-36.41)	(-46.03)	(-56.91)	(-38.91)	(-33.90)
EX + Vit. C	101.00 ± 10.58	94.00 ± 8.71	73.00 ± 9.66	69.00 ± 9.59	76.00 ± 7.77	75.00 ± 9.09	119.00 ± 9.93	104.50 ± 8.57	94.00 ± 9.56	88.00 ± 8.53	84.00 ± 9.56	87.5 ± 8.66*
(% Diff)		(-6.93)	(-27.72)	(-31.68)	(-24.75)	(-25.74)		(-12.18)	(-21.01)	(-26.05)	(-29.41)	(-26.47)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

Values of peak nasal inspiratory flow (PNIF) after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.34 and Figure 4.37, 4.38 and 4.39. The results showed that after nasal challenge 60 minutes, the EX and EX + Vit. C groups had a significantly higher ($p < 0.05$) PNIF when compared to pre-test. There were no significant difference in PNIF after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

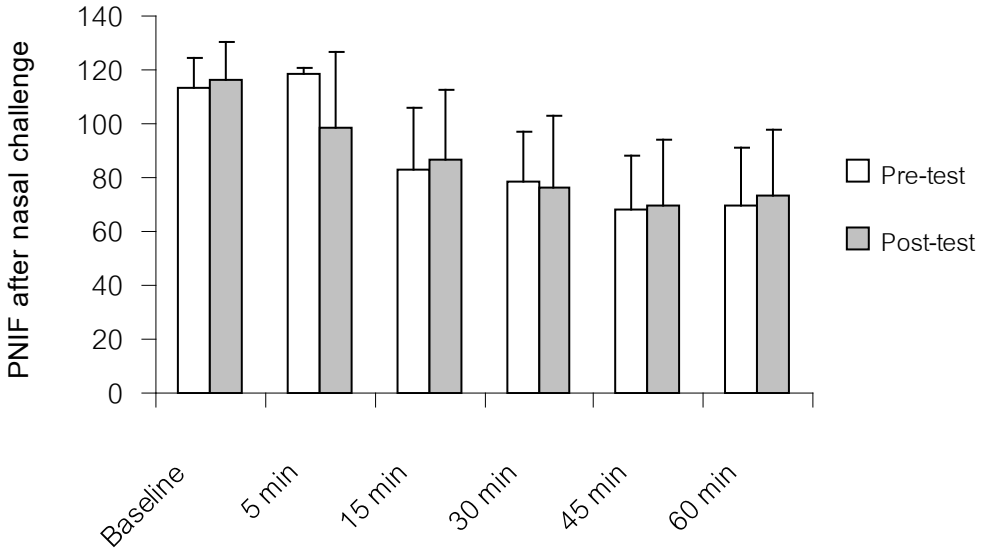
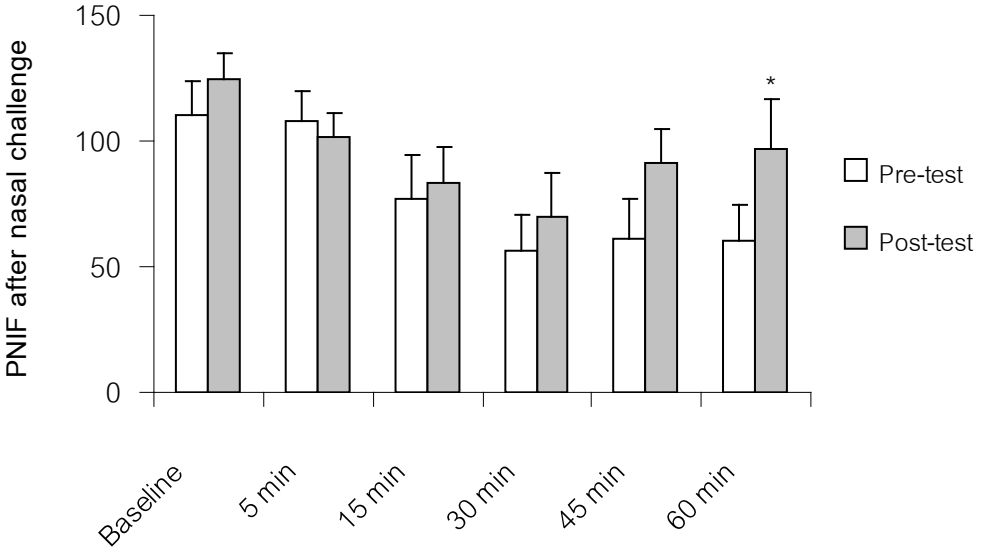
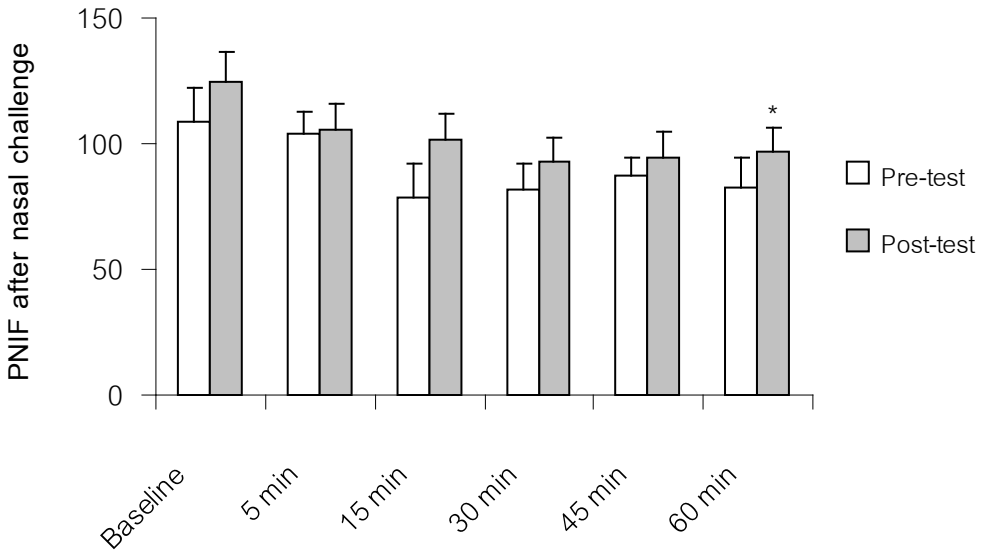


Figure 4.37 The comparison of PNIF after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in control group (CON).



*p < 0.05, significant different from pre-test.

Figure 4.38 The comparison of PNIF after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).



*p < 0.05, significant different from pre-test.

Figure 4.39 The comparison of PNIF after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C supplementation group (EX + Vit. C).

Values of nasal blood flow were shown in Table 4.35 and Figure 4.40. After 8 weeks of training, EX and EX + Vit. C groups had a significantly higher ($p < 0.05$) in nasal blood flow when compared to pre-test.

Table 4.35 The comparison of nasal blood flow (AU) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Nasal blood flow (AU)		t	P-value
	Pre-test	Post-test		
CON (n=8)	44.15 ± 6.75	47.55 ± 4.27	-1.06	0.32
EX (n=9)	46.11 ± 5.89	32.90 ± 2.44*	3.49	0.00
EX + Vit. C (n=10)	43.29 ± 5.54	33.24 ± 3.49*	2.57	0.03

Values are means ± SEM.

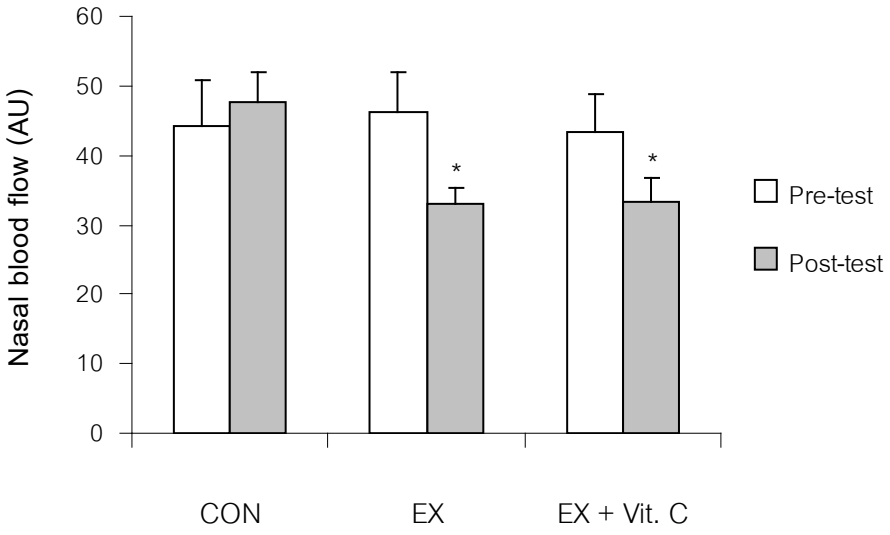


Figure 4.40 The comparison of nasal blood flow (AU) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Values of nasal blood flow (NBF) after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.36 and Figure 4.41, 4.42 and 4.43. The results showed that after nasal challenge 5 minutes and 30 minutes, the EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) NBF when compared to pre-test. Moreover, after nasal challenge 15 minutes, the EX groups had a significantly lower ($p < 0.05$) NBF when compared to pre-test.

There were no significant difference in NBF after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

Table 4.36 The comparison of NBF after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	NBF (AU)											
	Pre-test						Post-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	44.15 ± 6.75	64.48 ± 7.92	57.98 ± 6.88	51.02 ± 7.81	46.68 ± 4.36	42.61 ± 2.81	47.55 ± 4.27	62.33 ± 5.23	54.35 ± 5.86	53.76 ± 8.36	47.97 ± 7.47	44.92 ± 2.61
(%Diff)		(46.05)	(31.33)	(15.56)	(5.73)	(-3.49)		(31.08)	(14.30)	(13.06)	(0.88)	(-5.53)
EX	46.11 ± 5.89	69.05 ± 8.40	62.87 ± 6.78	53.68 ± 5.05	45.80 ± 5.70	43.85 ± 7.92	32.90 ± 2.44	44.46 ± 4.81*	43.60 ± 4.53*	41.57 ± 5.08*	39.58 ± 6.36	33.17 ± 6.82
(%Diff)		(49.75)	(36.35)	(16.42)	(-2.23)	(-4.90)		(35.14)	(32.52)	(26.35)	(20.30)	(0.82)
EX + Vit. C	43.29 ± 5.54	61.15 ± 5.85	52.91 ± 6.44	50.50 ± 3.38	47.82 ± 5.14	39.61 ± 6.69	33.24 ± 3.49	45.93 ± 4.40*	42.62 ± 5.19	41.70 ± 2.43*	39.69 ± 3.53	32.80 ± 3.98
(%Diff)		(41.26)	(22.22)	(16.66)	(10.46)	(-8.50)		(38.18)	(28.22)	(25.45)	(19.40)	(-1.32)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

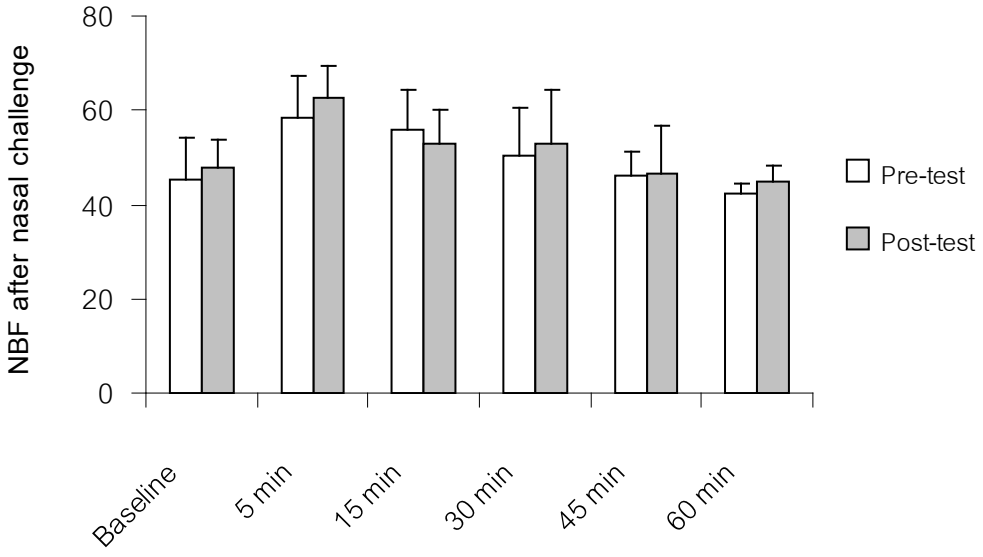
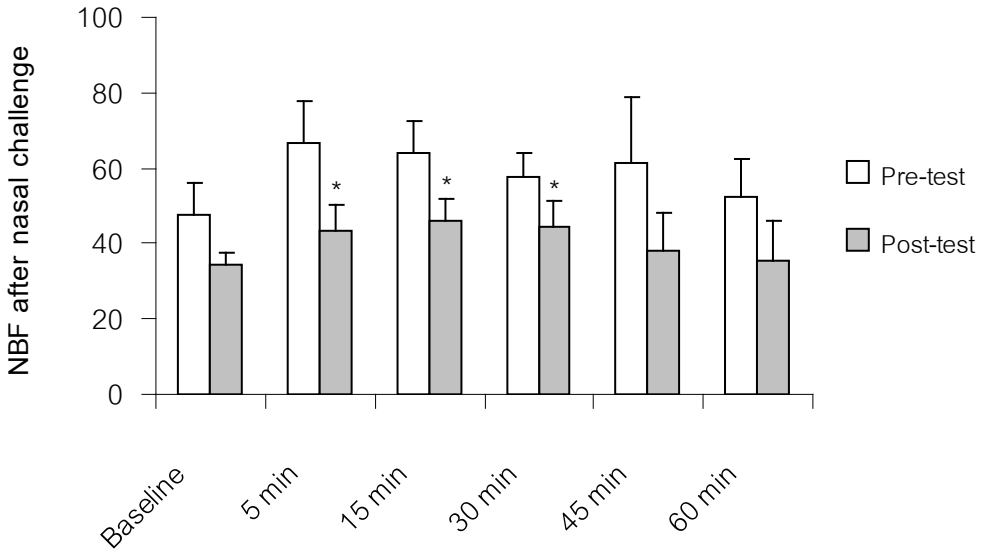
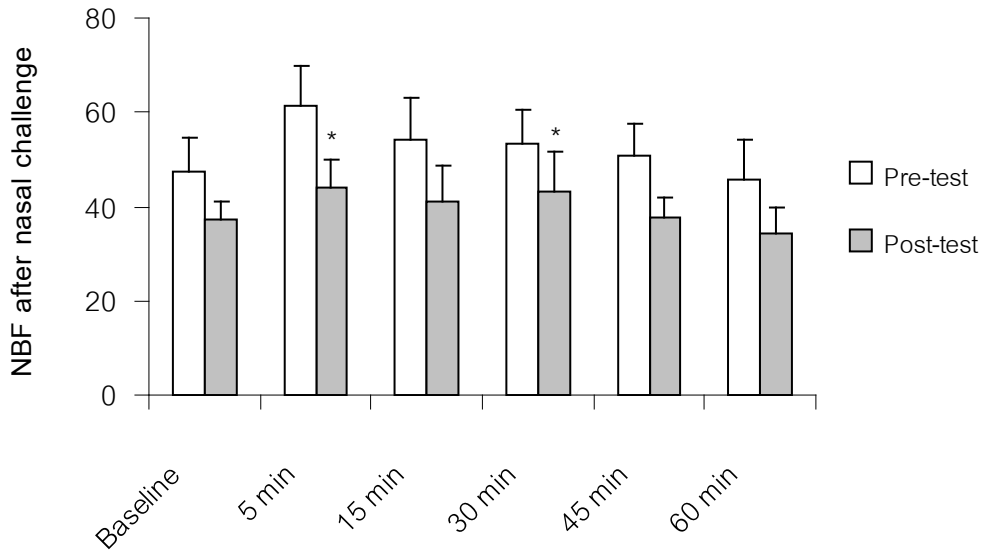


Figure 4.41 The comparison of NBF after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the control group (CON).



*p < 0.05, significant different from pre-test.

Figure 4.42 The comparison of NBF after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).



*p < 0.05, significant different from pre-test.

Figure 4.43 The comparison of NBF after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C supplementation group (EX + Vit. C).

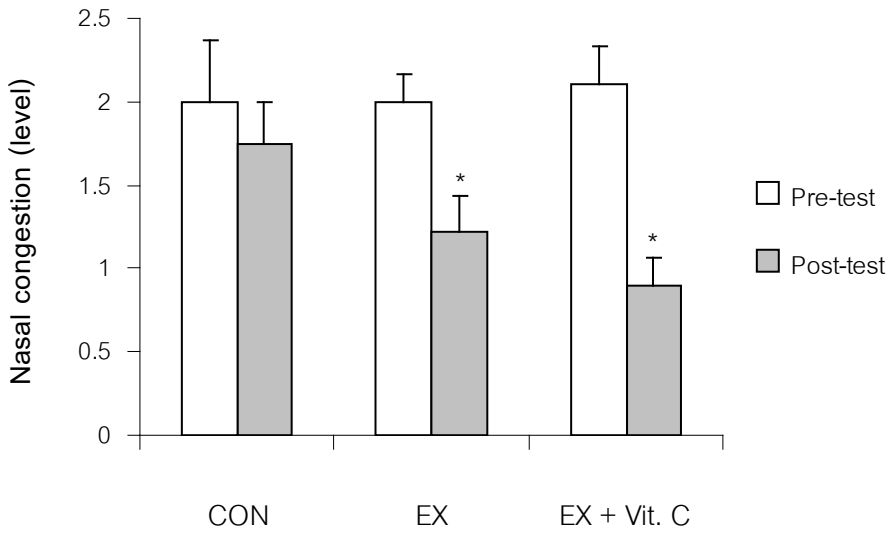
Values of nasal congestion were shown in Table 4.37 and Figure 4.44. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) nasal congestion when compared to pre-test.

Table 4.37 The comparison of nasal congestion (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Nasal congestion (level)		t	P-value
	Pre-test	Post-test		
CON (n=8)	2.00 ± 0.37	1.75 ± 0.25	0.79	0.45
EX (n=9)	2.00 ± 0.16	1.22 ± 0.22*	3.50	0.00
EX + Vit. C (n=10)	2.10 ± 0.23	0.90 ± 0.17*	4.81	0.00

Values are means ± SEM. (0 = none, 1 = mild, 2 = moderate, 3 = severe)

*$p < 0.05$, significant different from pre-test.



*$p < 0.05$, significant different from pre-test.

Figure 4.44 The comparison of nasal congestion (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

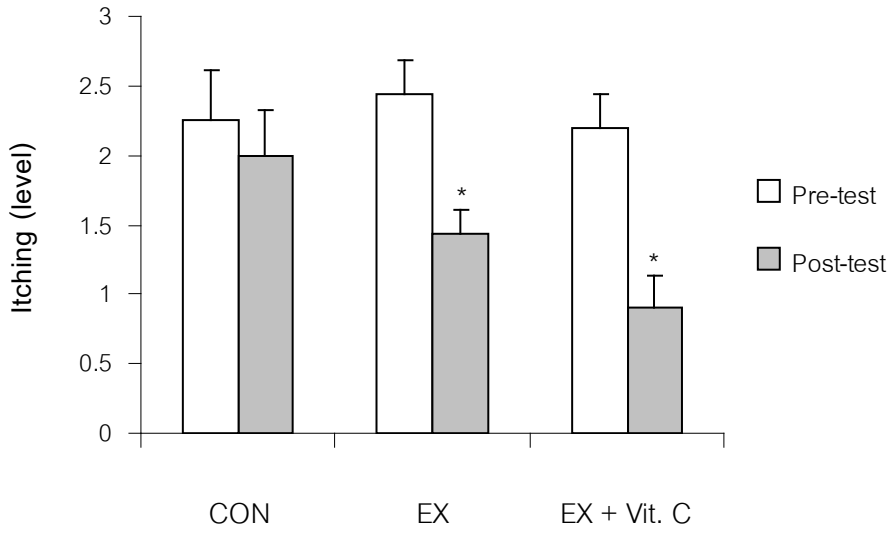
Values of itching were shown in Table 4.38 and Figure 4.45. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) itching when compared to pre-test.

Table 4.38 The comparison of itching (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Itching (level)		t	P-value
	Pre-test	Post-test		
CON (n=8)	2.25 ± 0.36	2.00 ± 0.32	1.52	0.17
EX (n=9)	2.44 ± 0.24	1.44 ± 0.17*	3.46	0.00
EX + Vit. C (n=10)	2.20 ± 0.24	0.90 ± 0.23*	3.88	0.00

Values are means ± SEM. (0 = none, 1 = mild, 2 = moderate, 3 = severe)

*p < 0.05, significant different from pre-test.



*p < 0.05, significant different from pre-test.

Figure 4.45 The comparison of itching (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

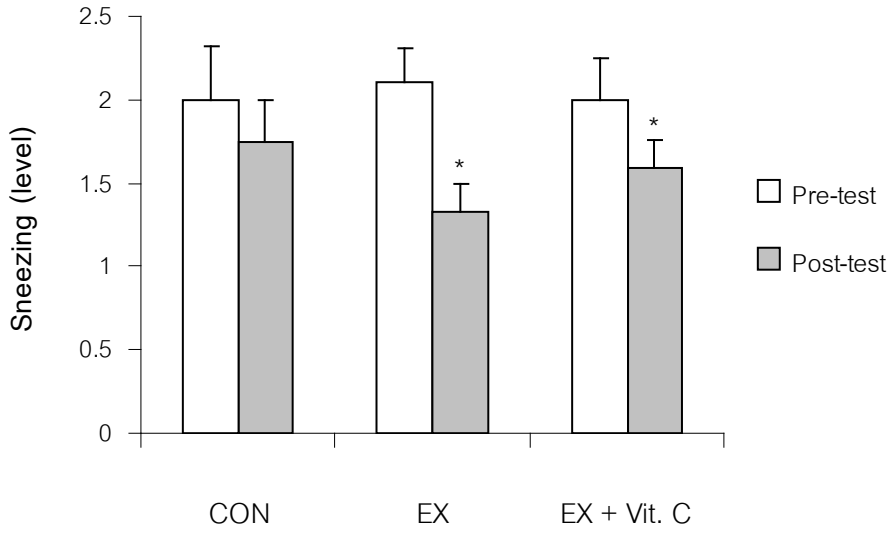
Values of sneezing were shown in Table 4.39 and Figure 4.46. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) sneezing when compared to pre-test.

Table 4.39 The comparison of sneezing (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Sneezing (level)		t	P-value
	Pre-test	Post-test		
CON (n=8)	2.00 ± 0.32	1.75 ± 0.25	1.00	0.35
EX (n=9)	2.11 ± 0.20	1.33 ± 0.16*	5.29	0.00
EX + Vit. C (n=10)	2.00 ± 0.25	1.59 ± 0.17*	3.97	0.00

Values are means ± SEM. (0 = none, 1 = mild, 2 = moderate, 3 = severe)

*$p < 0.05$, significant different from pre-test.



*$p < 0.05$, significant different from pre-test.

Figure 4.46 The comparison of sneezing (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

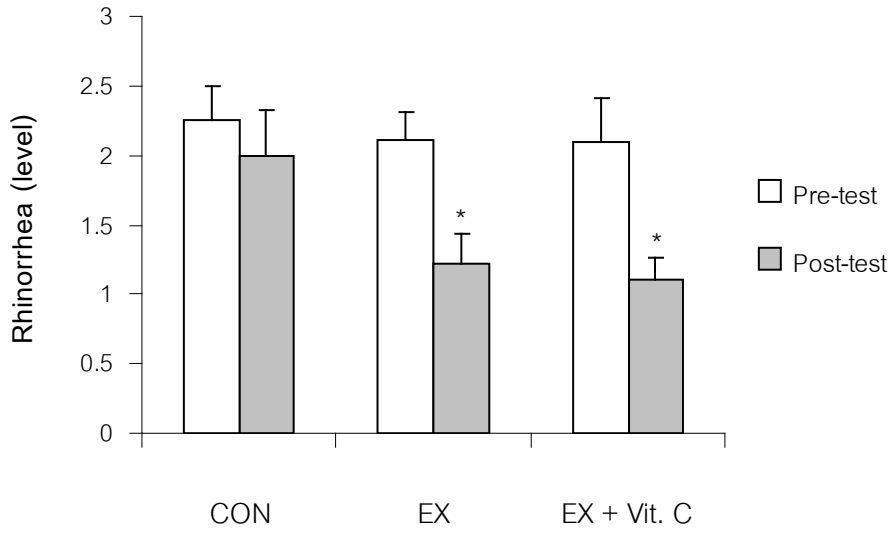
Values of rhinorrhea were shown in Table 4.40 and Figure 4.47. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) rhinorrhea when compared to pre-test.

Table 4.40 The comparison of rhinorrhea (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Rhinorrhea (level)		t	P-value
	Pre-test	Post-test		
CON (n=8)	2.25 ± 0.25	2.00 ± 0.32	1.52	0.17
EX (n=9)	2.11 ± 0.20	1.22 ± 0.22*	2.87	0.02
EX + Vit. C (n=10)	2.10 ± 0.31	1.10 ± 0.17*	2.73	0.02

Values are means ± SEM. (0 = none, 1 = mild, 2 = moderate, 3 = severe)

*p < 0.05, significant different from pre-test.



*p < 0.05, significant different from pre-test.

Figure 4.47 The comparison of rhinorrhea (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

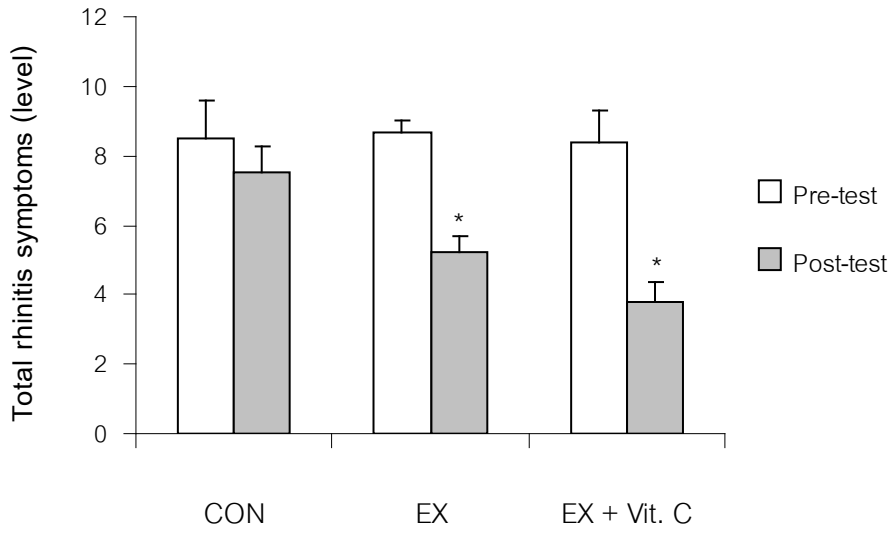
Values of total rhinitis symptoms were shown in Table 4.41 and Figure 4.48. After 8 weeks of training, EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) total rhinitis symptoms when compared to pre-test.

Table 4.41 The comparison of total rhinitis symptoms (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Total rhinitis symptoms (level)		t	P-value
	Pre-test	Post-test		
CON (n=8)	8.50 ± 1.11	7.50 ± 0.77	1.76	0.12
EX (n=9)	8.66 ± 0.37	5.22 ± 0.46*	5.93	0.00
EX + Vit. C (n=10)	8.40 ± 0.93	3.80 ± 0.57*	4.59	0.00

Values are means ± SEM. (0 = none, 1 = mild, 2 = moderate, 3 = severe)

*$p < 0.05$, significant different from pre-test.



*$p < 0.05$, significant different from pre-test.

Figure 4.48 The comparison of total rhinitis symptoms (level) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Table 4.42 The comparison of percent difference of the rhinitis symptoms variables among in control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Variables	CON (n=8)			EX (n=9)			EX + Vit. C (n=10)			F	P-value
	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff	Pre-test	Post-test	%Diff		
PNIF (liters/sec)	112.50 ± 8.60	106.88 ± 10.97	-5.00	101.11± 11.35	132.78 ± 10.90*	31.32†	101.00 ± 10.58	119.00 ± 9.93*	17.82†	6.06	0.00
Nasal blood flow (AU)	44.15 ± 6.75	47.55 ± 4.27	7.70	46.11 ± 5.89	32.90 ± 2.44*	-28.65†	43.29 ± 5.54	33.24 ± 3.49*	-23.22†	8.27	0.00
The level of rhinitis symptoms											
Nasal congestion	2.00 ± 0.37	1.75 ± 0.25	-12.50	2.00 ± 0.16	1.22 ± 0.22*	-39.00	2.10 ± 0.23	0.90 ± 0.17*	-57.14†	3.60	0.04
Itching	2.25 ± 0.36	2.00 ± 0.32	-11.11	2.44 ± 0.24	1.44 ± 0.17*	-40.98	2.20 ± 0.24	0.90 ± 0.23*	-59.10†	4.66	0.01
Sneezing	2.00 ± 0.32	1.75 ± 0.25	-12.50	2.11 ± 0.20	1.33 ± 0.16*	-36.97	2.00 ± 0.25	1.59 ± 0.17*	-20.50	2.13	0.14
Rhinorrhea	2.25 ± 0.25	2.00 ± 0.32	-11.11	2.11 ± 0.20	1.22 ± 0.22*	-42.18	2.10 ± 0.31	1.10 ± 0.17*	-47.62	1.98	0.16
Total rhinitis symptoms	8.50 ± 1.11	7.50 ± 0.77	-11.76	8.66 ± 0.37	5.22 ± 0.46*	-39.72†	8.40 ± 0.93	3.80 ± 0.57*	-54.76†	6.07	0.00

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same group. † $p < 0.05$, significant difference from CON group.

The percent difference of the rhinitis symptoms variables of control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C) are shown in Table 4.42. The data demonstrate that the percent difference of peak nasal inspiratory flow, nasal blood flow and total rhinitis symptom, of the both in EX and EX + Vit. C groups were significantly ($p < 0.05$) lower than CON group. Furthermore, the percent difference of nasal congestion and itching of the EX + Vit. C group were significantly ($p < 0.05$) lower than CON group.

Values of nasal congestion after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.43 and Figure 4.49, 4.50 and 4.51. The results showed that after nasal challenge15, 30 and 45 minutes, the EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) nasal congestion when compared to pre-test. Moreover, after nasal challenge 60 minutes, the EX + Vit. C groups had a significantly lower ($p < 0.05$) nasal congestion when compared to pre-test.

There were no significant difference in nasal congestion after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

Table 4.43 The comparison of nasal congestion after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Nasal congestion (Level)											
	Pre-test						Post-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	2.00 ± 0.37	1.37 ± 0.41	2.25 ± 0.25	2.25 ± 0.36	2.12 ± 0.39	1.50 ± 0.50	1.75 ± 0.25	1.87 ± 0.44	2.25 ± 0.25	2.37 ± 0.26	2.25 ± 0.31	1.87 ± 0.35
(%Diff)		(-31.50)	(12.50)	(12.50)	(6.00)	(-25.00)		(6.86)	(28.57)	(35.43)	(28.57)	(6.86)
EX	2.00 ± 0.16	1.00 ± 0.40	2.11 ± 0.38	2.44 ± 0.29	1.66 ± 0.40	1.77 ± 0.43	1.22 ± 0.22	0.77 ± 0.22	1.33 ± 0.23*	1.22± 0.36*	0.88 ± 0.35*	0.88 ± 0.35*
(%Diff)		(-50.00)	(5.50)	(22.00)	(-17.00)	(-11.50)		(-36.89)	(9.02)	(0.00)	(-27.87)	(-27.87)
EX + Vit. C	2.10 ± 0.23	1.40 ± 0.33	2.20± 0.20	2.50± 0.22	1.70 ± 0.30	1.40 ± 0.26	0.90 ± 0.17	1.20 ± 0.38	1.10 ± 0.31*	1.10 ± 0.23*	1.10 ± 0.23*	1.10 ± 0.17
(%Diff)		(-33.33)	(4.76)	(19.05)	(19.05)	(-33.33)		(33.33)	(22.22)	(22.22)	(22.22)	(2.22)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

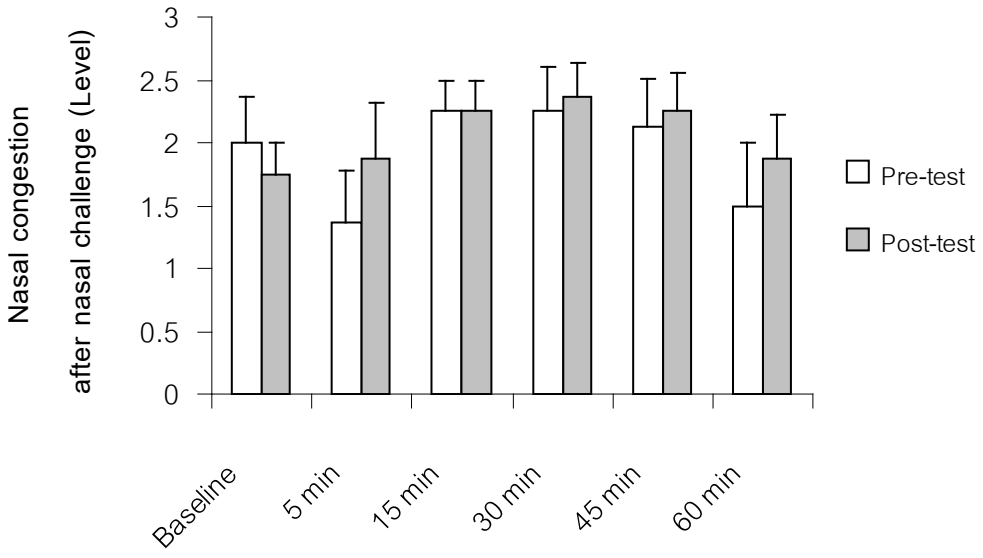
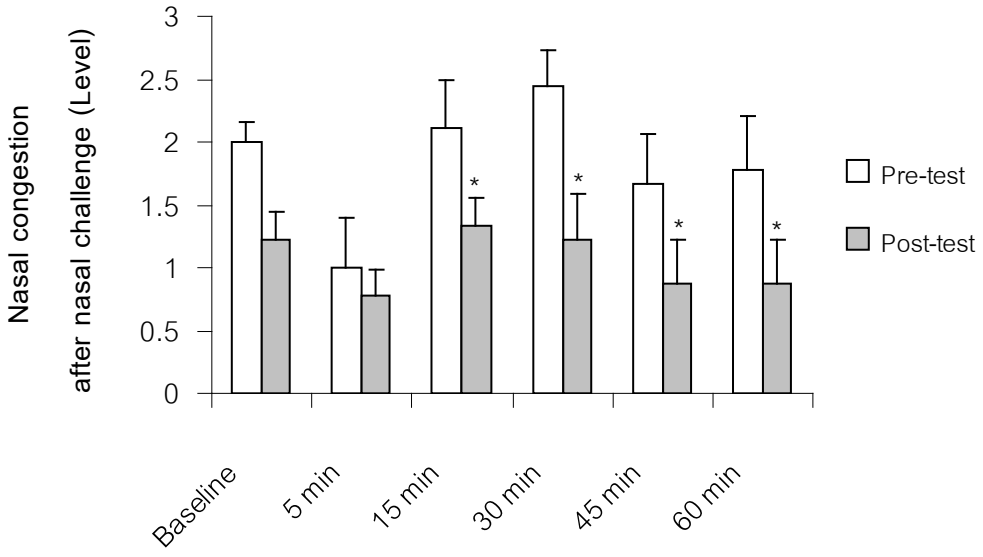
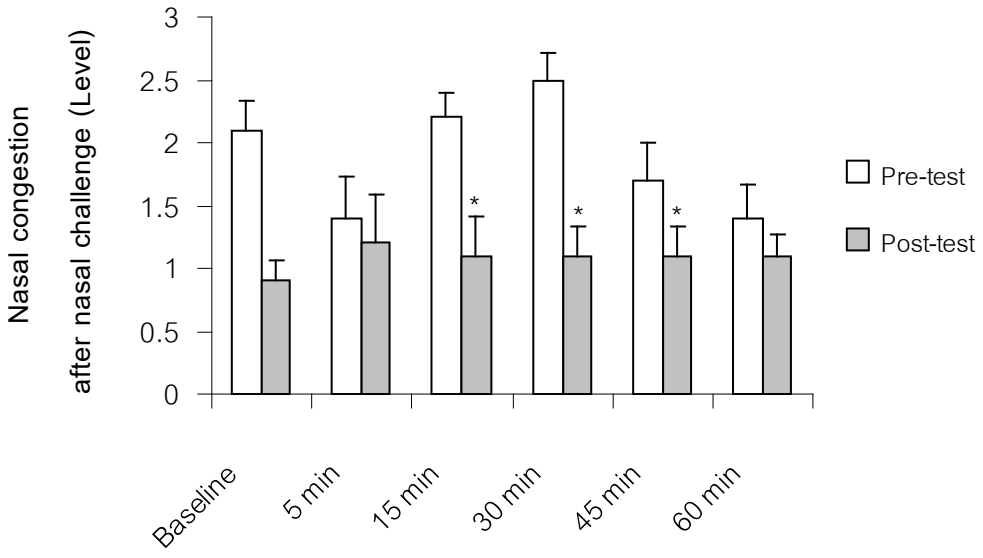


Figure 4.49 The comparison of nasal congestion after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the control group (CON).



*p < 0.05, significant different from pre-test.

Figure 4.50 The comparison of nasal congestion after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).



*p < 0.05, significant different from pre-test.

Figure 4.51 The comparison of nasal congestion after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C group (EX + Vit. C).

Values of itching after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.44 and Figure 4.52, 4.53 and 4.54. The results showed that after nasal challenge 15 and 30 minutes, the EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) itching when compared to pre-test. Moreover, after nasal challenge 45 minutes the EX group had a significantly lower ($p < 0.05$) itching when compared to pre-test.

There were no significant difference in itching after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

Table 4.44 The comparison of itching after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Itching (Level)											
	Pre-test						Post-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	2.25 ± 0.36	2.12 ± 0.29	1.25 ± 0.36	1.00 ± 0.37	0.87 ± 0.39	0.75± 0.31	2.00 ± 0.32	2.37 ± 0.37	1.50 ± 0.32	0.87 ± 0.29	0.75 ± 0.25	0.62 ± 0.26
(%Diff)		(-5.78)	(-44.44)	(-55.56)	(-61.33)	(-66.67)		(18.50)	(-25.00)	(-56.50)	(-62.50)	(-69.00)
EX	2.44 ± 0.24	2.33 ± 0.28	2.11 ± 0.38	1.88 ± 0.38	1.11 ± 0.20	0.77 ± 0.27	1.44 ± 0.17	1.33 ± 0.33*	0.77 ± 0.22*	0.22 ± 0.14*	0.11 ± 0.11*	0.11 ± 0.11
(%Diff)		(-4.51)	(13.52)	(-22.95)	(-54.51)	(-68.44)		(-7.64)	(-46.53)	(-84.72)	(-92.36)	(-92.36)
EX + Vit. C	2.20 ± 0.24	1.60 ± 0.37	1.60 ± 0.30	1.40 ± 0.37	1.00 ± 0.29	0.70 ± 0.21	0.90 ± 0.23	1.40 ± 0.40	0.90 ± 0.23*	0.60 ± 0.16*	0.50 ± 0.16*	0.50 ± 0.22
(%Diff)		(-27.27)	(-27.27)	(-36.36)	(-54.55)	(-68.18)		(55.56)	(0.00)	(-33.33)	(-44.44)	(-44.44)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

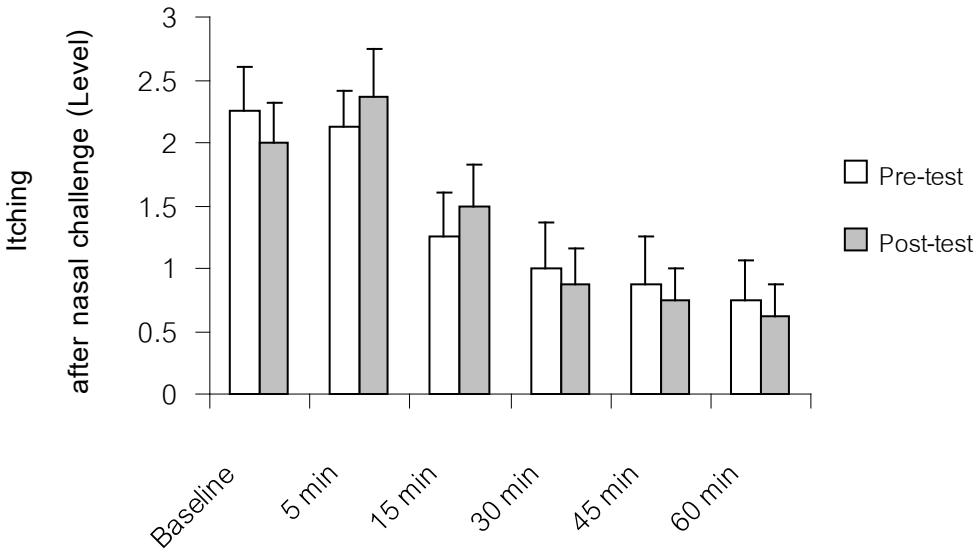
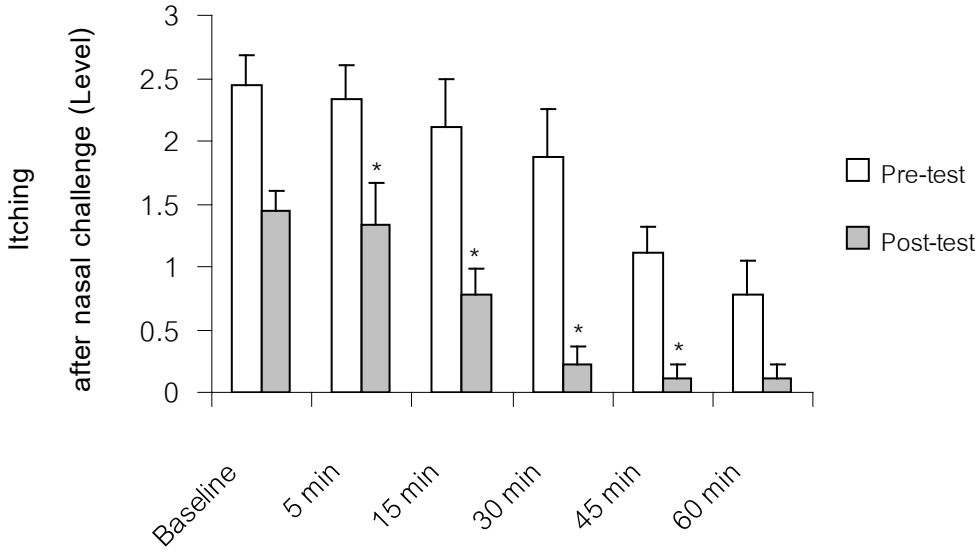
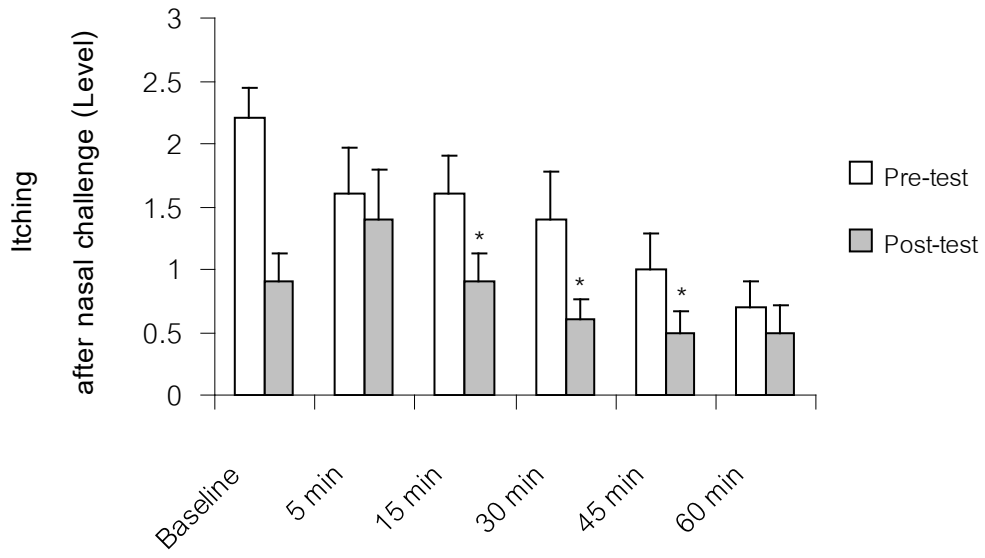


Figure 4.52 The comparison of itching after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the control group (CON).



*p < 0.05, significant different from pre-test.

Figure 4.53 The comparison of itching after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).



*p < 0.05, significant different from pre-test.

Figure 4.54 The comparison of itching after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C group (EX + Vit. C).

Values of sneezing after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.45 and Figure 4.55, 4.56 and 4.57. There were no significant difference in sneezing after nasal challenge 5, 15, 30, 45, 60 minutes when compared between pre- and post-test.

There were no significant difference in sneezing after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

Table 4.45 The comparison of sneezing after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Sneezing (Level)											
	Pre-test						Post-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	2.00 ± 0.32	1.62 ± 0.49	1.00 ± 0.32	0.37 ± 0.26	0.25 ± 0.16	0.12 ± 0.12	1.75 ± 0.25	1.87 ± 0.54	0.75 ± 0.25	0.12 ± 0.12	0.12 ± 0.12	0.12 ± 0.12
(%Diff)		(-19.00)	(-50.00)	(-81.50)	(-87.50)	(-94.00)		(6.86)	(-57.14)	(-93.14)	(-93.14)	(.93.14)
EX	2.11 ± 0.20	1.22 ± 0.40	1.00 ± 0.40	0.33 ± 0.23	0.11 ± 0.11	0.22 ± 0.14	1.33 ± 0.16	1.44 ± 0.37	0.22 ± 0.14	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
(%Diff)		(-42.18)	(-52.61)	(-84.36)	(-94.79)	(-89.57)		(8.27)	(-83.46)	(-100.00)	(-100.00)	(-100.00)
EX + Vit. C	2.00 ± 0.25	1.30 ± 0.42	0.80 ± 0.35	0.50 ± 0.30	0.10 ± 0.10	0.10 ± 0.10	1.59 ± 0.17	1.40 ± 0.36	0.40 ± 0.22	0.20 ± 0.13	0.00 ± 0.00	0.00 ± 0.00
(%Diff)		(-35.00)	(-60.00)	(-75.00)	(-95.00)	(-95.00)		(11.95)	(-74.84)	(-87.42)	(-100.00)	(-100.00)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

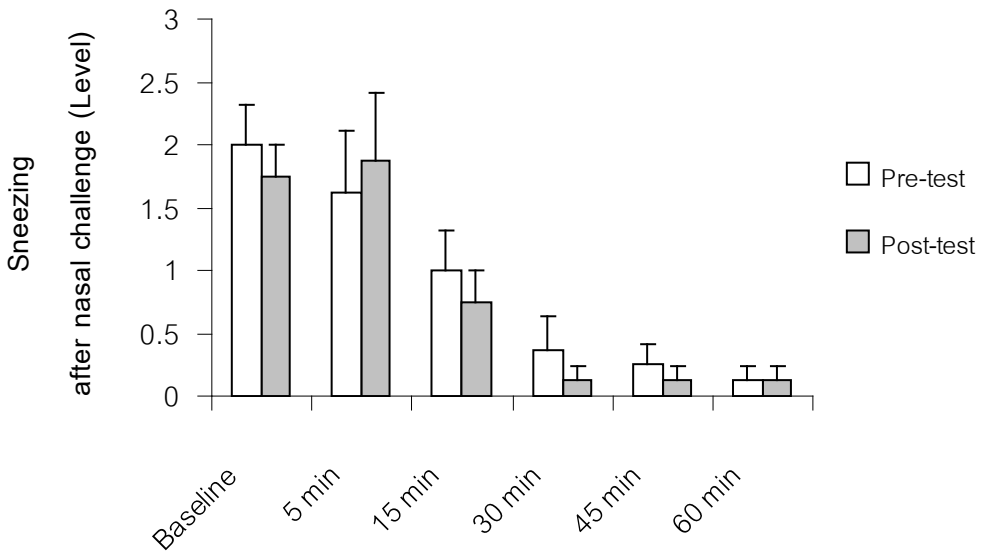


Figure 4.55 The comparison of sneezing after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the control group (CON).

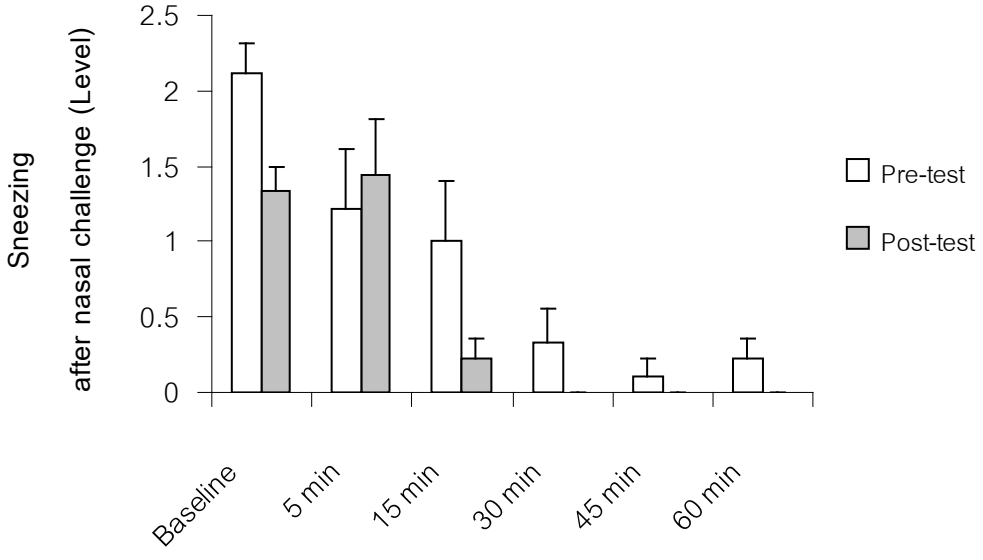


Figure 4.56 The comparison of sneezing after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).

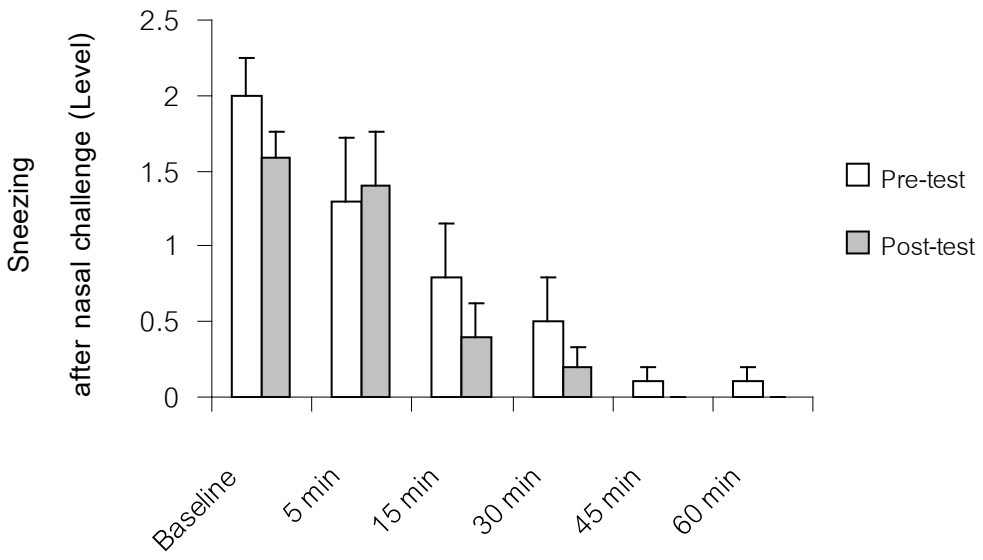


Figure 4.57 The comparison of sneezing after nasal challenge on 0, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C group (EX + Vit. C).

Values of rhinorrhea after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.46 and Figure 4.58, 4.59 and 4.60. The results showed that after nasal challenge 15, 30 and 45 minutes, the EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) rhinorrhea when compared to pre-test. Moreover, after nasal challenge 5 minutes the EX + Vit. C group had a significantly lower ($p < 0.05$) rhinorrhea when compared to pre-test.

There were no significant difference in rhinorrhea after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

Table 4.46 The comparison of rhinorrhea after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Rhinorrhea (Level)											
	Pre-test						Post-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	2.25 ± 0.25	1.87 ± 0.39	2.12 ± 0.35	1.75 ± 0.45	1.00 ± 0.37	0.87 ± 0.39	2.00 ± 0.32	1.87 ± 0.29	2.25 ± 0.31	1.37 ± 0.46	1.12 ± 0.44	1.12 ± 0.44
(%Diff)		(-16.89)	(-5.78)	(-22.22)	(-55.56)	(-63.33)		(-6.50)	(12.50)	(-31.50)	(-44.00)	(-44.00)
EX	2.11 ± 0.20	1.88 ± 0.35	2.22 ± 0.36	2.11 ± 0.38	1.22 ± 0.32	0.77 ± 0.22	1.22 ± 0.22	1.88 ± 0.26	1.44 ± 0.33*	0.66 ± 0.16*	0.22 ± 0.14*	0.22 ± 0.14
(%Diff)		(-10.90)	(5.21)	(0.00)	(-42.18)	(-63.51)		(54.10)	(18.03)	(-45.90)	(-81.97)	(-81.97)
EX + Vit. C	2.10 ± 0.31	1.90 ± 0.37	2.20 ± 0.32	1.80 ± 0.41	1.10 ± 0.27	0.70 ± 0.26	1.10 ± 0.17	1.00 ± 0.36*	1.20 ± 0.35*	0.50 ± 0.16*	0.30 ± 0.21*	0.40 ± 0.22
(%Diff)		(-9.52)	(4.76)	(-14.29)	(-47.62)	(-66.67)		(-9.09)	(9.09)	(-54.55)	(-72.73)	(-63.64)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

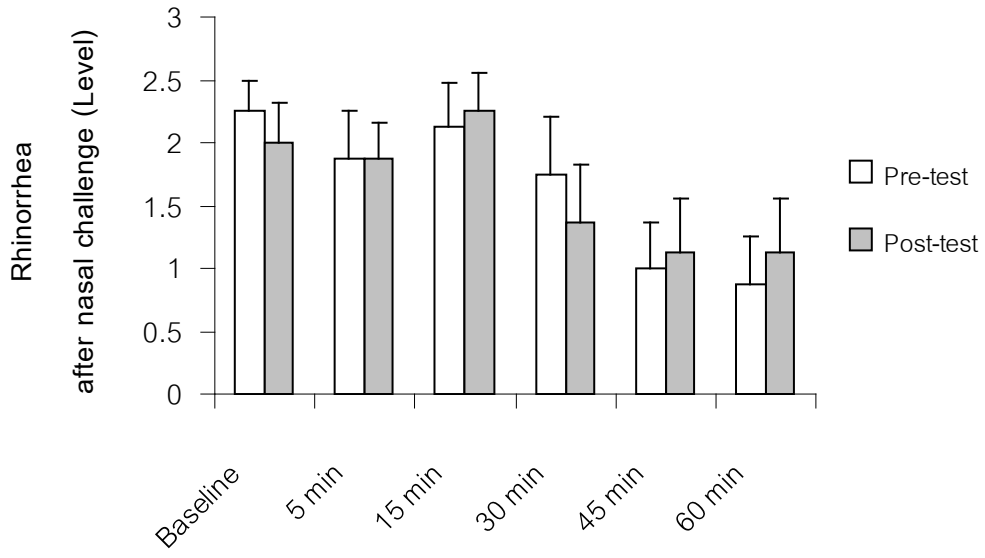
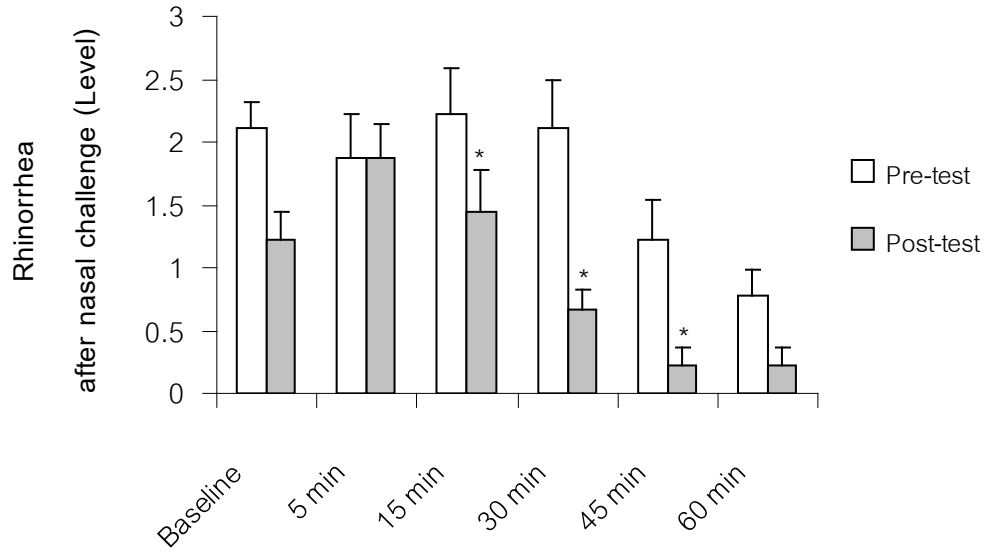
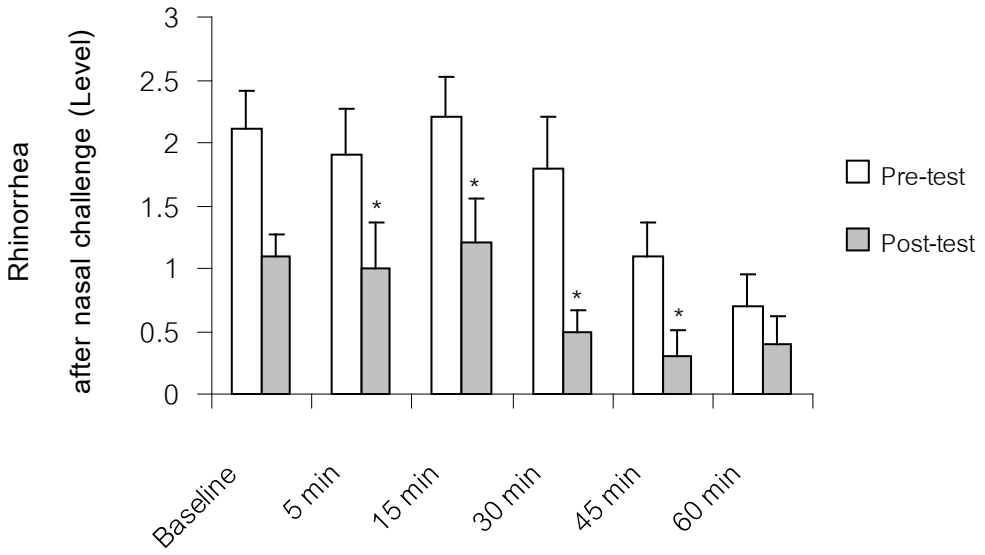


Figure 4.58 The comparison of rhinorrhea after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the control group (CON).



*p < 0.05, significant different from pre-test.

Figure 4.59 The comparison of rhinorrhea after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).



*p < 0.05, significant different from pre-test.

Figure 4.60 The comparison of rhinorrhea after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C group (EX + Vit. C).

Values of total rhinitis symptoms after nasal challenge by house dust mite (*D.pteronyssinus*) were shown in Table 4.47 and Figure 4.61, 4.62 and 4.63. The results showed that after nasal challenge 15, 30, 45 and 60 minutes, the EX and EX + Vit. C groups had a significantly lower ($p < 0.05$) total rhinitis symptoms when compared to pre-test. Moreover, after nasal challenge 0 minutes the CON group had a significantly higher ($p < 0.05$) total rhinitis symptoms when compared to pre-test.

There were no significant difference in total rhinitis symptoms after nasal challenge 5, 15, 30, 45, 60 minutes among three groups; CON group, EX group and EX + Vit. C group.

Table 4.47 The comparison of total rhinitis symptoms after nasal challenge by house dust mite (*D.pteronyssinus*) between pre- and post-training and among three groups of subjects: control group (CON), exercise group (EX) and exercise combined vitamin C supplementation group (EX + Vit. C).

Group	Total rhinitis symptoms											
	Pre-test						Pre-test					
	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min	baseline	After 5 min	After 15 min	After 30 min	After 45 min	After 60 min
CON	8.50 ± 1.11	7.00 ± 1.32	6.62 ± 0.73	5.37 ± 0.84	4.25 ± 0.55	3.25 ± 0.90	7.50 ± 0.77	8.00 ± 1.08	6.75 ± 0.67	4.75 ± 0.59	4.25 ± 0.52	3.75 ± 0.70
(%Diff)		(-17.65)	(-22.12)	(-36.82)	(-50.00)	(-61.76)		(6.67)	(-10.00)	(-36.67)	(-43.33)	(-50.00)
EX	8.66 ± 0.37	6.44 ± 1.91	7.44 ± 1.00	6.77 ± 0.96	4.11 ± 0.65	3.55 ± 0.68	5.22 ± 0.46	5.44 ± 0.86	3.77 ± 0.49*	2.11 ± 0.35*	1.22 ± 0.43*	1.22 ± 0.43*
(%Diff)		(-25.64)	(-14.09)	(-21.82)	(-52.54)	(-59.01)		(4.21)	(-27.78)	(-59.58)	(-76.63)	(-76.63)
EX + Vit. C	8.40 ± 0.93	6.20 ± 1.28	6.80 ± 0.72	6.20 ± 0.80	3.90 ± 0.64	2.90 ± 0.50	3.80 ± 0.57	4.30 ± 1.23*	3.60 ± 0.89*	2.40 ± 0.45*	1.90 ± 0.40*	2.00 ± 0.39*
(%Diff)		(-26.19)	(-19.05)	(-26.19)	(-53.57)	(-65.48)		(13.16)	(-5.26)	(-36.84)	(-50.00)	(-47.37)

Values are means ± SEM.

* $p < 0.05$, significant difference from pre-test in same time.

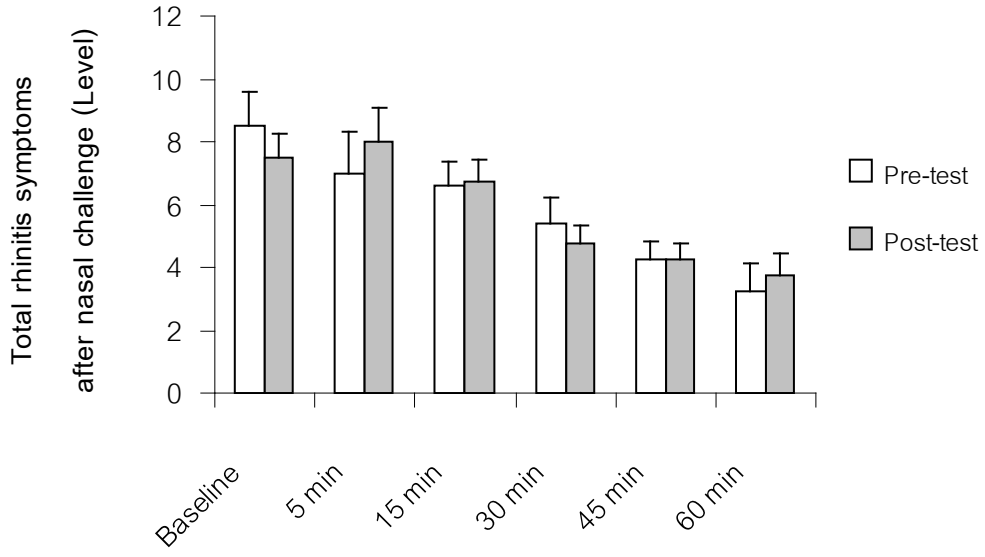
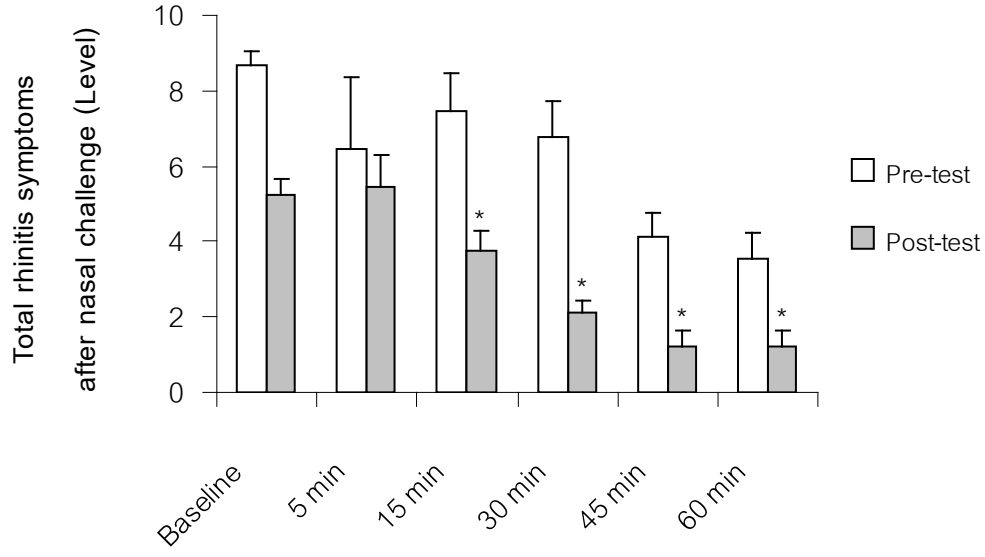
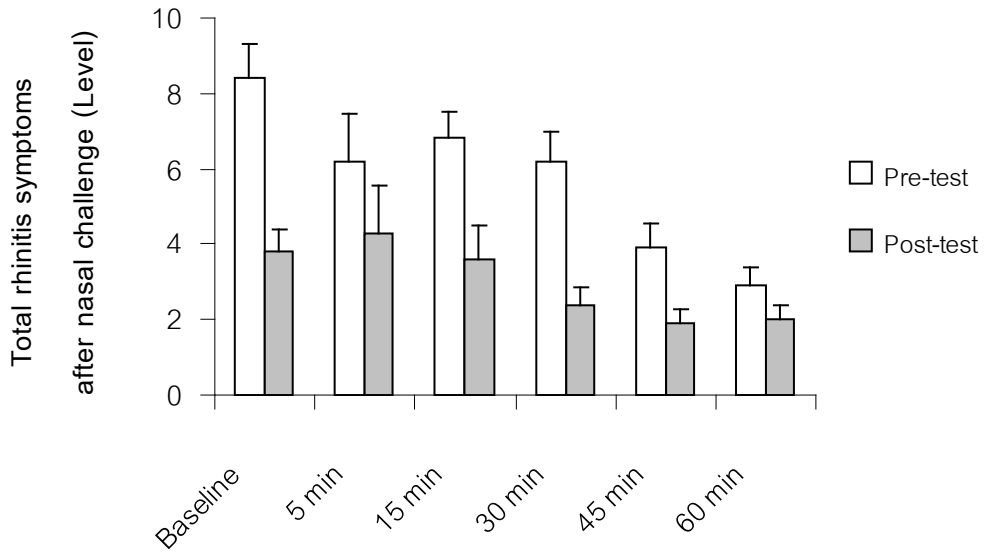


Figure 4.61 The comparison of total rhinitis symptoms after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the control group (CON).



*p < 0.05, significant different from pre-test.

Figure 4.62 The comparison of total rhinitis symptoms after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise group (EX).



*p < 0.05, significant different from pre-test.

Figure 4.63 The comparison of total rhinitis symptoms after nasal challenge on 5, 15, 30, 45 and 60 minutes between pre- and post-training in the exercise combined vitamin C group (EX + Vit. C).