



Prevalence of multiple behavioral risk factors for chronic diseases in medical students and associations with their academic performance

Manolis Linardakis^{1,2} · Angeliki Papadaki³ · Emmanouil Smpokos¹ · Anthony Kafatos¹ · Christos Lionis¹

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Abstract

Purpose Multiple behavioral risk factors (MBRFs) related to lifestyle have been associated with non-communicable diseases, but there is limited evidence on their prevalence in undergraduate medical students and their association with academic performance.

Methods During 1989–2017, data from 1447 medical students of the University of Crete, Greece (mean age 21.8 ± 2.2 years), were analyzed. MBRFs assessed included smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits and vegetables. Academic performance was based on the grades received in the mandatory Clinical Nutrition course and the overall medical degree (scale of 0–10).

Results Of the sample, 25.8% were smokers, 30.7% had high body weight, and 67.2% had low consumption of fruits and vegetables. Prevalence of having ‘no MBRFs’ and having ‘multiple clustering’ and ‘3+ factors’ was 15.8% and 12.3%, respectively. Men had almost twice the prevalence of multiple clustering compared with women (16.5% vs. 8.4%, $p < 0.001$). Participants who had none compared with 3+ MBRFs had higher mean grades in the Clinical Nutrition course (6.34 vs. 5.94, $p = 0.027$, $p = 0.003$) and overall degree (7.39 vs. 7.22, $p = 0.021$, $p = 0.002$). As the number of MBRFs increased (from ‘none’ to ‘1,’ ‘2’ and ‘3+’ factors), the proportion of graduates receiving a distinction also decreased (6.1%, 3.3%, 3.3% and 0.0%, respectively, $p = 0.001$).

Conclusion Overall, high prevalence of MBRFs was observed in this sample of medical students, while MBRF clustering was prospectively inversely associated with academic performance. These findings highlight the need for preventive lifestyle strategies to improve these students’ behavioral risk factors and academic performance during their studies.

Keywords Behavioral risk factors · Chronic diseases · Medical students · Academic performance · Grades · Bachelor

✉ Manolis Linardakis
linman@med.uoc.gr; <https://www.nutrition.med.uoc.gr>

Angeliki Papadaki
angeliki.papadaki@bristol.ac.uk

Emmanouil Smpokos
msbokos@edu.med.uoc.gr

Anthony Kafatos
kafatos@med.uoc.gr

Christos Lionis
lionis@galinos.med.uoc.gr

¹ Department of Social Medicine, Faculty of Medicine, University of Crete, Heraklion, 71003 Crete, Greece

² Internal Evaluation Group (IEG), Faculty of Medicine, University of Crete, Heraklion, 71003 Crete, Greece

³ Centre for Exercise, Nutrition & Health Sciences, School for Policy Studies, University of Bristol, Bristol, UK

Introduction

Lifestyle habits or multiple behavioral risk factors (MBRFs) involve unhealthy and risky behaviors which have been associated with increased morbidity and mortality from a variety of preventable chronic diseases (Fine et al. 2004; WHO 2014). These factors often refer to smoking, high body weight, unhealthy dietary choices, such as low consumption of fruits and vegetables and high consumption of red meat, physical inactivity and/or sedentary behavior, and risky alcohol consumption (Li et al. 2012; Linardakis et al. 2015). MBRFs contribute to the increase in the prevalence of non-communicable diseases (NCDs), such as cardiovascular disease, type 2 diabetes, chronic obstructive pulmonary disease, arthritis and certain types of cancer (WHO 2014). In 2012, it was estimated that two-thirds of all deaths globally were attributed to NCDs, while 42% of deaths occurred in individuals < 70 years of age (WHO 2014). The mortality burden is greater when MBRFs appear in clusters,

with the presence of 2+ factors associated with decreased life expectancy (Kvaavik et al. 2010).

The prevalence and definition of the clustering of behavioral risk factors (BRFs) appear to vary in different social or age groups and populations. For example, prevalence of the combination of five BRFs (cluster of 3+ factors) was 24.9% in a representative sample of the Chinese population aged 15–69 years (Li et al. 2012), whereas prevalence of having 2+ factors was 58% in Americans aged 18+ years (Fine et al. 2004), 53.4% in Europeans aged 50+ (Linardakis et al. 2015) and 39.0% in Canadians aged 12+ (Klein-Geltink et al. 2006). In these populations, the prevalence of MBRFs was most apparent in men and those who lived alone or had low educational status. In younger ages (adolescents and young adults), the prevalence of having 2+ factors has been reported to range from 6.0% to 65.0%, while the most commonly reported BRF appears to be physical inactivity (Alamian and Paradis 2009; Klein-Geltink et al. 2006; Kritsotakis et al. 2016; Smpokos et al. 2014).

The transition from adolescence to young adulthood (i.e., from high school to university) is a crucial period characterized by increased levels of independence and the acquisition of unfavorable lifestyle habits (Kritsotakis et al. 2016; Smpokos et al. 2014). A number of studies have reported that prevalence of smoking increases and consumption of fruits and vegetables decreases during individuals' undergraduate studies (Alexopoulos et al. 2010; Lionis et al. 2006; Steptoe et al. 2002). Moreover, the prevalence of having 2+ BRFs appears to reach 84.0% in medical students, the equivalent of 2.4 factors per student (Keller et al. 2008). Medical students, in particular, are a population of distinct interest, considering their future responsibility for population health care and public health. In addition, some studies have suggested that the adoption of unhealthy behaviors is inversely associated with medical students' academic performance (Gedefaw et al. 2015; Raupach et al. 2015). The evidence base is limited, however, and, to our knowledge, no study to date has examined the association between BRF clustering and academic performance. This is important before regular health assessment programs in medical students are put in place and appropriate preventive strategies to decrease the prevalence of MBRFs in this population are developed (Lionis et al. 2006).

The aim of this observational study was therefore to assess the prevalence of MBRFs among undergraduate medical students in Crete, Greece, and evaluate their associations with academic performance.

Methods

Participants

For the purpose of the current study, a subset of 1447 medical students (78.1%) (704 males/743 females), aged 19.5–

40.0 years, living in Crete, Greece, were selected from a total sample of 1852 students (Fig. 1). Participants were recruited from all students ($n = 1948$) who were registered in the second or third year of studies at the Medical School of the University of Crete during the period 1989–2011 (i.e., students who were admitted during the academic years 1986/1987 through to 2010/2011). Every academic year, these students participated in a Health and Nutrition survey, conducted as part of the requirements for the mandatory Clinical Nutrition course, run by the Preventive Medicine and Nutrition Clinic of the Medical School (Bertsias et al. 2003; Kafatos 2009; Mammass et al. 2003). Detailed information on the study design (recruitment procedures, response rates, ethical issues, etc.) was provided in earlier reports (Bertsias et al. 2003; Kafatos 2009; Mammass et al. 2003).

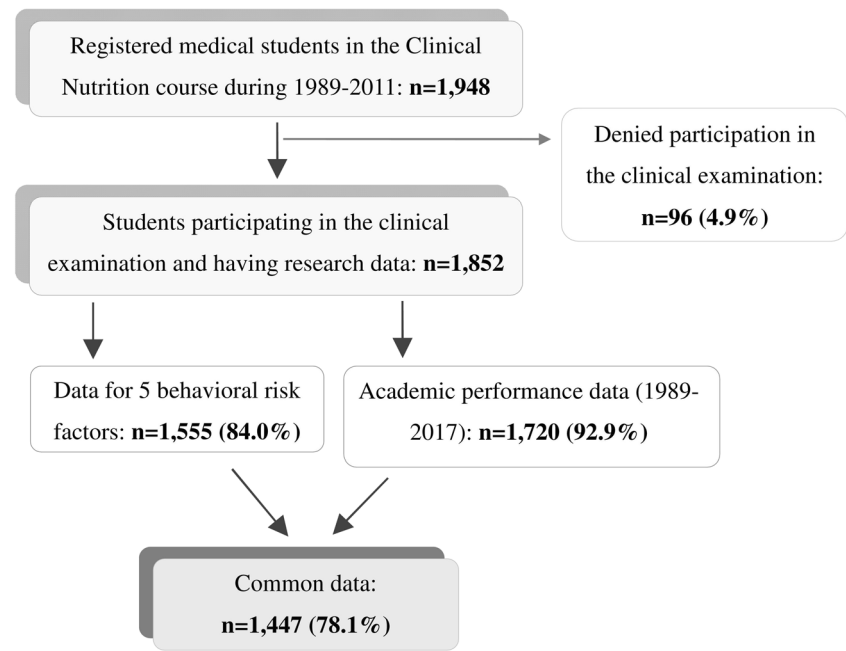
Data collection

During every academic year between 1989 and 2011, the aforementioned medical students underwent a clinical examination, where information on demographic characteristics, physical health status and lifestyle behaviors was collected and anthropometric, blood pressure and biochemical measurements were provided. Details of the methods used to collect data have been described elsewhere (Bertsias et al. 2003; Kafatos 2009; Mammass et al. 2003). The same questionnaires and assessment methods were applied during the research period (with additional questions or clinical examinations incorporated as newer methods became available, as appropriate), while detailed standard operating procedures ensured standardization in data collection. The MBRFs assessed (described in detail in the next section) were smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits and vegetables. Academic performance data were also collected up to the academic year 2016/2017.

Multiple behavioral risk factors (MBRFs)

Five MBRFs were assessed, which related to daily habits and health behaviors, including smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits and vegetables (Linardakis et al. 2015; Smpokos et al. 2014). Smokers were classified as those who stated smoking more than one cigarette per day for at least the last 3 consecutive months (Mammass et al. 2003). High body weight was determined, based on measurements of body weight and height, as having body mass index (BMI) $\geq 25.0 \text{ kg/m}^2$ (i.e., being overweight or obese). Weight was measured on calibrated digital scales (Seca 861) to the nearest 0.1 kg, and height was measured to the nearest 0.5 cm with a wall-mounted stadiometer (Seca 225) (Bertsias et al. 2003). Physical inactivity was defined, using a weighted weekday-

Fig. 1 Flowchart of participants in the research study. The clinical examination involved the collection of data on demographic characteristics, physical health status and lifestyle behaviors as well as anthropometric, blood pressure and biochemical measurements. The five behavioral risk factors assessed include smoking, high body weight, physical inactivity, risky alcohol consumption and low consumption of fruits and vegetables. Academic performance was based on the grades received in the mandatory Clinical Nutrition course ($n = 1447$) and the overall medical degree ($n = 1358$)



weekend physical activity questionnaire, as the lack of daily engagement in moderate-to-vigorous activities during the research period (i.e., having < 30 min/day of these activities) (Vardavas et al. 2009). Risky alcohol consumption was defined as the consumption of ≥ 12 servings/week of alcoholic beverages for at least 3 consecutive months or consuming ≥ 176 g/week of pure alcohol (Mammas et al. 2003). Low consumption of fruits and vegetables was determined by a 24-h dietary recall and defined as < 400 g/day (Bertsias et al. 2005).

To estimate the clustering of MBRFs, each factor was coded separately into a binary variable (0: absence; 1: presence). The prevalence of clustering was then estimated by adding the binary variables, resulting in a clustering score ranging from 0 to 5. ‘Multiple clustering of 3+ factors’ was considered to depict higher risk for chronic diseases (Linardakis et al. 2015; Smpokos et al. 2014).

Academic performance and other characteristics

Academic performance was based on the grades received in the mandatory Clinical Nutrition course (assessing clinical nutrition knowledge $n = 1447$) and medical degree (assessing overall undergraduate performance, $n = 1358$). The Clinical Nutrition course grades correspond to the average of a written examination taken at the end of the semester (or a re-sit in September of each academic year) and a group project involving the assessment and evaluation of patient case studies. Grades received in a course range from 0 to 10, with 5 representing the pass mark. For the purposes of the current study, the Clinical Nutrition grades included those of 37 students (2.6%) who had sat the examinations until the academic year 2016/2017 and failed (their grades were < 5). The

attempts to pass the Clinical Nutrition course were also recorded. For the overall medical degree, the grades of all students who had graduated by the end of academic year 2016/2017 (30 September 2017) were recorded (89 students did not graduate because of withdrawals, registration to other schools or inability to fulfill the university graduation requirements). Medical degree grades were classified according to the Greek Higher Education system as ‘good’ (pass, 5.00–6.49), ‘very good’ (merit, 6.50–8.49) and ‘excellent’ (distinction, 8.50–10.0).

Demographic characteristics assessed included age, gender and area of permanent residence. Academic information included collecting data on study periods [based on the initial database of 989 students in 1989–2001 (Bertsias et al. 2003; Mammas et al. 2003) and the a posteriori renewal of the database with data from 2002 to 2011]. Information on which academic semester students were registered in was also collected because of changes in the curriculum during the research period and classified into 5th, 6th or ≥ 7 th.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (IBM-SPSS, 24, 2011, Chicago, IL, USA). Prevalence of individual and BRF clusters with 95% confidence intervals (95% CIs) was estimated. In addition to the observed (O) prevalence, the expected (E) prevalence of individual and BRF clusters was assessed to estimate the O/E ratios and provide the most frequent combinations of the five BRFs (Linardakis et al. 2014; Schuit et al. 2002). For example, six students were found to be risky alcohol drinkers and physically inactive, and for this category of combinations the

observed prevalence of non-smoking was $100 - 25.8\% = 74.2\%$ (or 0.742), of normal weight $100 - 30.7\% = 69.3\%$ (or 0.693), of alcohol consumption 5.9% (or 0.059), of physical inactivity 12.7% (or 0.127) of regular consumption of fruits and vegetables $100 - 67.2\% = 32.8\%$ (or 0.328), and the expected prevalence for the combination of risky alcohol consumption and physical inactivity would be $0.742 \times 0.693 \times 0.059 \times 0.127 \times 0.328 = 0.13$ or 13% (Table 4). The chi-square test was used to examine differences in BRF prevalence according to gender and medical degree grade classification. Analysis of covariance, with gender, age, semester and study periods (due to potential heterogeneity caused by the long time period of the study) (Bertsias et al. 2003; Curran and Hussong 2009; Miech et al. 2017) as covariates, was used to examine differences and polynomial trends in BRF clustering ('0,' '1,' '2,' '3+' factors) according to academic performance (grades received in the Clinical Nutrition course and overall medical degree). The models' heterogeneity was tested using Levene's test.

Results

Table 1 presents the descriptive characteristics of participants. Mean age of participants was 21.8 years (± 2.2), 13.1% were aged ≥ 24.0 years, and 48.7% were men. The majority of participants (90.8%) came from urban or suburban areas, and 58.5% attended the Clinical Nutrition course in the ≥ 7 th semester.

Prevalence of BRFs in the total sample was 25.8% for smoking, 30.7% for high body weight, 5.9% for risky alcohol consumption, 12.7% for physical inactivity and 67.2% for low consumption of fruits and vegetables (Table 2). Prevalence of high body weight (43.9% vs. 18.2%, $p < 0.001$) and risky drinkers (9.2% vs. 2.8%, $p < 0.001$) was higher in men than women. Regarding clustering of BRFs (Table 3), only 15.8% (95% CI = 14.0–17.7) of participants had no risk factors, while 12.3% (95% CI = 10.6–13.9) had 3+ factors, with men having almost double the prevalence of this multiple clustering compared with women (16.5% vs. 8.4%, $p < 0.001$). The combination of risky alcohol consumption and physical inactivity had the greatest degree of clustering as the observed prevalence was 238% higher than the expected one (O/E = 3.28) (Table 4).

The mean levels of academic performance of participants (as indicated by the grades received) according to the clustering of MBRFs are illustrated in Fig. 2. Participants who had none compared with 3+ MBRFs had higher mean grades in the Clinical Nutrition course (6.34 vs. 5.94, $p = 0.027$, p trend = 0.003) and overall degree (7.39 vs. 7.22, $p = 0.021$, p trend = 0.002).

Regarding individual BRFs, smokers achieved lower mean grades in the Clinical Nutrition course (5.99 vs. 6.20, $p = 0.007$) and overall degree (7.21 vs. 7.35, $p < 0.001$) compared with non-smokers. In addition, participants who had high body weight compared with those with normal weight (7.25 vs. 7.34, $p = 0.012$) and participants who were physically active compared with those who were inactive (7.30 vs. 7.41, $p = 0.008$) achieved

Table 1 Descriptive characteristics of 1447 medical students in Crete, Greece, during 1989–2011

		<i>n</i>	%
Gender	Males	704	48.7
	Females	743	51.3
Age, years	< 21.0	500	34.6
	21.0–21.9	325	22.5
	22.0–22.9	306	21.1
	23.0–23.9	126	8.7
	≥ 24.0	190	13.1
Area of permanent residence ^a	Mean \pm SD (min, max)	21.8 \pm 2.2 (19.5, 40.0)	
	Urban/suburban	700	90.8
Study periods ^b	Rural	71	9.2
	1989–2001	816	56.4
Semesters ^c	2002–2011	631	43.6
	5th	250	17.3
	6th	350	24.2
	≥ 7 th	847	58.5

^aData were available for 771 students

^bStudy periods were classified according to a previous publication (Bertsias et al. 2003)

^cDuring 1989–2011, the Clinical Nutrition course changed and was taught in a different semester

Table 2 Prevalence of five multiple behavioral risk factors among 1447 medical students in Crete, Greece, according to gender

Behavioral risk factors		<i>n</i>	Percent, %	95% confidence intervals
Smoking, smokers	Males	192	27.3	24.0, 30.5
	Females	182	24.5	21.4, 27.6
	Total	374	25.8	23.4, 28.3
High body weight, overweight/obese	Males	309	43.9	40.1, 47.6
	Females	135	18.2	15.6, 20.9
	Total	444	30.7	28.2, 33.1
Alcohol consumption, risky drinkers	Males	65	9.2	7.1, 11.5
	Females	21	2.8	1.6, 4.0
	Total	86	5.9	4.7, 7.2
Physical inactivity	Males	80	11.4	9.0, 13.9
	Females	104	14.0	11.5, 16.5
	Total	184	12.7	11.0, 14.6
Low consumption of fruits and vegetables	Males	460	65.3	62.2, 69.1
	Females	513	69.0	65.6, 72.4
	Total	973	67.2	64.8, 69.8

Smokers were classified as those who stated smoking more than one cigarette per day for at least the last 3 consecutive months (Mammas et al. 2003). High body weight was determined as having body mass index (BMI) $\geq 25.0 \text{ kg/m}^2$ (i.e., being overweight or obese) (Bertsias et al. 2003). Physical inactivity was defined as the lack of daily engagement in moderate or vigorous activities during the research period (i.e., having $< 30 \text{ min/day}$ of these activities) (Vardavas et al. 2009). Risky alcohol consumption was defined as the consumption of ≥ 12 servings of alcoholic beverages per week for at least 3 consecutive months or consuming $\geq 176 \text{ g/week}$ of pure alcohol, based on a 24-h dietary recall (Mammas et al. 2003). Low consumption of fruits and vegetables was determined by a 24-h recall and defined as $< 400 \text{ g/day}$ (Bertsias et al. 2005)

Differences between genders were assessed using the chi-square test (strong evidence of a difference between genders was observed for high body weight and alcohol consumption, with $p < 0.001$)

lower mean grades in their overall degree. Finally, 4.1% ($n = 56$) of the students graduated with a ‘good’ degree classification, 92.6% ($n = 1257$) with ‘very good’ and 3.3% ($n = 45$) with ‘excellent.’ The mean number of attempts in succeeding in the Clinical Nutrition course examination was $1.59 (\pm 1.11)$, while 66.9% of participants passed on the first attempt. As the number of MBRFs increased (from ‘none’ to ‘1,’ ‘2’ and ‘3+’ factors), the proportion of graduates receiving a distinction also decreased (6.1%, 3.3%, 3.3% and 0.0%, respectively, $p \text{ trend} = 0.001$).

Discussion

This observational study assessed the prevalence of MBRFs and their association with academic performance in a sample of Greek undergraduate medical students. Overall, high prevalence of individual MBRFs was observed, with low consumption of fruits and vegetables being the most prevalent BRF. The findings also suggested that academic performance decreased with the increase in MBRF clustering.

Prevalence of unhealthy behaviors was apparent in this sample of students, which is in agreement with earlier studies

Table 3 Prevalence of clustering of behavioral risk factors among 1447 medical students in Crete, Greece, according to gender

Clustering of multiple behavioral risk factors	Total % (95% confidence intervals) [<i>n</i>]	Males	Females
0 (none)	15.8 (14.0, 17.7) [229]	13.1 (10.5, 15.6) [92]	18.4 (15.8, 21.5) [137]
1	40.2 (37.6, 42.7) [582]	36.5 (33.0, 39.9) [257]	43.7 (40.0, 47.3) [325]
2	31.7 (29.3, 34.2) [458]	33.9 (30.6, 37.6) [239]	29.5 (26.3, 32.8) [219]
3+	12.3 (10.6, 13.9) [178]	16.5 (13.7, 19.5) [116]	8.4 (6.4, 10.3) [62]

Differences between genders were assessed using the chi-square test (strong evidence of a difference between genders was observed for clustering of 3+ behavioral risk factors, with $p < 0.001$)

Table 4 Clustering of behavioral risk factors individually or in combination in 1447 medical students in Crete, Greece

Cluster of risk factor	Smoking, smokers	High body weight, overweight and obese	Alcohol consumption, risky drinkers	Physical inactivity	Low consumption of fruits and vegetables	n	O (%)	E (%)	O÷E	95% confidence intervals
None	-	-	-	-	-	229	15.83	13.86	1.14	0.63 1.83
1	+	-	-	-	-	41	2.83	4.82	0.59	0.09 1.66
1	-	+	-	-	-	94	6.50	6.14	1.06	0.41 2.24
1	-	-	+	-	-	7	0.48	0.87	0.55	0.01 4.24
1	-	-	-	+	-	30	2.07	2.02	1.03	0.12 3.58
1	-	-	-	-	+	410	28.33	28.39	1.00	0.66 1.43
2	+	+	-	-	-	30	2.07	2.13	0.97	0.11 3.39
2	+	-	+	-	-	11	0.76	0.30	2.52	0.01 15.58
2	+	-	-	+	-	6	0.41	0.70	0.59	0.01 5.27
2	+	-	-	-	+	142	9.81	9.87	0.99	0.45 1.80
2	-	+	+	-	-	7	0.48	0.38	1.26	0.01 9.71
2	-	+	-	+	-	10	0.69	0.89	0.77	0.01 5.25
2	-	+	-	-	+	177	12.23	12.58	0.97	0.49 1.67
2	-	-	+	+	-	6	0.41	0.13	3.28	0.01 28.38
2	-	-	+	-	+	14	0.97	1.78	0.54	0.01 2.62
2	-	-	-	+	+	60	4.15	4.13	1.00	0.26 2.48
3	+	+	+	-	-	3	0.21	0.13	1.55	0.01 28.37
3	+	+	-	+	-	4	0.28	0.31	0.89	0.01 11.90
3	+	+	-	-	+	68	4.70	4.37	1.07	0.31 2.50
3	+	-	+	+	-	1	0.07	0.04	1.57	- -
3	+	-	+	-	+	17	1.17	0.62	1.90	0.04 8.99
3	+	-	-	+	+	24	1.66	1.44	1.16	0.07 4.46
3	-	+	+	+	-	0	-	0.06	-	- -
3	-	+	+	-	+	3	0.21	0.79	0.26	0.01 4.66
3	-	+	-	+	+	24	1.66	1.83	0.91	0.05 3.50
3	-	-	+	+	+	0	-	0.26	-	- -
4	+	+	+	+	-	0	-	0.02	-	- -
4	+	+	+	-	+	10	0.69	0.27	2.52	0.01 17.31
4	+	+	-	+	+	12	0.83	0.64	1.30	0.01 7.30
4	+	-	+	+	+	5	0.35	0.09	3.84	- -
4	-	+	+	+	+	2	0.14	0.11	1.21	0.01 33.53
5	+	+	+	+	+	0	-	0.04	-	- -

+: presence of behavioral risk factor
Observed (O) and expected (E) combination frequencies of risk factors

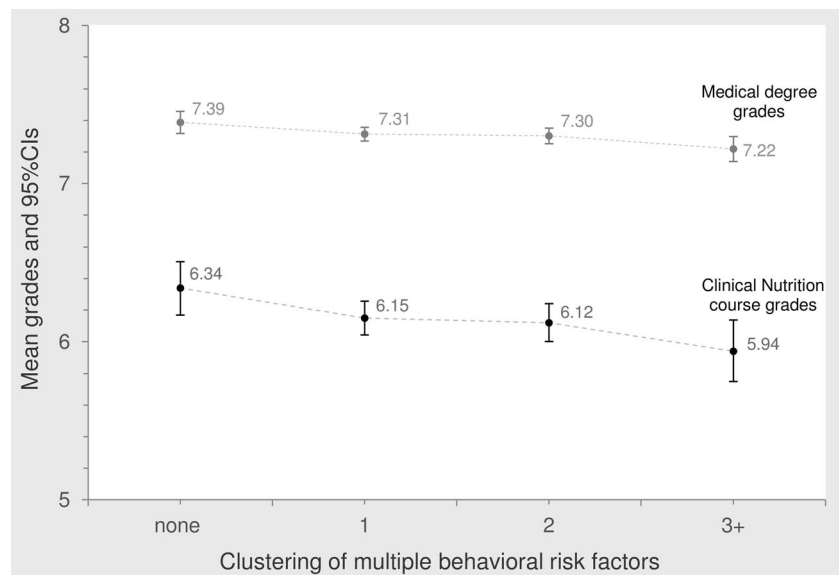


Fig. 2 Academic performance of medical students according to clustering of multiple behavioral risk factors. 95% CIs, 95% confidence intervals. Academic performance was based on the grades received in the mandatory Clinical Nutrition course ($n = 1447$) and the overall medical degree ($n = 1358$). The mean medical degree grade was 7.31 (± 0.53) and the mean Clinical Nutrition course grade was 6.15 (± 1.34), including the grades of 37 students (2.6%) who sat the examinations until the summer of 2017 but they failed (their grade was < 5). The mean number of

attempts to pass the examination was 1.59 (± 1.11) (66.9% passed on the first attempt). Differences according to clustering of behavioral risk factors were assessed using analysis of covariance (medical degree grades: $p = 0.021$ and polynomial p trend = 0.002; Clinical Nutrition course grades: $p = 0.027$ and polynomial p trend = 0.003). Gender, age, semester (5th, 6th, ≥ 7 th) and study period (1989–2001 and 2002–2011) were used as covariates. Heterogeneity was tested by Levene's test

in other student or population groups (Anderson and Good 2017; Burrows et al. 2017; Chourdakis et al. 2010; Kritsotakis et al. 2016; Mekonen et al. 2017; Steptoe et al. 2002; Suraya et al. 2017). The behavioral profile of undergraduate medical students, already adopted in their teenage years and carried through to adulthood upon university entry, constitutes a particularly interesting trait of this population group. This is because this profile stems not only from all the lifestyle choices medical students will make, but also from the healthy behaviors they will adopt because of their clinical, person-centered training and which they might pass on to their patients in future consultations (Gedefaw et al. 2015; Kafatos 2009; Raupach et al. 2015). A common feature of earlier studies investigating MBRFs for non-communicable diseases is the focus on combined (clustered) BRF prevalence and thereafter its relationship with overall morbidity and mortality (Kvaavik et al. 2010; Linardakis et al. 2015). It also appears that a variety of multiple behaviors during medical students' undergraduate studies should be considered when attempting to assess their health-related risk (Kritsotakis et al. 2016). The role of clinicians' lifestyle choices in screening and counseling of their patients is evident in other studies, such as the Women Physician's Health Study of approximately 4500 general practitioners (Frank et al. 2000), particularly regarding lifestyle behaviors such as smoking and alcohol consumption. In this study, general practitioners who themselves were attempting to improve their lifestyle behaviors were more likely to discuss these behavioral risk factors with their patients. It was

also suggested that practicing healthy lifestyle behaviours themselves offered general practitioners a means of continuous professional development regarding prevention-related counseling and screening, which would be invaluable for practitioners' training in preventing MBRFs (Frank et al. 2000).

One of the main findings of the present study was the high prevalence of both individual BRFs and their clusters. The most prevalent BRF was the low consumption of fruits and vegetables, as 67.2% of participants consumed < 400 g/day. Earlier studies among Greek university students have reported conflicting findings for this BRF. In 1058 first-year students of technological schools in Crete in 2012, only 9.4% reported consuming fruits and vegetables > 1 time/day (Kritsotakis et al. 2016), whereas regular consumption of fruits and vegetables was observed in a sample of 390 medical students in Northern Greece in 2009 (Chourdakis et al. 2010). An earlier longitudinal study of approximately 20,000 university students in 13 European countries also found that daily fruit consumption decreased by 15% between 1990 and 2000 (Steptoe et al. 2002). Overall, these findings highlight the importance of intervention strategies to promote the recommended intake of fruits and vegetables among University students. Although the current study did not suggest that levels of academic performance differed according to the presence or not of low intake of fruits and vegetables, small-to-moderate consumption of fruit (≥ 2 servings/day) has previously been positively associated with academic performance (odds ratio =

1.09; 95% CI = 1.05–1.13) (Burrows et al. 2017). Fruits and vegetables, however, are only one dietary component among others (including regular breakfast consumption, lower consumption of junk foods and the intake of essential micronutrients, such as iron and folate), which have been associated with higher levels of academic performance in university students (Anderson and Good 2017; Burrows et al. 2017). Ideally, future studies in this sample of medical students should explore a wider range of nutritional factors to establish associations with this outcome.

Those participants who were smokers and those with high body weight had lower levels of academic performance compared with non-smokers and those with normal BMI, respectively. The use of various substances (e.g., current smoking, chewing khat, drinking alcohol on a daily basis) has previously been inversely associated with academic performance (Mekonen et al. 2017). University students who are smokers have been found to face health complications that might affect their engagement with or performance in their studies, such as higher rates of respiratory infections or bacterial meningitis, exacerbated by living in dorms (Lussier 2015). The association between high body weight and low academic performance has also been suggested by earlier studies among Saudi Arabian (Suraya et al. 2017) and American (Anderson and Good 2017) university students. Similar to the role of fruits and vegetables in academic performance, individuals with increased body weight might struggle academically because of other dietary habits, such as regular fast food consumption or high intakes of saturated fat and added sugars, which in turn have been linked to cognitive decline (Anderson and Good 2017). In addition, the role of physical activity in enhanced academic performance has been widely documented (Al-Drees et al. 2016; Lizandra et al. 2016). In contrast, participants who engaged in moderate-to-vigorous physical activity in the current study achieved a lower mean grade in their overall degree compared with those who were inactive. The grade of the degree, however, is determined by the overall academic performance over the 5 years of undergraduate medical studies, whereas physical activity in the current study, in addition to the other BRFs of interest, was assessed over a short period of time (before or during the Clinical Nutrition course) at the beginning or in the middle of participants' undergraduate studies. Particularly for participants recruited during their seventh semester of studies, the potential effect of the level of study commitment and difficulty of coursework should be taken into consideration when interpreting these findings, as the study requirements might interfere with and limit participation in physical activity or organized sports (Lizandra et al. 2016).

Regarding the prevalence of BRF clustering, it was observed that approximately 12% of participants had 3+ MBRFs, in contrast to the higher prevalence (53%) reported among German university students (Keller et al. 2008). In

addition, men had almost twice the prevalence of BRF clustering compared with women. One of the most important findings of the current study, however, was that levels of academic performance, demonstrated by the grades achieved in both the Clinical Nutrition course and the overall medical degree, decreased as clustering of BRFs increased. To our knowledge, this is the first study to investigate the association between BRF clustering and academic performance, which hinders comparisons with other studies. However, given the plausibility of this association, this finding highlights the need for preventive measures to reduce the prevalence of MBRFs in this sample of medical students, mainly via their undergraduate education (Kafatos 2009). This could involve interventions through the medical curriculum, with expansion in the scope of educational materials, but also environmental interventions to encourage the adoption of healthier lifestyles and/or discourage the adoption or maintenance of risky behaviors, which, in turn, might positively impact these medical students' future patients (Gedefaw et al. 2015; Kafatos 2009; Raupach et al. 2015).

Regarding specific combinations of BRFs, the combination of risky alcohol consumption and physical inactivity had the greatest degree of clustering in the current study and was 238% higher than expected ($O/E = 3.28$). This is in contrast to earlier studies, which have reported low clustering of these BRFs among Canadian children and adolescents aged 10–17 years (boys = 0.70; girls = 0.43) (Alamian and Paradis 2009) and Dutch adults aged 20–59 years (males = 0.4; females = 0.5) (Schuit et al. 2002), a difference that reveals the potential distinctiveness of medical students as a population sub-group susceptible to adopting MBRFs and in need of intervention to reduce their clustering.

The lack of a common definition of MBRFs, particularly regarding their number and cutoff points (Linardakis et al. 2015), is an important limitation of this study. In addition, were collected over a period of 24 years, which might conceal secular trends in BRF prevalence and/or academic performance. However, adjusting analyses for the study period (1989–2001 and 2002–2011) should have helped overcome this limitation (Bertsias et al. 2003; Curran and Hussong 2009; Miech et al. 2017). Furthermore, factors such as participants' medical history, their overall dietary assessment and biochemical profiles might have mediated the relationship between MBRFs and academic performance, but such investigation was beyond the scope of the current report. Finally, MBRF assessment was conducted at a given point in time and was retrospectively associated with the academic performance achieved in the Clinical Nutrition course and throughout participants' studies. These measures, however, were considered to be the best available objective academic performance indicators compared with self-reported academic achievement, for example.

Conclusion

Overall, high prevalence of MBRFs was observed in this sample of medical students, while prevalence of MBRF clustering was prospectively inversely associated with academic performance. As medical students will be responsible for patients of their own, to whom they will act as role models (Gedefaw et al. 2015; Kafatos 2009; Labadarios and Kafatos 1991; Raupach et al. 2015), preventive strategies are needed to improve the lifestyle and behavioral risk factors in this population group during their undergraduate studies.

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Compliance with ethical standards

Disclosure of potential conflicts of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee of the University Hospital of Heraklion, Crete, Greece, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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