Changes in Physical Fitness and Anthropometric of Medical Cadets Over Their Study Period in Phramongkutklao College of Medicine

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Objective: *To assess changes in physical fitness level and anthropometric characteristics of medical cadets in Phramongkutklao College of Medicine (PCM).*

Material and Method: *A prospective study was conducted in 73 male and 20 female medical cadets at PCM during their study through medical education between April 2008 and July 2012. Anthropometric measurement and physical fitness test were performed at initial, preclinical year, and clinical year including body weight, height, waist-hip circumference, body mass index (BMI), waist-hip ratio (WHR), waist-height ratio (WHtR), % body fat, grip and leg strength, maximal oxygen uptake (VO_2max), 2-minute push-ups, 2-minute sit-ups, and 2-kilometer run for time.*

Results: *Through the course of medical education, significant increase ($p<0.05$) in body weight, height, waist circumference, hip circumference, BMI, WHR, WHtR, and % body fat were detected. The increments in body weight and BMI in males were greater than in females. When compared to initial fitness, medical cadets in preclinical year could improve physical fitness variables with statistical significance reported in VO_2max, numbers of push-ups, sit-ups, and 2-kilometer run. When compared to preclinical year, VO_2max was significant decreased and run time was significant increased in clinical year ($p<0.05$).*

Conclusion: *Male medical cadets tended to gain more weight over the four years spent at PCM. Health-related physical fitness of medical cadet improved in preclinical year and cardiorespiratory fitness declined in clinical year. To establish motivation to have regular physical activity in medical student, physical fitness test and anthropometric measurement should be integrated into the medical student's curriculum.*

Keywords: *Health-related physical fitness, Anthropometric, Medical cadet, Medical education*

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Health-related physical fitness consists of body composition, cardiorespiratory endurance, muscle strength, muscle endurance, and flexibility[1,2]. Having good health-related physical fitness is associated with lower risk of diseases and improved quality of life[2]. Clearly, medical professionals are expected to be the role models for healthy behavior in order to promote good health to patients in clinical practice. Previous studies recommended that medical school should add knowledge of physical activity benefits and enhance counseling skills for changing patient's lifestyle[3,4]. In addition, good physical fitness and healthy behavior should be established at the early stage of medical education to encourage participation in regular exercise as activities of daily living and appropriate physical training.

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There are some investigations about personal physical fitness and health status of medical students. Those researches demonstrated that the trend of physical fitness level decreased during medical education. A retrospective cohort study conducted at the Uniformed Services University in military medical students resulted in a decreased cardiorespiratory fitness as measured by run times[5]. Furthermore, a 4-year prospective study found that physical fitness levels declined significantly as medical students participated in preclinical years[6]. It has also been reported that physical fitness of US army physicians declined during residency program[7]. Many reasons were concerned to deal with physically inactive lifestyle in medical professionals such as heavy workload, work-related stress, and lack of time to exercise, study hard, laziness, and advance technology.

Phramongkutklao College of Medicine (PCM) is a military medical school in Thailand for physicians that serves the Armed Forces and Ministry

of Public Health. All medical cadets studied at PCM are under military rules and regulations from the second-year to the sixth-year, after they graduate pre-medical curriculum in the first-year from civilian university. Besides studying medical education and basic military training, after class or at free time, medical cadets must enroll in physical activities such as group calisthenics, stretching, or running to prepare physical readiness for military environment, especially during the two years in preclinical study. A prior study reported that PCM medical cadets had physical fitness improvement during the second-year class after being trained throughout the year[8]. The objective of the present study, thus, was to further assess changes in physical fitness and anthropometric parameters of medical cadets as they progressed through medical curriculum at PCM.

Material and Method

After receiving ethically approval from the Institutional Review Board, The Royal Thai Army (RTA) Medical Department; the prospective cohort study was conducted in all medical cadets in class 33 (79 male, 20 female) attending medical curriculum at PCM between 2008 and 2012, and receiving written informed consents. Physical fitness test and anthropometric measurement were analyzed three times as followed, at the initial-level physical fitness (the second-year class) in April 2008, at the end of preclinical year (the third-year class) in May 2010, and during the clinical year (the sixth-year class) in July 2012. Subjects were excluded if they did not complete physical fitness test three times as mentioned.

Anthropometric measurement

Body weight and height were measured in light clothing without shoes. Body mass index (BMI) was calculated from the measured body weight (kg) divided by the square of the height (m^2). Waist-hip circumference was taken with a tape measure. Waist circumference (WC) was measured at the level of umbilicus and hip circumference (HC) at the widest point around buttocks. Waist-hip ratio (WHR) was calculated as WC (cm) divided by HC (cm). Waist-height ratio (WHtR) was calculated as WC (cm) divided by height (cm). Body fat percentage was derived by using 4-skinfold equations (triceps, biceps, subscapular, and suprailiac) with Lange calipers by the same trained technician from Division of Sport Medicine, Phramongkutklao Hospital.

Physical fitness test

Grip and leg strength were measured in a standing position by calibrated dynamometers. Each measurement was taken twice. The best result was chosen as the outcome. Maximal oxygen uptake (aerobic capacity, VO_2max) was calculated by the nomogram of Astrand and Rhyming with a 6-minute submaximal cycle ergometer test. Before the test, workload was set based on gender and age. Heart rate was recorded every minute. If it did not reach 120 beats/minute, the workload would be adjusted during the test. RTA physical fitness test was also operated as a group testing including 2-minute push-ups, 2-minute sit-ups, and 2-kilometer run for time. In order to assess physical fitness level, the number of push-ups, sit-ups, and 2-kilometer run time were converted into a score based on a scoring table for each test and the subject's age, as previous reports[9,10]. Each test was given a maximum score of 100 points. The minimum passing score must achieve 50% of average RTA physical fitness test results.

Statistical analysis

Ninety-nine medical cadet in class 33 in the academic year 2008 were enrolled in the present study. Six medical cadets were excluded because of learning problem and unable to complete physical fitness test in clinical year. Therefore, the final samples included 73 males and 20 females. Data were analyzed using STATA version 12MP (Stata Corp., Texas, USA). Basic descriptive statistics were used, for continuous data were mean ± standard deviation (SD). Change in physical fitness and anthropometric parameters over the study period was evaluated using a mixed-model for repeated measures followed by post hoc tests for linear trends over time. Statistically significant differences were considered at $p<0.05$.

Results

All medical cadets of class 33 who entered PCM on April 2008 were healthy and were planning to study for 5 years. At the beginning of the present study, the age of medical cadets ranged from 18 to 21 years (mean 19.2±0.6).

Anthropometry

The anthropometric measurements were summarized in Table 1. Generally, male medical cadets were taller, heavier and had a greater waist circumference, hip circumference, and BMI than female, but % body fat in female was greater. The

Table 1. Changes in anthropometry of medical cadets

Gender	Variables	At initial	Preclinical year	Clinical year	Δ	%Δ[a]	*p*-value[b]
Male	Body height (cm)	171.4±5.5	172.2±5.3	172.6±5.4	1.2	0.7	<0.01
	Body weight (kg)	67.4±10.9	67.4±9.9	70.7±9.8	3.3	5.0	<0.01
	BMI (kg/m^2)	22.9±3.3	22.7±2.9	23.7±2.9	0.8	3.5	<0.01
	Waist circumference (cm)	78.0±8.7	78.0±6.8	85.3±7.9	7.3	9.4	<0.01
	Hip circumference (cm)	94.0±6.7	90.5±7.0	98.0±6.0	4.0	4.3	<0.01
	WHR	0.83±0.05	0.86±0.05	0.87±0.04	0.04	4.8	<0.01
	WHtR	0.46±0.5	0.45±0.4	0.50±0.5	0.04	8.7	<0.01
	% body fat	20.3±4.2	17.8±4.3	21.1±4.3	0.8	3.8	<0.05
Female	Body height (cm)	160.4±5.3	161.5±5.1	161.6±5.5	1.3	0.8	<0.01
	Body weight (kg)	53.0±6.5	52.6±6.0	54.8±5.4	1.8	3.4	<0.05
	BMI (kg/m^2)	20.6±2.3	20.2±2.2	21.0±2.1	0.4	1.8	<0.05
	Waist circumference (cm)	67.8±6.6	66.9±4.3	74.2±3.7	6.5	9.5	<0.01
	Hip circumference (cm)	91.4±5.2	85.6±6.7	94.8±4.2	3.4	3.7	<0.01
	WHR	0.74±0.05	0.78±0.03	0.78±03	0.04	5.4	<0.01
	WHtR	0.42±0.4	0.42±0.3	0.46±0.3	0.04	9.5	<0.01
	% body fat	29.9±3.2	27.8±3.8	32.3±2.5	2.4	8.0	<0.01

BMI = body mass index; WHR = waist-hip ratio; WHtR = waist-height ratio
All values are mean ± SD
[a] Calculated as (Clinical year - At initial) / At initial x 100%
[b] Compared between at initial and clinical year using general linear model from repeated measures

average body weight and BMI in males at clinical year increased 5% and 3.5% respectively compared to the initial level. This was greater than those in females. However, the increment in % body fat in males (3.8%) was lesser than in females (8%). Compared to initial measurement, BMI, and % body fat was less at preclinical year. However, through the course of medical education, significant increase in body weight, height, waist circumference, hip circumference, BMI, WHR, WHtR, and % body fat was detected in the clinical years both males and females. In males, the average value of WHtR was at the upper level of normal range (0.5).

Physical fitness

When compared to initial fitness, medical cadets in preclinical year could improve fitness variables with statistical significance reported in numbers of sit-ups, push-ups, VO_2max, and 2-kilometer run as shown in Fig. 1. Comparison between preclinical year and clinical year, the average numbers of push-ups were 37.6 and 41.8, and the average numbers of sit-ups were 47.2 and 46.6, respectively in males. For females, the average numbers of push-ups were 21.7 and 20.5, and the average numbers of sit-ups were 42 and 47.3, respectively. Grip and leg strength did not significantly change throughout the study in males. Nevertheless, average leg strength in females significantly increased from 1.38 kg/BW at initial to 1.58 kg/BW in clinical year (p<0.05) as shown in Fig. 1B. Notably, average VO_2max significantly increased in preclinical year and decreased in clinical year. The time for the 2-kilometer run was also decreased in preclinical year and increased in clinical year. Average runtimes at initial, at preclinical year and at clinical year were 10:52, 10:15, and 10:40 minutes in males and 14:10, 12:23, and 13:04 minutes, respectively, in females. With regard to the scoring standard of RTA physical fitness test, the average scores of male and female medical cadets were significantly increased at preclinical year to 57.1% (p<0.05) and 58.5% (p<0.001), respectively as shown in Fig. 2.

Discussion

The present study showed that medical cadets had an improvement in physical fitness: muscle strength as measured by leg strength, muscle endurance as measured by sit-ups and push-ups, cardiorespiratory endurance as measured by 2-kilometer run, and VO_2max during a-2-year preclinical study. Under basic cadet training and cadet regulations in PCM, medical cadets' routine daily life differed from civilian university. They had to engage in regular physical activity, thus, resulting in an increased in all fitness parameters at preclinical year. However, their physical fitness levels could not sustain throughout medical education.

Before entering the PCM, the average RTA physical fitness score of medical cadets were 51.8% in

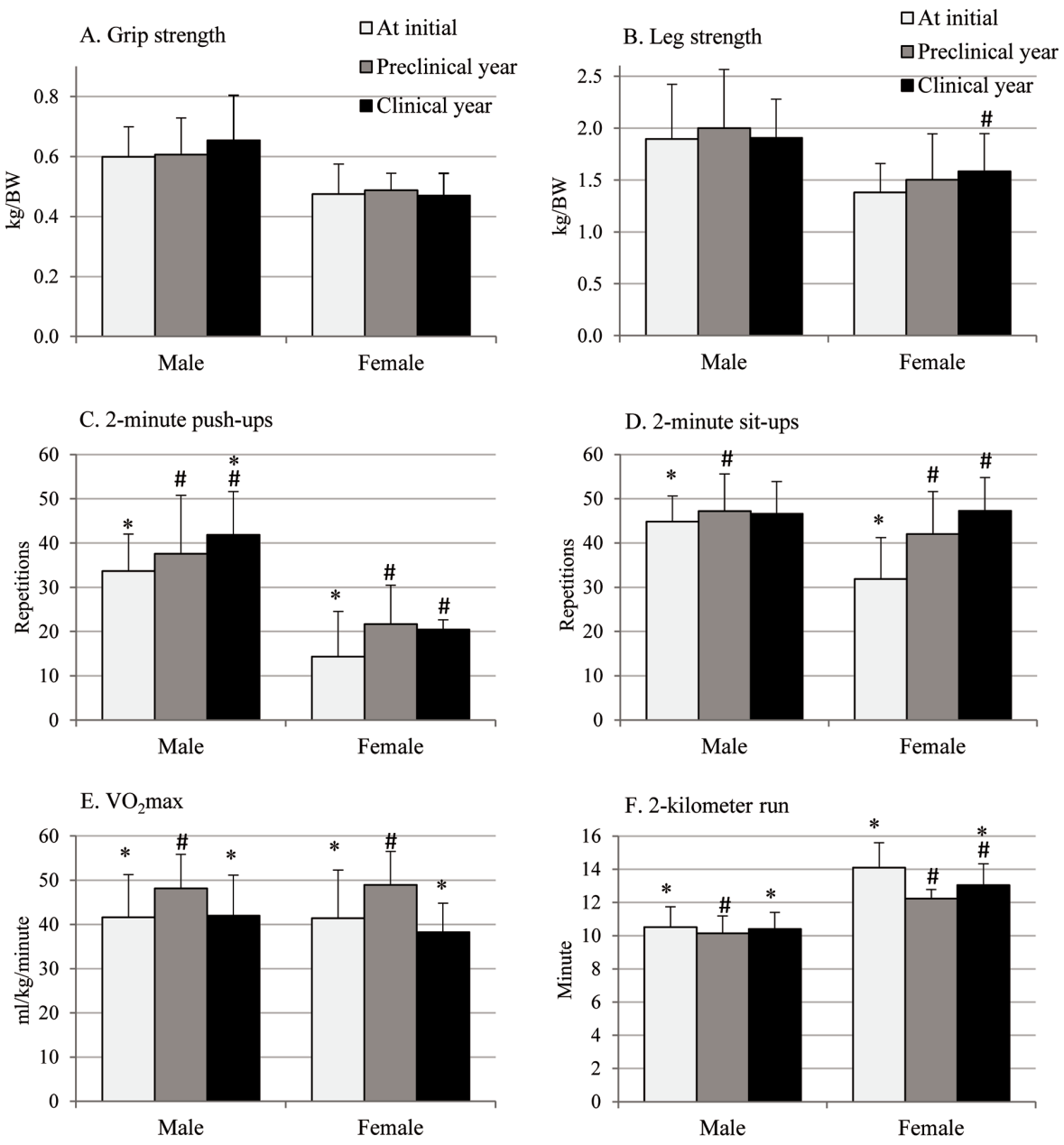

Fig. 1 Changes in physical fitness (A. Grip strength, B. Leg strength, C. 2-minute push-ups, D. 2-minute sit-ups, E. VO_2max, F. 2-kilometer run) of medical cadets in male and in female at initial fitness assessment, in preclinical year, and clinical year. Values are means ± SD. # $p<0.05$ compared to an initial, * $p<0.05$ compared to preclinical year.

males and 39.1% in females (Fig. 2). Comparison to the minimum passing score (at least 50%) of The RTA physical fitness test criteria[9,10], these scores showed that medical cadets were unfit and had initial low levels of physical fitness. A significant fitness improvement was found at preclinical level after they had performed basic cadet training and enrolled in cadet's activities regularly for two years. To our knowledge, there was few data about the physical fitness of high school students in Thailand. From our results, thus, the exercise campaign should be promoted early in Thai youth to improve their physical fitness.

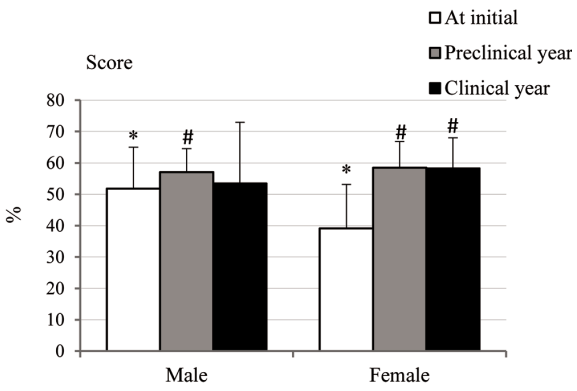

Fig. 2 Changes in physical fitness scores of medical cadets in male and in female at initial fitness assessment, in preclinical year, and clinical year. Values are means ± SD. # $p<0.05$ compared to an initial, * $p<0.05$ compared to preclinical year.

During clinical years, both increased in anthropometric characteristics and decreased in cardiorespiratory fitness indicated that medical cadets became less fit. Reasons behind this included studying hard, less time to exercise, performing fitness test without maximum effort or not compulsory to enroll in physical activities. Another factor might be an inappropriate time to test their fitness levels. For example, some medical cadets just finished their night shift on the day that the researchers set for physical fitness test and this was the limitation of the present study that we could not arrange time to suit everyone. When compared to civilian university, the average VO_2max of the medical cadets in clinical year (male = 42.0±9.2 ml/kg/minute, female = 38.2±6.5 ml/kg/minute) were greater than those in the fifth-year medical students at Chiang Mai University (male = 38.4±7.6 ml/kg/minute, female = 37.9±9.4 ml/kg/minute)[11]. Thus, it might be that the physical fitness decrement in medical cadets was not real decline but it would occur from such factors as stated before or lack of motivation. However, there was a study showed that medical cadets had good attitudes toward exercise for health promotion[12]. Another previous study indicated that the requirement for good physical fitness before graduation and self-recognition in physical fitness could induce fitness improvement in medical students[6]. Such requirement together with an increased medical student's motivation for exercise might be good suggestions for improving physical fitness in medical school.

It is widely known that the well-established health-related physical fitness is related to well-being and reduction in disease risk factors[2]. To establish motivation to have regular exercise in medical students, physical fitness test and anthropometric measurement should be integrated into medical students' curriculum in medical schools. As well as the facilities and equipment for self-assessment such as weight equipment, measuring tape and time to exercise should be provided.

Conclusion

In conclusion, the authors would recommend that medical students should perform cardiorespiratory, resistance, flexibility, and neuromotor exercise regularly in order to improve and maintain physical fitness and healthy as suggested by American College of Sports Medicine[13]. Moreover, medical schools should schedule physical fitness testing and assess health-related physical fitness at least three times throughout medical education, such as at the enrolling, at the end of preclinical year and before graduation, in order to decrease disease risk factors for non-communicable diseases in medical students and to provide healthy and fit physicians to community. Furthermore, information on the factors related to health-related physical fitness should be educated to the medical students. These may increase their understanding of the importance of good physical fitness and their self-awareness which will help medical student to provide better preventive care to their patient in clinical practice in the future.

What is already known on this topic?

Having good health-related physical fitness and healthy lifestyle are related to positive effects on health outcomes. Health professionals are anticipated to be health promotion leaders to create awareness in self-health care. However, several factors such as heavy workload, study hard, and lack of time to exercise make physician and medical student physically inactive lifestyle.

What this study adds?

During preclinical program at PCM, medical students must participate in many physical activities throughout basic cadet training leading to physical fitness improvement. Medical curriculum is proposed to should be designed to make medical students' awareness of the importance of healthy lifestyle that encourage them to provide self-care to patients in clinical practice.

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Potential conflicts of interest

None.

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การเปลี่ยนแปลงสมรรถภาพกายและสัดส่วนร่างกายของนักเรียนแพทย์ทหาร ช่วงที่ศึกษาในวิทยาลัยแพทยศาสตร์พระมงกุฎเกล้า

พรรณเพ็ญ นาประดิษฐ์, ปนัดดา หัตถโชติ

วัตถุประสงค์: *เพื่อประเมินการเปลี่ยนแปลงสมรรถภาพกายและลักษณะสัดส่วนร่างกายของนักเรียนแพทย์ทหาร วิทยาลัยแพทยศาสตร์พระมงกุฎเกล้า*

วัสดุและวิธีการ: *การศึกษาไปข้างหน้าในนักเรียนแพทย์ทหาร วิทยาลัยแพทยศาสตร์พระมงกุฎเกล้า เพศชาย 73 คน หญิง 20 คน ตลอดการศึกษาหลักสูตรแพทยศาสตร์ ตั้งแต่ เดือนเมษายน พ.ศ. 2551 ถึง กรกฎาคม พ.ศ. 2555 การวัดสัดส่วนร่างกาย และการทดสอบสมรรถภาพกายดำเนินการเมื่อเริ่มเข้ารับการศึกษา ชั้นปรีคลินิก และชั้นคลินิก ประกอบด้วย การชั่งน้ำหนัก วัดส่วนสูง รอบเอว รอบสะโพก ดัชนีมวลกาย รอบเอวต่อรอบสะโพก รอบเอวต่อส่วนสูง เปอร์เซ็นต์ไขมันในร่างกาย แรงบีบมือ แรงเหยียดขา ความสามารถในการใช้ออกซิเจนสูงสุด ดันพื้น ลุกนั่งใน 2 นาที และวิ่งจับเวลาระยะทาง 2 กิโลเมตร*

ผลการศึกษา: *ตลอดการศึกษาหลักสูตรแพทยศาสตร์ น้ำหนัก ส่วนสูง รอบเอว รอบสะโพก รอบเอวต่อรอบสะโพก รอบเอวต่อส่วนสูง ค่าดัชนีมวลกาย รอบเอวต่อรอบสะโพก รอบเอวต่อส่วนสูง และเปอร์เซ็นต์ไขมันในร่างกาย เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$) การเพิ่มขึ้นของน้ำหนักและค่าดัชนีมวลกายในเพศชายมากกว่าในเพศหญิง เมื่อเปรียบเทียบกับเมื่อเริ่มเข้ารับการศึกษา สมรรถภาพกายของนักเรียนแพทย์ทหารในชั้นปรีคลินิกในการใช้ออกซิเจน จำนวนครั้งของดันพื้น ลุกนั่ง และวิ่งระยะทาง 2 กิโลเมตร ดีขึ้นอย่างมีนัยสำคัญทางสถิติ เมื่อเปรียบเทียบกับชั้นปรีคลินิกในชั้นคลินิกมีความสามารถในการใช้ออกซิเจนสูงสุดลดลงและเวลาในการวิ่งเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.05$)*

สรุป: *นักเรียนแพทย์ทหารชายมีแนวโน้มน้ำหนักเพิ่มขึ้นในช่วงมากกว่า 4 ปี ที่ศึกษาในวิทยาลัยแพทยศาสตร์พระมงกุฎเกล้า สมรรถภาพกายที่สัมพันธ์กับสุขภาพของนักเรียนแพทย์ทหารดีขึ้นในชั้นปรีคลินิก และสมรรถภาพกายของระบบไหลเวียนและหายใจลดลงในชั้นคลินิก เพื่อสร้างแรงจูงใจในการออกกำลังกายอย่างสม่ำเสมอในนักศึกษาแพทย์ การทดสอบสมรรถภาพกายและการวัดสัดส่วนร่างกายควรจะถูกบูรณาการเข้าไปในกำหนดการการศึกษาในโรงเรียนแพทย์*