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Exploratory study of factors related to educational scores of first preclinical year medical students

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Sitticharoon C, Srisuma S, Kanavitoon S, Summachiwakij S. Exploratory study of factors related to educational scores of first preclinical year medical students. *Adv Physiol Educ* 38: 25–33, 2014; doi:10.1152/advan.00162.2012.—The relationships among the scores of major subjects taught in the first preclinical year of a Thai medical school, previous academic achievements, and daily life activities are rarely explored. We therefore performed an exploratory study identifying various factors possibly related to the educational scores of these medical students. Questionnaires were sent out to all first preclinical year medical students, with 79.8% being returned (245/307 questionnaires). Positive correlations were revealed between the premedical year grade point average (pre-MD GPA) and anatomy, physiology, and biochemistry scores (R = 0.664, 0.521, and 0.653, respectively, $P < 0.001$ for all) by Pearson's method. Using multiple linear regression analysis, anatomy scores could be predicted by pre-MD GPA, student satisfaction with anatomy, the percentage of expected reading, monthly earnings, reading after class and near exam time, and duration of sleeping periods near exam time ($R = 0.773$, $R^2 = 0.598$, $P < 0.001$). Physiology scores could be estimated by pre-MD GPA, the percentage of expected reading, monthly earnings, and percentage of those who fell asleep during class and near exam time ($R = 0.722$, $R^2 = 0.521$, $P < 0.001$). Biochemistry scores could be calculated by pre-MD GPA, the percentage of expected reading, motivation to study medicine, student satisfaction with biochemistry, and exam performance expectations ($R = 0.794$, $R^2 = 0.630$, $P < 0.001$). In conclusion, pre-MD GPA and the percentage of expected reading are factors involved in producing good academic results in the first preclinical year. Anatomy and biochemistry, but not physiology, scores are influenced by satisfaction.

physiology; anatomy; biochemistry; preclinical; score

STUDYING IN A MEDICAL CURRICULUM requires a great deal of cognitive abilities, a positive attitude, and the ability to manage time, feelings, and reactions to challenges during training, or so-called proper self-management. Medical students are considered to be able to manage themselves when confronted by various kinds of stresses, especially when they finish the premedical year and then continue their preclinical years in different environments. Premedical study is different from preclinical study in several aspects, such as the distinct scope of each course studied, which is related to medicine, an enormous increase in the amount of learning material, relocation to a new campus (university hospital), greater student responsibilities, and an increased workload required to accomplish the courses. Stressful environments and conditions exert negative impact on academic achievement of medical students (9, 15). Several studies from medical schools in Thailand have attempted to define various factors affecting academic grades, including high school grade (7), type of medical school admission (7, 15), and sleep duration and sleep deprivation (9).

Academic achievement in preclinical study is an important dimension during training in medical school. Several factors have been similarly identified to affect the academic achievement of medical students in preclinical and clinical years, such as the motivation to study in medical school (15). Interestingly, Pinyopornpanish and colleagues (15) demonstrated that students who were originally not interested in medical school training but were eventually influenced to do so did not have difficulties in their premedical years. However, these students faced more academic difficulties and began to develop poor grades during the first year of preclinical training. The increase in poor academic performance was more apparent in their clinical years (15). On the other hand, there were some factors that affected medical students during preclinical years but not in clinical years. Iramaneerat (7) showed that standardized entrance examination scores after the completion of high school could be one predictive indicator for academic grades in the clinical year but not in preclinical years.

Preclinical study is integral for clinical year training because medical students are supposed to apply and implement their knowledge during clinical practice. Therefore, we aimed to explore the activities and learning behavior of medical students during the first preclinical year. In addition, the purpose of our study was to identify the correlations of academic scores in three main courses and student factors in various aspects, including demographic information, student performance, student learning behavior, and lifestyle during training in the first preclinical year at the Faculty of Medicine Siriraj Hospital of Mahidol University.

METHODS

Study protocol. The study protocol was approved by the Siriraj Institutional Review Board (si546/2010). All participants gave written informed consent before the study. The questionnaire was delivered to 307 medical students who were in their second year of the full 6-yr medical curriculum. Only 243 students (79.8%) completed the questionnaires and returned them to the investigator.

Type of curriculum and course setup. The Doctor of Medicine program offered at the Faculty of Medicine Siriraj Hospital of Mahidol University is a 6-yr course; the first year is a premedical year, the second and third years are preclinical years, and the fourth, fifth, and sixth years are clinical years. Student admission relies on three systems: the national entrance exam (exam), the undergraduate quota admission for excellence in certain areas (quota), and the collaborative project to increase production of rural doctors, which is called One District One Doctor (ODOD). During the first year or premedical year, students took basic physical and biological science courses, humanities, and social sciences at Salaya campus, Phuttamonthon District, Nakhon Pathom Province, which is situated just outside Bangkok's city limits, 20 km away from Siriraj Hospital. Students

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who had passed the premedical year continued into the second year of the curriculum and moved to the Bangkok Noi campus, the location of Siriraj Hospital in Bangkok.

The second year of the medical curriculum is the first preclinical year, which focuses on anatomy, biochemistry, and physiology. Anatomy (including gross anatomy, microanatomy, and embryology), biochemistry, and physiology are major compulsory subjects offered in a block system in the second year and are traditionally taught via lectures, practical sessions, and small-group case study sessions by providing several clinical case scenarios related to previous lectures. All practical sessions and case study sessions involve faculty-student interactions. The exams used for analysis took place after the completion of the course contents at the end of the first semester as follows: the regions of the head and neck and thorax for gross anatomy, metabolism of nucleic acid and molecular biology for biochemistry, and cardiovascular physiology. The proportion of teaching/learning formats delivered in this block is shown as a percentage of lecture:laboratory:case study as follows: gross anatomy (14.29:75.00:10.71), biochemistry (61.90:19.05:19.05), and physiology (45.45:40.91:13.64). All 243 students finished their first semester and self-reported the data of exam scores of all three main courses taken at the end of the first semester. Scores from all these exams were used as the basis for further analysis throughout the study.

Questionnaire. Questions in the questionnaire were in Thai language. Several questions were provided with choices for self-reporting by ticking the box containing the corresponding answer according to each of the various aspects. This type of question was used to identify the type of admission to medical curriculum (exam, quota, and ODOD), exam performance expectations, learning behaviors (individual or group learning, preferred seat location, and frequency of reading after class), and activity and lifestyle (including number of friends, type of groups of friends with common interests, and relationships with classmates or someone special) during the study of medicine in preclinical year. Some questions were provided with choices using a five-point Likert scale, such as course/subject satisfaction, self-reported perception of stress level, and self-reported perception of impact of health problems on learning during the study of medicine. The response to these two types of questions (choices provided and five-point Likert scale) was reported as frequency and percentages according to each categorical variable. In addition, several variables related to the students' lifestyle were formulated to provide comparison between a regular period and a period approaching an examination.

Questions with numbers needed to be fill in a blank included sociodemographic information, past education history [high school grade point average (GPA) and premedical (pre-MD) GPA], self-reported scores of three main subjects, monthly income, monthly expenses, numbers and types of meals, duration of performing weekly physical exercise, sleeping patterns, duration of internet use for nonacademic purposes, and frequency of on-campus dormitory stay. Exam scores from the three courses are shown for comparison according to each categorical variable.

Each questionnaire item was piloted and reviewed by a group of students. The questionnaire item was printed on a sheet of paper and was manually delivered by a group of volunteers to all students. All students were informed about this study, and their informed consent was granted. Students were requested to check their score from the database before answering the questionnaire. Questionnaires showed no identification numbers; therefore, we had no intention of rechecking exam scores of each of the students. Participants were requested to complete the questionnaire and return it to an assigned and sealed box to assure anonymity. The project and questionnaire were approved by the Institutional Review Board of the Faculty of Medicine Siriraj Hospital of Mahidol University.

Statistical analysis. Data were analyzed using SPSS (version 11.5) to determine frequency and percentages of each factor. The Kolomonov-Smirnov test was performed to test normality. Student's unpaired *t*-test was used for exam score comparisons between two groups, and one-way ANOVA was used for data comparisons for more than two groups. Post hoc analyses were followed, where appropriate, using a Tukey test with P values of <0.05 to compare the exam scores (percentages) earned in the course for gross anatomy, biochemistry, and physiology. Students were asked to compare several variables between a regular period and a period approaching an examination. A paired *t*-test was used for comparison of these variables. To determine the association among the average grades of the premedical year and the exam scores of three courses of preclinical years, Pearson product-moment correlation coefficient was used. To test which factors (all numeric, nominal, and ordinal variables) had a significant contribution to the exam scores of each course, multiple linear regression was used. For ordinal variables, we assigned rating scores to reflect the true order of the categories, such as the level of satisfaction. For non-normal distributed and ordinal variables, a nonparametric test was used. All statistical analyses were conducted under the assumption of a type I error rate of 0.05.

RESULTS

Demographic data of the subjects. Demographic comparisons from the questionnaires are shown in Table 1. The student sex ratio was equivalent. Generally, students were admitted to the Faculty of Medicine Siriraj Hospital, Mahidol University, by three systems: the national entrance exam (81%); the undergraduate quota admission for excellence in sport, art, International Olympiad representative, Muslim community (16%); and ODOD (3%). Many students had a body mass index in the normal range (64%, body mass index between 18.5 and 23) (22). The majority of students had a moderate (48%) to high (48%) degree of motivation to study medicine. About three-quarters of students reported that Bangkok and its metropolitan area comprise their hometown.

In relation to student learning behaviors, the self-report of students' preferences to study in groups or as individuals showed that ~78% of students studied alone, whereas ~22% studied together in groups. They considered their preferred seat location to be at the front (28.40%), middle (40.74%), and back (30.86%). The majority of students had friends who shared educational interests (43.10%), activity interests (17.15%), and both educational and activity interests (8.37%), whereas 31% did not, in particular, define the common interests in their friendship. Almost 40% of the students had breakfast 5 days/wk. students reported that ~83% had junk food as their meals <3 times/wk, but a few of them (2.47%) had junk food more frequently than 5 times/wk.

Lifestyle of the students. We chose to compare student lifestyles between a regular period (general) and a period approaching an exam (near exam time; Table 2). Most students went to bed by 2 AM during the regular period, whereas up to 40% of them went to bed after 2 AM at the time approaching an exam. The wake-up time of approximately half of the students was between 6 to 7 AM both during the regular period and period approaching an exam. The sleep duration of most students was 4 to 8 h long during a regular period. During the period approaching an exam, the trend of sleep duration, however, turned out to be shorter, as we observed a shift toward a short sleep duration (Table 2). A noteworthy 5.37% of students reported they slept <4 h during the period approaching an exam, whereas <1% reported sleeping <4 h during the regular period. students tended to spend less time in exercise and internet use during the period approaching an exam than

Table 1. *Demographic data of the subjects*

	Percentage
Sex	
Men	49
Women	51
Type of entrance	
Examination	81
Quota	16
One Doctor One District	3
Body mass index	
Lean (<18.5)	19
Normal (18.5–22.9)	64
Overweight (23.0–24.9)	12
Obese (>25.0)	5
Motivation to study medicine	
Low	4
Moderate	48
High	48
Hometown	
Metropolitan	9
Regional	26
Bangkok	64
Learning behavior	
Alone	22
Group	78
Seat location	
Back	31
Middle	41
Front	28
Number of friends	
One individual	6
Two to three individuals	44
More than three individuals	50
Group of friends with common interests	
Nothing	32
Education	43
Social	17
Education + social	8
Breakfast, day(s)/wk	
0	7
1	3
2	7
3	12
4	14
5	34
6	5
7	18
Junk food, meals/wk	
<3	84
3–5	14
>5	2

n = 242–243 students.

during the regular period. During the period approaching an exam, students selected to stay at the on-campus dormitory more frequently compared with the regular period. Students also considered that there was an increase in health problems and stress levels during the period approaching an exam compared with the regular period.

Correlations between previous academic achievement and scores of major subjects. To define the association of previous academic achievement and exam scores of the three main courses taken during the preclinical years, the premedical grades during the first year of the medical curriculum (pre-MD GPA) had a significantly positive association with exam scores of all three main courses (Table 3). Students who had higher premedical grades tended to gain high exam scores in gross anatomy, biochemistry, and physiology ($P < 0.001$). Moreover, students who had a high score in one of the courses tended to similarly obtain high score in the other two courses ($P < 0.001$).

Factors affecting the scores of major subjects. We sought to determine whether there was a difference in exam scores compared with various times spent in physical exercise. Students who spent 2 h and over in performing physical exercise did not have different exam scores compared with students who spent <2 h doing exercise (data not shown). We compared exam scores of the three main courses performed by students with various types of admission. Overall, it seemed that there was no statistical difference in exam scores of physiology and biochemistry among students admitted by each type; however, for gross anatomy, students admitted by undergraduate quota obtained a significantly higher score than students admitted by national entrance examination ($P < 0.05$; Fig. 1*A*). We further determined the difference in exam scores among the students with varying degrees of motivation to study medicine. Overall, there seemed to be no statistical difference in physiology exam scores among students with various levels of motivation (Fig. 1*B*). On the other hand, students with high motivation obtained significantly higher scores on gross anatomy and biochemistry compared with those with moderate and low levels of motivation ($P < 0.05$).

Each medical student may prefer and be satisfied with one course over the others, thereby causing them to have better performance in one particular course over the others. We attempted to determine whether students with various levels of course satisfaction obtained different exam scores. Students with a high level of course satisfaction obtained a significantly higher score in that particular course ($P < 0.05$; Fig. 1*C*). Interestingly, students significantly more satisfied with physiology obtained higher scores on biochemistry than those less satisfied with physiology (data not shown). We further compared exam scores with various levels of exam performance expectations. Students with high expectations obtained significantly higher exam scores in each of the courses (Fig. 2*A*). In addition to attitude, friendships among students may influence their learning behaviors and exam scores. Students sharing education interests with their peers received significantly higher exam scores on all three courses compared with students who shared nothing in particular with their peers ($P < 0.05$; Fig. 2*B*).

We determined exam scores based on the variety of learning behaviors. The results showed that students sitting in different seat locations did not have significantly different scores in any of the three courses (data not shown). Students who studied in groups obtained significantly higher scores on the physiology exam than those who studied individually (71.10 ± 12.50, n = 179, vs. 68.78 ± 11.20, n = 50, averages ± SD, $P < 0.05$; Fig. 2*C*). Students, however, did not obtain different scores in gross anatomy and biochemistry when they learned together in groups compared with the individual learning mode.

In congruence with learning behaviors, students with increasing number of friends tended to significantly obtain higher scores in gross anatomy and physiology exams in a number-dependent fashion (Fig. 2*D*). A similar finding was not observed to be of significance when we determined biochemistry exam scores. Studying before class attendance is usually recommended for students. Our study showed that there was no significant difference in exam scores of any courses with

Table 2. *Lifestyles of students*

	Regular Period		Period Approaching an Examination	
	Percentage	Mean ± SE	Percentage	Mean ± SE
Bedtime		24.10 ± 0.12		01.06 ± 0.13*
22.00–24.00 hours	54		25	
>24.00–02.00 hours	38		34	
02.00–04.00 hours	8		41	
>04.00 hours	0		0	
Wake up time		6.57 ± 0.05		7.11 ± 0.27
<6.00 AM	5		7	
6.00–7.00 AM	61		53	
>7.00–7.30 AM	5		3	
>7.30–8.00 AM	29		33	
>8.00 AM	1		3	
Sleep period, h		6.35 ± 0.06		5.43 ± 0.08*
<4	1		5	
4–6	55		76	
6–8	38		15	
≥8	7		3	
Exercise, h/wk		2.50 ± 0.18		1.79 ± 0.13*
<2	38		74	
2–4	41		20	
4–6	14		5	
≥6	6		1	
Internet (nonacademic) use, h/day		2.85 ± 0.13		1.79 ± 0.13*
<2	19		54	
2–4	58		36	
4–6	18		8	
≥6	5		2	
Dormitory stay, day(s)/wk		4.33 ± 0.12		4.98 ± 0.14*
0	12		11	
1	0		0	
2	4		4	
3	4		4	
4	11		6	
5	56		35	
6	3		4	
7	11		37	
Stress level (5-point scale)		2.35 ± 0.06		3.87 ± 0.06*
Extremely low	19		2	
Low	34		3	
Moderate	40		25	
High	5		47	
Extremely high	1		23	
Impact of health problem on learning (5-point scale)		1.95 ± 0.07		2.59 ± 0.08*
None	44		28	
Mild	26		19	
Moderate	23		27	
High	6		20	
Extremely high	2		7	

*$P < 0.001$ between groups.

various degrees of self-studying before class either at the regular period or the period approaching an exam (data not shown). On the other hand, the exam scores of gross anatomy and biochemistry exam were significantly higher with an increasing frequency of self-studying after class both during the regular period and the period approaching an exam ($P < 0.05$; Fig. 3, *A* and *B*). Interestingly, a similar observation did not apply for the physiology exam scores.

We compared the exam scores among the groups with various durations of internet/nonacademic activities at the regular period and period approaching an exam. Students with ≤2-h internet use obtained significantly higher scores for gross anatomy than those with >4-h use at the regular period ($P < 0.05$; Fig. 3*C*). During the period approaching an exam, students with >4-h internet use obtained significantly lower scores for biochemistry and physiology than <4-h internet use ($P < 0.05$; Fig. 3*D*).

Preclinical exam scores in prediction. In addition to the demographic data, lifestyle, and learning behaviors of medical students observed in a descriptive fashion, we identified the aforementioned factors predicting the exam scores of the three main courses during the first preclinical year of the curriculum. We set all independent variables in a multiple linear regression analysis (Table 4). The regression equation for each score course was used to represent related factors and β-coefficient values. We identified pre-MD GPA, student satisfaction with anatomy, percent reading to level of expectation, monthly stipend (baht), reading frequency after class in the period approaching an exam, and sleep duration in the period approaching an exam as predictors for the gross anatomy exam

Table 3. *Correlations between previous academic achievement and scores of major subjects*

Factors	R	R^2	P Value
Pre-MD GPA			
Gross Anatomy	0.644	0.414	<0.001*
Physiology	0.521	0.271	<0.001*
Biochemistry	0.653	0.426	<0.001*
Scores of major subjects			
Biochemistry-physiology	0.655	0.429	<0.001*
Gross anatomy-physiology	0.605	0.365	<0.001*
Gross anatomy-biochemistry	0.716	0.512	<0.001*

R, Pearson correlation; pre-MD GPA, premedical grade point average. *Statistically significant difference.

score with a statistically significant positive association ($P < 0.001$). For interpretation, each of the factors does not have the same range and unit; therefore, one cannot determine the meaningful influence from coefficient values alone. For example, the range of pre-MD GPA values was between 0 and 4, although its β-value was the highest. For every 1 increment in GPA, gross anatomy score has been predicted to increase by 16.28. The range of monthly earning was in thousands of baht, whereas its coefficient value was 0.001. If the monthly stipend increased by 10,000 baht, gross anatomy score was predicted to rise up to 10.

In predicting the biochemistry score, all of the following factors, pre-MD GPA, percent reading to level of expectation, motivation to study medicine, satisfaction with biochemistry, and biochemistry exam performance, had, together, a significantly positive association with the biochemistry exam score ($P < 0.001$). In predicting the physiology score, pre-MD GPA, percent reading to level of expectation, and monthly expense (baht) had a significantly positive association; in contrast, the duration of falling asleep during class in the period approaching an exam had a significantly negative association with the physiology exam score ($P < 0.001$).

DISCUSSION

We carried out this study with the aims of identifying daily life activities and the relationships of these activities and academic exam scores of the three main courses of second-year (first preclinical year) medical students from a 6-yr curriculum in medicine. We used questionnaires from medical students to determine their daily life activities and the scores of three major courses in recent examinations. Several activities were shown that seemed to affect the exam scores. Using multiple linear regression analyses, we found out that the average grade during the premedical year (pre-MD GPA) and reading percentage to level of expectation in each course were common predictors for academic exam scores in the first preclinical year.

Several factors related to students' activities and lifestyle are considered as unmodifiable (e.g., sex, hometown location, ethnicity, type of entrance, pre-MD GPA, and motivation to study medicine). Several local and international studies have shown that more male medical students have relatively lower performance on academic achievement compared with female medical students (13, 14, 23). In our study, we detected no significant difference in academic scores of the three main subjects between sexes (data not shown). A study by Yates and colleagues (23) has shown that medical students with a permanent address in the country where the medical school is

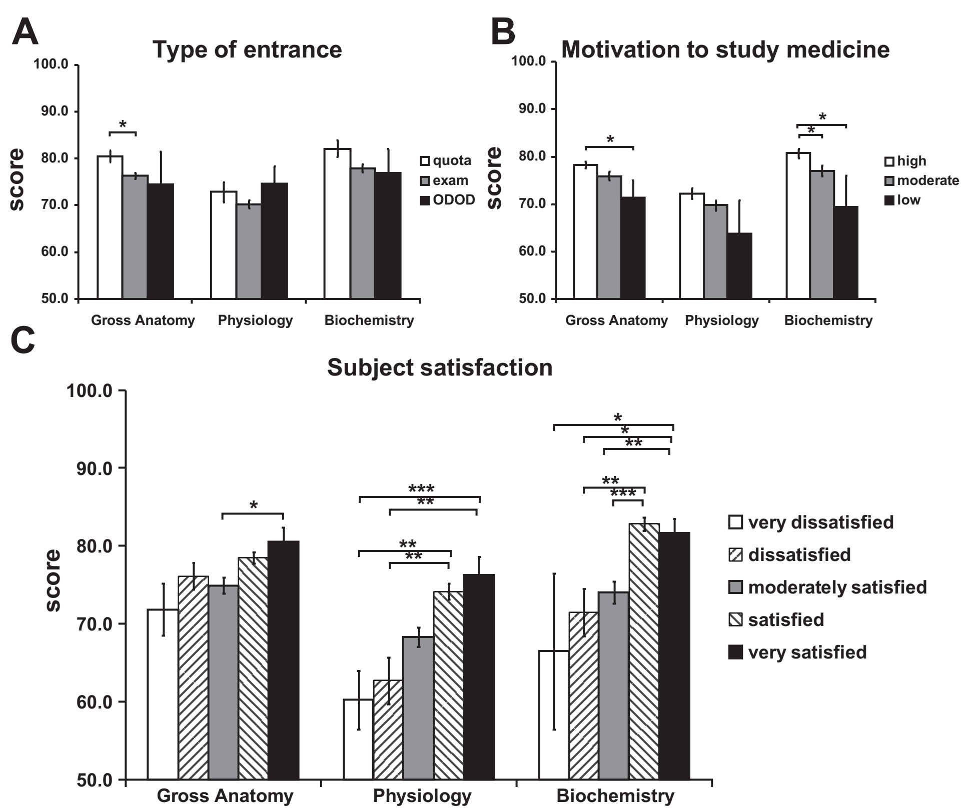

Fig. 1. Factors affecting scores of major subjects. ODOD, One District One Doctor. Data are shown as means ± SE. $*P < 0.05$, $**P < 0.01$, and $***P < 0.001$ between groups.

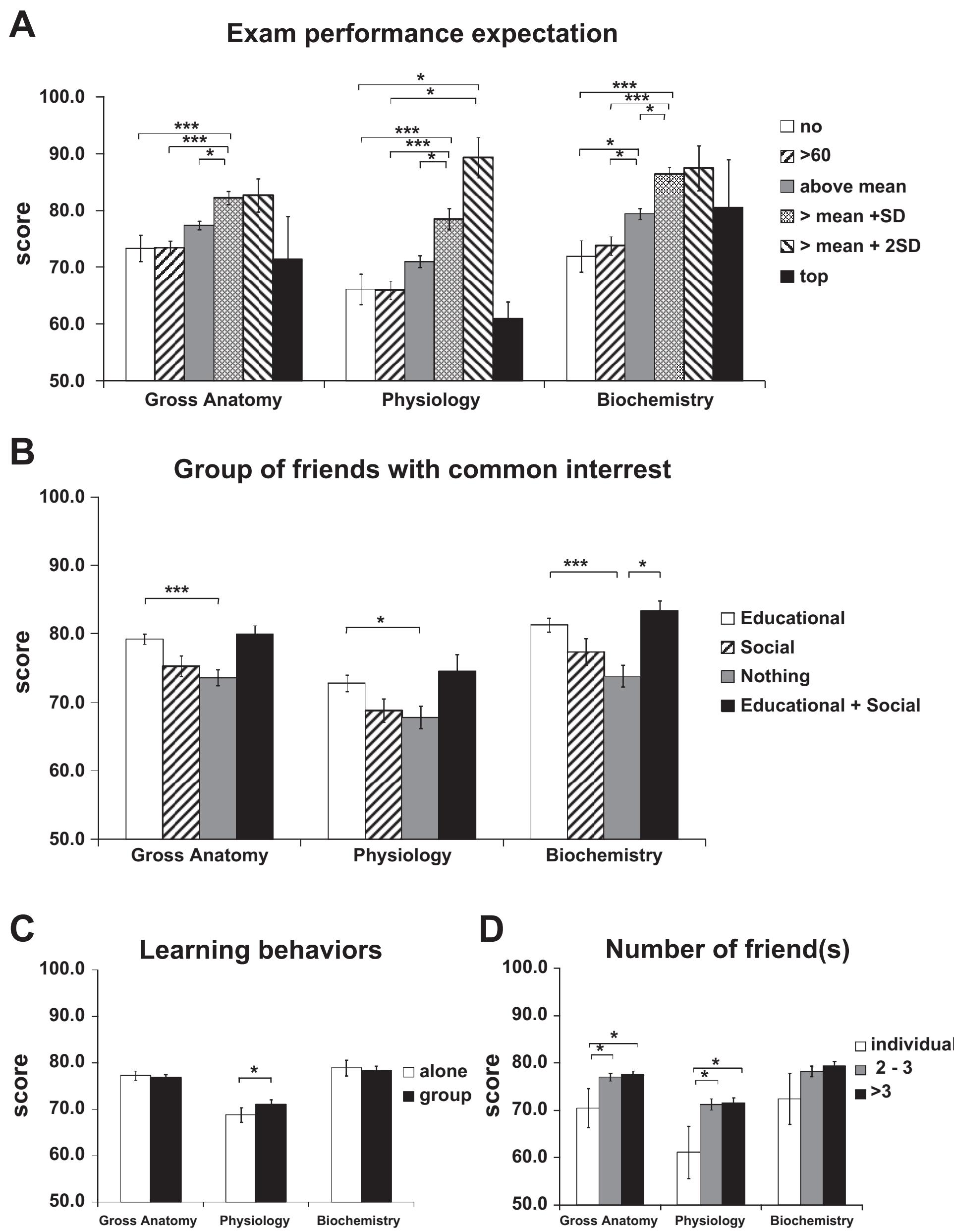

Fig. 2. Factors affecting scores of major subjects. Data are shown as means ± SE. $*P < 0.05$ and $***P < 0.001$ between groups.

located seemed to have a positive influence on academic performance in some courses taken during preclinical years. All students in our cohort had permanent addresses in Thailand, but we intended to correlate different hometown locations and academic scores. We did not observe any significant differences in exam scores among all students with various locations of hometown. Perhaps the hometown location may not be a sole factor related to exam scores; however, this could be further complicated by the type of entrance examination for medical school. Students accepted by ODOD likely have a hometown outside Bangkok and other metropolitan areas. This could be further complicated by the effects of ethnicity. All students in our cohort had the same nationality, but we did not inquire specifically about the ethnicity; therefore, we had no data on this matter.

Other studies, including ours, have shown that some factors, such as pre-MD GPA, have been consistent predictors of academic achievement in studying medicine during both preclinical and clinical years (16). These findings, therefore, should be promoted and emphasized to all teachers and student advisors as well as medical students at the beginning of the medical curriculum. It would also be interesting to determine whether close and early advice for the students, for example, to maintain a high pre-MD GPA and to appreciate medical professionalism, could somewhat modify their ideas and lifestyles with regard to handling this task in a sound fashion.

High school students with good grades in Thailand are encouraged by their families to apply for a medical curriculum, regardless of their personal motivation toward a medical career. The motivation toward medical professionalism was found by several studies to be one of the significant predictors for academic achievement (6, 10, 15, 18). Enrolling students with low motivation could lead to low achievement in their academic grades, leading to academic failure. The percentage

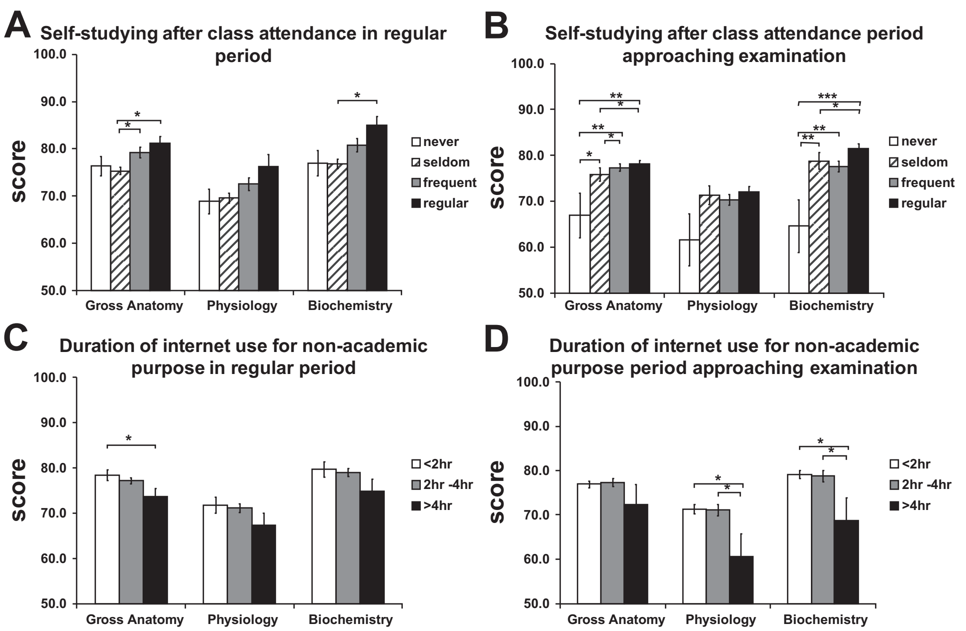

Fig. 3. Factors affecting scores of major subjects. Data are shown as means ± SE. $*P < 0.05$, $**P < 0.01$, and $***P < 0.001$ between groups.

of students with self-reported low motivation was 4% in our study. In fact, several ways to enhance the students' motivation are at hand for any teacher. Several studies have suggested that motivation could be intrinsically enhanced by multiple ways of active and independent studies, such as small-group teaching and early exposure to patients (10) and, additionally, introducing clinical case studies (1, 8). Teachers of the medical curriculum can play a significant role in motivating students by creating a course of medical professionalism and medical education as early as the beginning of the preclinical year. The teacher can create learning activities for students to interact with patients (10, 18). Early contact with patients strongly helps students realize their role and responsibility as future physicians (4, 20). Teachers could illustrate how students could implement the knowledge obtained during the preclinical year in improving or promoting the health of the community. Inspiring and motivating students is very important for their long-term success in the medical curriculum.

Our study showed a large proportion of different learning behaviors, types of friendships, and levels of course satisfaction among students who completed the questionnaires. Moreover, group versus individual study, types of friendships, and course satisfaction were associated with exam scores, particularly those of gross anatomy and physiology. Although individual learning behavior is a personal issue, it should be somewhat modifiable to enhance student motivation. A teacher

Table 4. *Multiple linear regression analysis*

	Model							
Dependent Variable	R	R^2	*P* value		Coefficient	SE	*T* Value	*P* Value
Gross Anatomy	0.773	0.598	0.000*	Constant	−7.189	6.217	−1.156	0.249
				Pre-MD GPA	16.828	1.400	12.021	0.000*
				Satisfaction with gross anatomy	1.875	0.541	3.464	0.001*
				Percent reading to level of expectation	0.062	0.029	2.157	0.033*
				Earnings/month	0.001	0.000	3.233	0.002*
				Reading after class near exam time	1.898	0.637	2.977	0.003*
				Sleeping period near exam time	0.974	0.418	2.329	0.021*
Biochemistry	0.794	0.630	0.000*	Constant	−19.341	6.736	−2.871	0.005*
				Pre-MD GPA	20.347	1.892	10.754	0.000*
				Percent reading to level of expectation	0.136	0.036	3.753	0.000*
				Motivation to study medicine	2.979	1.183	2.519	0.013*
				Satisfaction with biochemistry	1.731	0.745	2.323	0.022*
				Exam expectation	1.594	0.696	2.290	0.023*
Physiology	0.722	0.521	0.000*	Constant	−10.068	7.806	−1.290	0.199
				Pre-MD GPA	17.664	2.108	8.381	0.000*
				Percent reading to level of expectation	0.241	0.041	5.866	0.000*
				Expenses/month	0.001	0.000	2.783	0.006*
				Percent time falling asleep during class near exam time	−0.077	0.035	−2.168	0.032*

Responses to satisfaction with gross anatomy were scored as follows: *1* = very dissatisfied, *2* = dissatisfied, *3* = moderately satisfied, *4* = satisfied, and *5* = very satisfied. Responses to reading after class and near exam time were scored as follows: *1* = never, *2* = seldom, *3* = frequent, and *4* = regular. Reponses to motivation to study medicine were scored as follows: *1* = low, *2* = moderate, and *3* = high. Responses to satisfaction with biochemistry were scored as follows: *1* = very dissatisfied, *2* = dissatisfied, *3* = moderately satisfied, *4* = satisfied, and *5* = very satisfied. *Statistically significant difference.

can use multiple learning activities, rather than traditional lecture, to present information; some approaches may be preferred by individual students and not by others. Therefore, student learning is enhanced by the availability of multiple approaches (19, 21). Teachers can create learning activities for students to foster cooperative learning among them and enhance their group communication. Such arrangements could lead them into active thinking, participation, and modification of their learning behavior. Active involvement among students also improves students' conceptualization and increases the knowledge retention of students, thus elevating students' course satisfaction (3).

Studying the contents of each segment of subject regularly before classes is encouraged for students. Our findings showed no significant differences in exam scores among students with various reading frequencies before the class during regular periods and the period approaching an exam. On the other hand, studying after class regularly seemed to relate to a higher score in anatomy and biochemistry. This study was performed in a retrospective fashion, and it did not really determine the specific effects of reading before the class on exam score; therefore, the impact of reading before class on exam scores is difficult to be ruled out. In addition, students could likely catch up with the content any time before the examination.

Studying medicine is stressful and demanding, leaving minimal opportunities for relaxation. Performing physical exercise at the period approaching an exam may reduce studying time; exercise, however, is considered to be important for health promotion and stress relief. We therefore wanted to observe any alteration in the frequency of exercise performance when the time of examination approaches. Our study showed a significant change in student proportions of spending $<$2-h exercise weekly at the period near an exam time compared with the regular period. Interestingly, students who exercised $>$2 h did not show a significant decrease in their academic score compared with those with $<$2 h even in the period approaching an exam. Therefore, exercise is still important and always encouraged during regular periods or the period near an exam.

Several studies using a model of sleep disruption have supported observations showing that sleep affects memory processing and retention; sleep deprivation could be one of the causes of impaired performance (5, 9, 11, 12). Our study determined that some medical students had sleep deprivation. In our study, many medical students even reported falling asleep during class attendance. One study (17) has reported there was no significant relationship between any aspects of sleep and academic performance in medical students. Although our study could not identify any relationships between sleep pattern and academic achievement with regard to the three major courses for medical students, we could identify the "falling asleep" period during class attendance to be a negative indicator for the physiology exam score but not for gross anatomy and biochemistry exam scores. Although we did not identify the causes resulting in this relationship, this information suggested, on the student side, that attending a physiology class actively influences both student learning and exam results given that physiology is considered to be a subject that is complicated and difficult. On the other hand, this notion could be recommended for instructors to make the class "fun" and interactive for students who try to catch up during class for improving their score. The information regarding sleep pattern, sleep style, and sleep quality of medical students, however, needs to be further explored and elaborated before recommendations can be implemented in improving student sleep health.

We did not identify any score differences for anatomy and biochemistry in relation to whether students studied on their own or in groups. However, the exam scores of gross anatomy and biochemistry exams were significantly higher with an increasing frequency of self-studying. Similar findings were not observed with the exam scores of physiology. All these findings may be related to the fact that these two subjects require, to some extent, the memorization of vast amounts of information. Frequent self-studying may, therefore, promote retention of content and information for the anatomy and biochemistry examinations. Compared with physiology, which requires clarity of concepts, students studying in groups obtained significantly higher scores on the physiology exam than those who studied individually; hence, group study helps.

Exam scores were asked to be filled in the questionnaires by the students to maintain the students' privacy. The accuracy of exam scores, therefore, may be a concern. Although the students may not be able to remember their exact score and the investigators did not obtain scores directly from databases, students were asked to check their score from the database before answering the questionnaire. Thus, this potential concern was mitigated.

In conclusion, all these findings could assist teachers in a medical curriculum understand the activities and lifestyles of medical students and help them guide ways to improve students' academic achievements. Students' appreciation of medical professionalism during the premedical years or at the beginning of the medical curriculum needs to be seriously considered and taken in action to enhance their motivation and satisfaction as well as to optimally modify their life and learning behavior. Students also need early and close advice by their advisors, counselors, and all teachers in the medical curriculum regarding the factors and behaviors associated with prediction on their academic achievement in the main subjects. Students should be advised to study hard during their premedical (first) year to maintain their knowledge and their study achievement in terms of GPA, since their academic achievement during this premedical year is highly associated with similar achievements during preclinical years. Students at the beginning of their preclinical (second) years should be advised to pay complete attention and participate during the class of physiology to understand and realize class concepts as well as appreciate underlying physiology concepts of further clinical application. In addition, there is also a need to consider changes in teaching objectives that foster cooperative learning and actively participate in the professional development of medical students as an essential aspect of their role as medical science educators.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: C.S., S. Srisuma, S.K., and S. Summachiwakij conception and design of research; C.S., S. Srisuma, S.K., and S. Summachiwakij performed experiments; C.S., S. Srisuma, S.K., and S. Summachiwakij analyzed data; C.S., S. Srisuma, S.K., and S. Summachiwakij interpreted results of experiments; C.S., S. Srisuma, S.K., and S. Summachiwakij prepared figures; C.S., S. Srisuma, S.K., and S. Summachiwakij drafted manuscript; C.S., S. Srisuma, S.K., and S. Summachiwakij edited and revised manuscript; C.S., S. Srisuma, S.K., and S. Summachiwakij approved final version of manuscript.

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