Improved Physical Fitness of Military Medical Students after A-1-year Pre-clinical Study at Phramongkutklao College of Medicine

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[**Abstract**] **Objective** To monitor physical fitness level in medical student during pre-clinical study at Phramongkutklao College of Medicine (PCM), Royal Thai Army (RTA). **Methods** A prospective cohort study was conducted in second-year class of PCMs medical students. Each participant answered a self-administered questionnaire. Physical examinations and blood examination were performed. Physical fitness assessment was conducted twice at the beginning and the end of the academic year. Body height and weight, waist and hip circumference, percent body fat, grip and leg strength, flexibility, maximal oxygen uptake (VO_{2max}), 2-minute push ups/sit-ups and 2-kilometer run were measured. **Results** Ninety-six medical students were followed during pre-clinical year from late April 2008-May 2009. Physical fitness assessment was compared to initial fitness. Nearly all fitness variables were improved with statistical significance reported in % body fat, grip strength, VO_{2max}, flexibility, sit-ups, 2-kilometer run and RTA fitness score in male medical students. In female students, average VO_{2max}, flexibility, numbers of push-ups, sit-ups and RTA physical fitness test score significantly increased and 2-kilometer run times significantly decreased. **Conclusion** Physical training and military environment in 1-year preclinical year at PCM led to lower percent body fat, higher aerobic capacity and better fitness scores on many measures of strength and flexibility. Further physical fitness studies in clinical year need to be followed up.

[**Key words**] physical fitness; physical activity; military medical student; medical education

1 Introduction

Physical fitness is related to health status. Exercise and active lifestyle are also well known to be health beneficial. Several studies have demonstrated that low physical fitness levels increase risk of cardiovascular disease, hypertension, Type 2 diabetes, obesity and physical injuries[1-8]. Moreover, a study reported that fit people had greater longevity than unfit one[9]. Thus, improving fitness by increasing physical activity can improve overall health status and reduce health risks. For military, physical fitness is an important component that can indicate combat readiness and performance. Many national armed forces use annually physical fitness test to assess personnel's physical health and to promote more physical activity. When focusing on military physicians, they are expected to be as good role models for healthy lifestyle in order to promote health and fitness in soldiers, patients and so on. Remarkably, a study conducted at US Army Medical Center found that physical fitness among military physicians declined during residency training[10]. As reported in another study, cardiorespiratory endurance declined in military medical students throughout medical school[11]. For the past 20 years, it has been also demonstrated that civilian physicians were less physically active than general population[12]. Many factors were proposed to lead to physically inactive lifestyle in physicians such as heavy workload, work-related stress, lack of time to exercise, study hard, laziness and advance technology.

The hypothesis of the present study was that medical student's physical fitness depended on the living habits and physical training during early stage of medical education. Thus, the objective was to monitor physical fitness level in medical student during preclinical study at Phramongkutklao College of Medicine (PCM), Royal Thai Army (RTA). The main missions of PCM are to provide an exceptional environment for medical education and military training for medical students. These military medical students study at PCM from the second-year to the sixth-year class after they finish pre-medical program in the first-year class from civilian university. Unlike general medical students, PCM medical students not only have to adapt themselves from civilian life to a military environment, military rules and regulations but also have to engage 4-week basic cadet training on arrival at PCM in order to prepare physical readiness, learn a military lifestyle and build a foundation of teamwork. Besides studying medical curriculum, after class or free time medical students at PCM must take part in learning military customs and in physical training like cadet activities such as group calisthenics, stretching, running, etc.

2 Methods

All of the second-year medical students in the academic year 2008 enrolled at PCM participated in the prospective cohort study which was ethically approved by the Institutional Review Board, RTA Medical Department. After giving written informed consents, each participant answered a self-administered questionnaire for health risk behavior, health history and current medical profile. Physical examinations were performed. Resting blood pressure (BP) and pulse rate were measured in the sitting position using standard methods. Blood samples were collected for complete blood count and blood chemistry examination. Levels of hemoglobin (Hb), hematocrit (Hct), fasting plasma glucose, blood urea nitrogen (BUN), creatinine (Cr), serum uric acid, fasting triglycerides (TG), total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), aspatate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALK) were analyzed by the automated techniques in a standard laboratory of Division of Analysis, Armed Forces Research Institute of Medical Sciences.

Physical fitness assessment includes measures of body composition, cardiorespiratory endurance, muscular fitness and musculoskeletal flexibility which were conducted twice at the beginning and at the end of the academic year (1 year interval). The first assessment was on 22-23 April 2008 and the second assessment was on 13, 27 May 2009. Before the physical fitness test, participants were measured for body height to the nearest 0.1 cm using a stadiometer and body weight to the nearest 0.1 kg using a balance scale in light clothing without shoes. Body mass index (BMI) was calculated as the weight (kg) divided by the

square of the height (m). Waist circumference was taken with a tape measure at the level of the navel (the smallest diameter between the costal margin and the iliac crest). Hip circumference was taken at the widest diameter around the greater trochanter. Waist-hip ratio (WHR) was calculated as the waist circumference divided by the hip circumference. Percent body fat was estimated by the 4-skinfold-thickness method (biceps, triceps, subscapular and suprailiac) using Harpenden calipers.

Muscle strengths including grip and leg strength were measured using calibrated dynamometers. For grip strength, participants used the musculature of one hand to squeeze the hand dynamometer as tightly as possible. For leg strength, participants held leg dynamometer's bar with both hands and pulled on the chain as hard as possible with back and legs straighten. Each measurement was taken twice. The maximum value was recorded to the nearest 0.1kg.

Flexibility was measured using a sit and reach box. Participants sat on the floor with legs fully extended and soles of feet level with the base of the sit and reach box (with legs held straight), then bent forward slowly with fingertips of both hands remaining in contact with the slide. The farthest extension point of two trails was recorded to the nearest 0.1cm.

Maximal oxygen uptake (VO_{2max}) was predicted by the nomogram of Astrand and Rhyming with a 6-minute submaximal cycle ergometer test using Cateye ergociser. Before the test, bike seat was adjusted with knee almost completely extended and bike workload was set based on gender and age. By recording heart rate every minute, participants were instructed to keep pedal revolutions around 50 revolutions per minute. During the test the workload would be adjusted if the heart rate did not reach 120 beats per minute. VO_{2max} was calculated using published correction factor and expressed in ml/(kg · min).

Participants were also completed the RTA physical fitness test using the maximum number of push-ups completed in 2 minutes, the maximum number of sit-ups completed in 2 minutes and a 2-kilometer run for time to measure muscular strength/endurance and cardiorespiratory endurance, respectively. These field tests were operated as a group testing. The number of push-ups, sit-ups and the 2-kilometer run time were converted into a score based on the participant's age and gender following a scoring table for each item. Each item of the RTA physical fitness test was given a maximum score of 100 points. The score of all three items were combined and expressed as fitness score. Participants must obtain an overall score at minimum 150 points (50%) to pass RTA physical fitness test[13-14].

All measurements were assessed following standard procedures and were supervised by trained technicians from Division of Sport Medicine, Phramongkutklao Hospital and staffs from Department of Physiology, Phramongkutklao College of Medicine.

3 Statistical analysis

Data were analyzed using SPSS for windows version 16.0. Reported values for continuous data were mean ± standard deviation (SD) and for categorical data were percentage. Two-tailed paired t tests were used to compare the different values between the beginning and the end of the second-year class. For all statistical analyses, P value less than 0.05 were considered a significant result.

4 Results

During studying in the second-year class, 3 male students resigned from PCM (not included in analysis). The remaining 96 medical students in second-year class consisted of 76 (79.2%) male and 20 (20.8%) female with an average age of 19.2±0.7 years and 19.1±0.4 years, respectively. Laboratory results at initial are provided in Tab. 1. Mean all blood chemistry examinations were within normal ranges. None of them had severe and chronic diseases. Of 96 students, 13 (13.5%) and 2 (2.1%) were determined as overweight (BMI 25-29.9kg/m^2) and obesity (BMI≥30kg/m^2), respectively. Mean resting BP was also within a normal range; however diastolic BP and systolic BP were higher in males than those of females (Tab. 2).

Tab. 1 Mean, standard deviation and range of laboratory results in PCM medical students

Variables	Male (n=76)		Female (n=20)	
	Mean±SD	Range	Mean±SD	Range
Age (years)	19.23±0.67	18-21	19.05±0.39	18-20
Hb (g/dl)	15.08±1.21	9.52-16.50	12.88±0.67	11.22-13.80
Hct (%)	45.25±2.34	33.82-47.60	39.14±1.87	34.82-42.00
Glucose (mg/dl)	81.97±7.20	61-107	77.15±7.98	64-97
BUN (mg/dl)	15.61±3.00	9-24	13.05±2.78	9-18
Cr (mg/dl)	1.11±0.11	0.86-1.33	0.85±0.09	0.70-1.01
Uric acid (mg/dl)	6.90±1.58	3.5-12.4	6.21±0.72	5.1-7.9
AST (U/L)	27.24±18.31	13-122	20.60±6.38	15-41
ALT (U/L)	23.86±14.36	10-80	15.85±5.24	6-31
ALK (U/L)	73.70±18.68	39-120	59.50±15.43	23-85
Chol (mg/dl)	174.79±28.00	120-243	179.25±25.27	121-244
TG (mg/dl)	59.86±19.51	31-132	54.60±22.43	33-137
HDL-C (mg/dl)	61.71±11.65	38-91	72.05±11.75	60-110
LDL-C (mg/dl)	101.25±25.30	51-170	96.30±20.06	52-126

PCM medical students performed the first physical fitness test when entering to PCM campus a few days and the second assessment was on the end of the academic year. Comparison between the first and the second anthropometric assessments (Tab. 2), a significant increase in height in both gender and a significant decrease in % body fat in male were observed. In male students, average grip strength, flexibility, VO_{2max}, numbers of sit-ups and RTA physical fitness test score significantly increased and 2-kilometer run times significantly decreased during a one-year period. In female students, average VO_{2max}, flexibility, numbers of push-ups, sit-ups and RTA physical fitness test score significantly increased and 2-kilometer run times significantly decreased. Although not statistically significant, the mean numbers of push-ups tended to increase in male and average grip strength tended to increase in female. There were significance differences between male and female for height, weight and run times.

Before studying at PCM, only 37 (38.5%) medical students exercised more than 2 sessions per week. They exercise more during the second-year class in PCM. Most increased physical activity, but 24 (25.0%) reported frequency of exercise 0-1 sessions per week (Tab. 3). In addition to basic cadet training, most students participated in aerobic fitness activities (jogging), organized sport and strength training. When compare to standard criterion of Thai people, physical fitness levels of medical students in nearly all tests were poor-fair at initial as shown in Tab. 3.

Tab. 2 Characteristic, anthropometric parameters and physical fitness results compare between 1st- and 2nd-assessment in male and female medical students at PCM

Variables	Male			Female		
	1st-assessment	2nd-assessment	*P*-value	1st-assessment	2nd-assessment	*P*-value
GPA	2.69±0.39	2.77±0.42	<0.001	2.99±0.41	3.03±0.46	<0.001
Systolic BP (mmHg)	118.8±20.9	118.7±10.5	NS	107.6±7.8	103.3±5.6	NS
Diastolic BP (mmHg)	70.8±7.8	71.1±6.6	NS	67.6±5.6	66.4±5.1	NS
Pulse rate (beat/min)	77.0±9.9	69.6±9.8	<0.001	77.0±11.3	70.3±7.4	NS
Weight (kg)	67.8±11.1	67.5±9.3	NS	53.0±6.5	53.2±5.8	NS
Height (cm)	171.5±5.4	172.2±5.3	<0.001	160.4±5.3	160.8±5.3	<0.001
BMI (kg/m^2)	23.02±3.30	22.71±2.71	0.045	20.63±2.28	20.59±2.09	NS
Waist (cm)	78.2±8.7	78.3±7.3	NS	67.8±6.6	68.0±4.5	NS
Hip (cm)	94.2±6.8	94.7±5.6	NS	91.4±5.2	89.9±4.2	NS
WHR	0.83±0.05	0.83±0.04	NS	0.74±0.05	0.76±0.03	NS
% body fat	20.4±4.1	17.8±3.6	<0.001	29.9±3.2	28.9±3.0	NS
Grip strength (kg/weight)	0.60±0.11	0.62±0.11	0.011	0.48±0.10	0.49±0.10	NS
Leg strength (kg/weight)	1.97±0.59	1.99±0.43	NS	1.50±0.44	1.40±0.26	NS
Flexibility (cm)	3.99±8.16	6.70±7.59	<0.001	5.62±8.30	8.26±9.03	0.020
VO_{2max} (ml/kg/min)	41.54±9.55	48.42±8.64	<0.001	41.44±10.85	49.38±7.49	0.014
Push-ups (repetitions)	36.2±14.6	38.7±9.2	NS	14.3±10.3	38.4±12.5	<0.001
Sit-ups (repetitions)	46.7±9.3	53.8±8.3	<0.001	31.9±9.3	47.3±12.8	<0.001
2-kilometer run (min)	10.55±01.28	09.10±00.51	<0.001	14.11±01.51	11.08±00.56	<0.001
Fitness score (point)	154.7±39.3	190.1±20.1	<0.001	117.4±42.1	208.9±29.0	<0.001

Tab. 3 Distribution of the second-year medical students on frequency of exercise, passing RTA scores and fitness classification according to Thai people Norms

Variables	1st-assessment	2nd-assessment
Frequency of exercise		
0-1 sessions per week	59(61.5%)	24(25.0%)
2-3 sessions per week	25(26.0%)	49(51.0%)
>3 sessions per week	12(12.5%)	23(24.0%)
Passing score(>150 points)		
Pass	48(50.0%)	93(96.9%)
Fail	48(50.0%)	3(3.1%)
% body fat		
Good-excellent	1(1.0%)	4(4.2%)
Average	21(21.9%)	45(46.9%)
Poor-fair	74(77.1%)	47(48.9%)
Grip strength		
Good-excellent	5(5.2%)	5(5.2%)
Average	24(25.0%)	25(26.0%)
Poor-fair	67(69.8%)	66(68.7%)
Leg strength		
Good-excellent	21(21.9%)	14(14.6%)
Average	30(31.2%)	27(28.1%)
Poor-fair	45(46.9%)	55(57.3 %)
Flexibility		
Good-excellent	9(9.3%)	10(10.4%)
Average	23(24.0%)	31(32.3%)
Poor-fair	64(66.7%)	55(57.3%)
VO_{2max}		
Good-excellent	23(24.2%)	55(57.3%)
Average	27(28.4%)	32(33.3%)
Poor-fair	45(47.4%)	9(9.3%)

Over one-year period in PCM campus, there were changes in the numbers of medical student physical fitness levels. The proportion of poor-fair level was decreased and transferred to average and good-excellent level for % body fat, flexibility and VO_{2max}. The highest change was determined for the VO_{2max} as the percentage at poor-fair level dropped from 47.4% to 9.3% and the percentage increased from 24.2% to 57.3% at good-excellent level. With regard to scoring standard of RTA physical fitness test, the numbers of medical students (96.9%) who passed minimum score at 150 points were increased.

5 Discussion

The PCM medical students, before entering the second year, were in good health as confirmed by normal values of all blood chemistry tests and normal blood pressure. It was shown that the PCM medical students were able to maintain their BMI throughout their second year. The results demonstrated a decrease in percent body fat and increase in cardiorespiratory endurance as time to complete 2-kilometer run decreased and VO_{2max} increased significantly at the second assessment. As the numbers of sit-ups significantly increased in both genders and although only in female that push-ups numbers went up, however, suggesting increased muscular endurance. Collectively, muscle flexibility was found to be significantly improved and also muscle strength as determined from increased grip strength.

During the study period, most medical students participated in sports and other aerobic activities and had more frequent exercise. According to frequency of exercise, at the first assessment there were 38.5% of PCM medical students who reported exercising more than 2 sessions per week. At the second assessment, the proportion of students participating in exercise more than twice a week increased to 75%. Moreover these students also participated in other aerobic activities and also cadet activities. This may reflect either positive attitude of PCM students toward exercise or military life in the PCM campus, thus higher levels of doing exercise and activities were reported. It has been founded that exercise once or twice a week may have beneficial effects in term of VO_{2max} and increased fitness was associated with

more frequent exercise[15]. Thus, the increased aerobic activities and increased exercise frequency performed by medical students over a period of study, in addition to basic physical training, may help to improve their physical fitness. In another word, the medical students become increasingly more fit at the end of second year as compared to at the beginning. Our results, however, differed from the study of Mitchell *et al* which demonstrated a declined cardiorespiratory endurance in US military medical students during a 3-year period in medical school[11]. It is possible that increased academic workload as the students progressed through medical school and changes in exercise habits may account for this difference in cardiorespiratory fitness.

In comparison to Thai general population, at the beginning of second year the PCM medical students had a poor to fair level of physical fitness and only half of students passed the fitness score of 50%, suggesting less fit than published norms. Similar to a recent study in the fifth-year medical students at Chiangmai University, the aerobic capacity was in poor- average level[16]. After a year, the proportion of PCM medical students at poor to fair level of physical fitness tended to decreased and shifted to average or good-excellent physical fitness level. Moreover increased percentage of medical students who had fitness score more than 50% was observed. Again, engaged in basic physical training together with increased other aerobic activities may responsible for this physical fitness improvement. Data presented in this study, therefore, support our hypothesis that physical fitness depends on living habits and physical training at early stage of medical education.

Although medical students enrolled daily life in military environment and took part in cadet activities but medical educational outcome was not worsen. Grade point average (GPA) at the end of the second-year class was found significant better than at the first-year as shown in Tab. 2. This finding indicates that physical training and exercise do not disturb the educational outcome. Thus, medical schools must leave extra time for medical students to participate in sports and exercise. Promoting more physical activity during the early year of medical education and providing knowledge of physical activity may be necessary for medical students in order to give counseling about physical activity to patients[17].

Limitation of this study was small numbers of participant; however the results provided significant baseline information on PCM medical student fitness which may be useful for further research. Additionally, the data obtained may be utilized to develop policies for both PCM and other medical schools to promote good physical fitness for the medical students or even adding physical training in medical curriculum.

6 Conclusion

The PCM medical students had physical fitness improvement as lower percent body fat, higher aerobic capacity and better levels on many measurements of strength and flexibility after one year during preclinical year. Given these findings, such basic physical training and a fitness test program at least once a year should be added in curriculum for both preclinical and clinical years of every medical school. Additionally, according to general recommendations[18], exercise the large muscle groups for at least 20-60min, 3-5 times a week, at an intensity of 60%-90% maximum heart rate is suggested. Cohort studies for health status and physical fitness assessment are needed to follow up.

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