Physical activity and academic achievement among the medical students: A cross-sectional study

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Abstract

Aims: To explore physical activity (PA) habits among the medical students and examine the correlation with their grade point average (GPA) achievement at College of Medicine, King Saud University, Riyadh, Saudi Arabia.

Methods: A cross-sectional study was conducted among the medical students ($n = 409$), during the academic year 2012–2013. Students' physical activity habits were self-reported. GPA, body mass index (BMI) and body fat percent (BF%) were collected and analyzed with SPSS software.

Results: Out of 409 students, 193 (47.2%) students reported being physically active. Our result showed a significant positive association between students' PA habits and high-GPA achievement ($\chi^2 = 10.65$, $p = 0.001$). The greatest odds ratio of high GPA was found among the fourth year students (OR = 3.08, CI: 1.15–8.28, $p = 0.025$) and fifth year students (OR = 5.07, CI: 1.48–17.31, $p = 0.010$). In addition, significant association was found between the normal BMI and high-GPA achievers ($\chi^2 = 8.30$; $p = 0.016$). However, no statistically, significant association was found between BF% and GPA.

Conclusions: The present study showed a positive associations was found between PA habits and high academic achievement. In addition, positive association was found between PA, obese students and GPA achievement. Therefore, there is a need for the establishment of physical activity education and public health programs to promote importance of PA in Saudi population.

Introduction

Physical activity (PA) is defined as any bodily movement, produced by skeletal muscles, which results in an energy expenditure above basal level (Ainsworth et al. 2000). In addition, PA is a complex behavior commonly described by four different dimensions, including frequency, duration, intensity and different types (Warren et al. 2010). World health organization (WHO) recommend at least 150 minutes of moderate exercise or 75 minutes of vigorous exercise on a weekly basis (WHO 2011). However, exercise is not a synonymous with PA (Howley 2001).

Observational and clinical studies reported that the increase in PA level have protective role against chronic diseases and helped in the improvement of cognitive function (Ignarro et al. 2007; Warren et al. 2010). However, decrease in PA level can affect normal body physiology leading to poor health and increasing the likelihood for an early onset of chronic disease (Booth et al. 2008; Durstine et al. 2013). Lack or decrease in PA was reported in Saudi population especially in females (Khalaf et al. 2013). Moreover, a local study reported physical inactivity among Saudi adults and children ranging between 43% and 99% (Al-Hazzaa 2004). Furthermore, 41% of physical inactivity was reported among medical students at King Faisal University, Saudi Arabia (El-Gilany & El-Masry 2011).

Practice points

- The medical students who had physically active habits were high academic achievers.
- The GPA was decreased from normal weight to obese students in the study population.
- The obese students who had high-GPA were physically active.
- The high-GPA achievers who had perform physical activity at least 30 minutes/day for 5 days in a week.

Two most common obstacles which may prevent PA in Saudi population are hot weather during most of the year ranging between 37° and 48 °C and lack of PA facilities. The hot weather in Saudi Arabia, especially in the central region restricts outdoor activities like walking, cycling and jogging. In addition, there are lack of appropriate social culture, affordable PA facilities and outdoor spaces for activities like parks and sport clubs, especially for women (Benjamin & Donnelly 2013). Therefore, physical inactivity is a major risk factor for obesity that predispose Saudi population to major health problems (Al-Nozha et al. 2007; Al-Shehri et al. 2013).

Students' academic achievement is affected by many factors, including motivation, physical and emotional well

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being (Bye et al. 2007). Moreover, high levels of stress in medical students may have a negative impact on cognitive functioning and learning (Abdulghani et al. 2011; 2014a), which could be reflected by their low academic achievement. However, there is an increasing body of evidence showing the benefits of PA in improving the cognition and students' learning abilities (Hillman et al. 2008; Sallis 2010). Students' involvement in PA have been shown to improve self-concept, improve cognition, induces arousal, reduces boredom, reduces stress, stabilizes mood, improves sleep, increases attention span and concentration (Coe et al. 2006; Biddle & Asare 2011). In addition, psychological and physiological mechanisms have been introduced as a key player to explain the association between PA and academic achievement (Angevaren et al. 2008; Lees & Hopkins 2013; Ardoy et al. 2014). It has been reported that the brain is activated during PA by increasing brain-derived neurotrophic factors, increasing volume of hippocampus and increasing brain cortical blood flow, which may stimulate learning, increase intelligence and reasoning ability (Davis et al. 2011; Erickson et al. 2011). Therefore, PA interventions are used as a potential mediator of behavioral change including self-efficacy, enjoyment, attitudes, behavioral capability, intentions, outcome expectancies, social support and self-concept (Eather et al. 2013).

Today medical students will be tomorrow physicians, where they can play a major role in public health awareness about importance of PA. Frank et al. (2008) did a survey on medical students in USA and found positive correlation between medical students' PA habits and counseling patients about importance of PA. Therefore, medical students' perception about the benefit of PA will be useful in motivating patients, increasing awareness and disease prevention in their future clinical practice (Stanford et al. 2012).

An extensive electronic search did not reveal any local study which investigated such important issues. Therefore, the aim of this study was to assess the habits of PA among medical students and to examine the correlation of academic achievement, PA, BMI and body fat percentage (BF%) in medical students.

Methods

Study subjects

The study was conducted during the academic year 2012–2013, at the College of Medicine, KSU, Riyadh, KSA. All male and female medical students were invited to participate in the study. The sample size was calculated based on the pilot study, which was carried out on 15 medical students who were representative for the targeted population of the study. The prevalence of the physical activity (PA) was estimated to be nine students out of 15 (9/15) in this population. The sample size of 369 students was calculated at 95% level of significance and 5% allowable error.

Data collection method

The study followed a cross-sectional design. A self-administrated questionnaire was developed after an extensive literature review. The first part of the questionnaire gathered information about gender, age, academic year and grade point average (GPA). The second part of the questionnaire contained information about the types of PA (walking, jogging, football playing, swimming and weight lifting), frequency (one–seven days/week), duration (<30 minutes, 30–60 minutes and >60 minutes) and motivating factors. A nonrandom, convenient sampling technique was employed to collect the data to improve the response and get target number of students. The participants answered the questions by ticking the appropriate choices or adding more items to the list.

The body composition of the participants was assessed using the "body composition analyzer machine according to the company instructions (Biospace, Korea). Participants' anonymity was assured by assigning a code number to each student and cross-matched with his/her body composition analyzer results and GPA.

Body mass index (BMI) was calculated as the weight in kilograms divided by the square of height in meters and categorized as normal weight ($18.5–24.9\,kg/m^2$), overweight ($25.0–29.9\,kg/m^2$) and obese ($30.0\,kg/m^2$ or more) (WHO, 2011). Body fat percentage (BF%) was categorized taking into consideration the participants' age and gender and classified as normal fat percentage (BF% $= 8–19.9$) and high-fat percentage (BF% $= \geq 20$) (Gallagher et al. 2000).

The students' GPA was taken as students' academic achievement indicator. The students were categorized as high academic achievers if their GPA scores were ≥85% and low achiever if their GPA scores were <85% based on a local study findings (Abdulghani et al. 2014b).

Statistical analysis

The collected data were entered in Excel 2007 (Microsoft office) and analyzed using the SPSS program (version 21; IBM Corporation, Armonk, NY). The descriptive statistics (mean, standard deviation and percentages) were used for summarizing the study outcome variables. Pearson's chi-square test and odds ratios (OR) with 95% confidence intervals (CI) were used for observing and quantifying the association between physically active and inactive participants.

Ethical approval

All participants were informed about the objectives of the study, the questionnaire information items were explained, and participants' anonymity was assured by assigning each student with a code number for the purpose of the analysis only. The study was approved by IRB of the Research Centre, College of Medicine, King Saud University.

Results

A total of 409 students participated in this study, among them, 205 (50.1%) were male and 204(49.9%) were female students. The basic characteristics of the students are presented in the Table 1.

Out of 409 students, 193(47.2%) reported being physically active. The male students were significantly involved more in PA 101 (49.3%) than the female 92(45.1%) (OR = 1.18, CI: 0.80–1.74). The BMI of the participants showed that

253(61.9%) of students were normal weight, 97(23.7%) were overweight and 59(14.4%) were obese. Out of 409 students, 222 (54.3%) had excess BF%, among them 105(47.3%) were male and 117 (52.7%) were female students. The BF% of the students was significantly correlated with the BMI ($\chi^2 = 36.97$; $p = 0.001$).

Our result showed a significant positive association between PA and high-GPA achiever ($\chi^2 = 10.65$, $p = 0.001$) (Table 2). The greatest odds ratio of high-GPA was found among the fourth year students (OR = 3.08, CI: 1.15–8.28, $p = 0.025$) and fifth year students (OR = 5.07, CI: 1.48–17.31, $p = 0.010$) (Table 3). In addition, significant association was found between the normal-BMI and high-GPA achiever ($\chi^2 = 8.30$; $p = 0.016$). However, no significant association was found between BF% and GPA achiever (χ^2 test $p = 0.413$) (Table 4). Furthermore, significant positive association was found between high-GPA achiever who performed PA at least 30 minutes/day for 5 days in a week ($p = 0.001$) (Table 5).

Multivariate logistic regression analysis of academic performance in relation to PA, after adjusting for the covariate variables (academic year, gender, BMI, BF% and duration of PA) showed a significant association between high achievers and PA ($p = 0.002$, Adjusted OR = 1.95; CI: 1.28–2.95).

The most selected PA modality was walking (135, 69.9%) and least selected PA modality was swimming (35, 18.1%) as shown in the Table 6. The major motivating factors for PA performance were mood improvement (119, 61.7%), followed by staying in shape (115, 59.6%). However, the major obstacles preventing the students from PA were laziness 112 (51.9%), lack of time 94 (43.5%), studying 84 (38.9%), lack of interest 9 (4.2%), and other factors 18(8.3%) (Table 6).

Discussion

To the best of our knowledge, this is the first Saudi Arabian study that endeavored to look into the medical students' PA habits and GPA. The result showed that 47.2% of the students reported PA habits, which is lower than the PA habits (61%) in USA medical student (Frank et al. 2008). Moreover, it was reported that PA habits are brought with the medical students rather than established during medical school (Konen & Fromm 1992), which raise the need for promoting PA habits among population. In addition, the results showed that PA was positively associated with high academic achievement. These findings are consistent with previous studies, which reported positive associations between PA and academic achievement (Edwards et al. 2011; Donnelly et al. 2013;

Table 1. The characteristics of the participants.

Characteristic	Range	Mean ± SD*
Age (years)	18–25	21.33 ± 1.52
Height (cm)	145–194	166.92 ± 9.29
Weight (Kg)	38–168	69.49 ± 19.67
BMI (Kg/m²)	15–56.9	24.68 ± 5.45
Body fat (%)	2.4–50.6	27.15 ± 8.8

*Standard deviation.

Table 2. Academic achievement versus physical activity (PA).

Subjects	Physical activity	Participants n (%)	High GPA achievers n (%)	Low GPA achievers n (%)	Odd ratio	CI* (95%)	p
Male	Yes	101(49.3)	70(69.3)	31(30.7)	1.79	1.01–3.18	0.046
	No	104(50.7)	58(55.8)	46(44.2)	1		
Female	Yes	92(45.1)	69(75.0)	23(25.0)	2.50	1.37–4.57	0.003
	No	112(54.9)	61(54.5)	51(45.5)	1		
Total	Yes	193(47.2)	139(72.0)	54(28.0)	2.09	1.39–3.17	0.001
	No	216(52.8)	119(55.1)	97(45.0)	1		

*Confidence interval.

Table 3. Academic achievement among various academic year students.

Academic years	Physical activity	Participants n (%)	High GPA achievers n (%)	Low GPA achievers n (%)	Odd ratio	CI* (95%)	p
First	Yes	41 (50.0)	40 (97.6)	1 (2.4)	4.32	0.46–40.47	0.119
	No	41 (50.0)	37 (90.2)	4 (9.8)	1		
Second	Yes	41(51.3)	38 (92.7)	3 (7.3)	2.77	0.66–11.60	0.163
	No	39 (48.7)	32 (82.1)	7 (17.9)	1		
Third	Yes	44 (46.3)	29 (65.9)	15 (34.1)	1.35	0.58–3.12	0.478
	No	51 (53.7)	30 (58.8)	21 (41.2)	1		
Fourth	Yes	29 (40.8)	19 (65.5)	10 (34.5)	3.08	1.15–8.28	0.025
	No	42 (59.2)	16 (38.1)	26 (61.9)	1		
Fifth	Yes	38 (46.9)	13 (34.2)	25 (65.8)	5.07	1.48–17.31	0.010
	No	43 (53.1)	4 (9.3)	39 (90.7)	1		

*Confidence interval.

Table 4. Academic achievement vs BMI and body fat (BF, %).

Subjects	BM1	Participants n (%)	High GPA achievers n (%)	Low GPA achievers n(%)	Odd ratio	CI* (95%)	p
Male	Normal weight	96 (46.8)	66 (68.8)	30 (31.3)	2.01	0.98–4.15	0.05
	Overweight	63 (30.7)	38 (60.3)	25 (39.7)	1.39	0.64–3.00	0.39
	Obese	46 (22.4)	24 (52.2)	22 (47.8)	1		
Female	Normal weight	157 (77.0)	106 (67.5)	51 (32.5)	3.32	1.03–10.67	0.043
	Overweight	34 (16.7)	19 (55.9)	15 (44.1)	2.03	0.54–7.49	0.289
	Obese	13 (6.3)	5 (38.5)	8 (61.5)	1		
Total	Normal weight	253 (61.9)	172 (68.0)	81 (32.0)	2.19	1.23–3.90	0.007
	Overweight	97 (23.7)	57 (58.8)	40 (41.2)	1.47	0.77–2.82	0.243
	Obese	59 (14.4)	29 (49.2)	30 (50.8)	1		
Male	Normal BF	100 (48.8)	65 (65.0)	35 (35.0)	1.24	0.70–2.18	0.46
	Excess BF	105 (51.2)	63 (60.0)	42 (40.0)	1		
Female	Normal BF	87 (42.6)	57 (65.5)	30 (34.5)	1.14	0.64–2.04	0.646
	Excess BF	117 (57.4)	73 (62.4)	44 (37.6)	1		
Total	Normal BF	187 (45.7)	122 (65.2)	65 (34.8)	1.18	0.79–1.78	0.406
	Excess BF	222 (54.3)	136 (61.3)	86 (38.7)	1		

*Confidence interval

Table 5. Academic achievement with respect to duration of physical activity.

Duration (min/day)	Participants n (%)	High GPA achievers n (%)	Low GPA achievers n (%)	Odd ratio	CI* (95%)	p
>60	47 (11.5)	35 (74.5)	12 (25.5)	2.37	1.17–4.82	0.016
>30–60	87 (21.3)	60 (69.0)	27 (31.0)	1.81	1.06–3.07	0.027
30	59 (14.4)	48 (81.4)	11 (18.6)	3.56	1.75–7.22	0.001
0	216 (52.8)	119 (55.1)	97 (44.9)	1		

*Confidence interval.

Table 6. Exercise modalities, motivation and obstacles are perceived by study population.

*Exercise modalities (N = 193)	n (%)
Walking	135 (69.9)
Jogging	94 (48.7)
Weight lifting	59 (30.6)
Football playing	56 (29.0)
Swimming	35 (18.1)
Others	52 (26.9)
*Motivation factors (N = 193)	n (%)
To stay in shape	115 (59.6)
To improve mood	119 (61.7)
Body building	112 (58.0)
To reduce stress	82 (42.5)
*Obstacles factors (N = 216)	n (%)
Laziness	112 (51.9)
Lack of time	94 (43.5)
Studying	84 (38.9)
No interest	18 (8.3)
Others	9 (4.2)

*Categories are not mutually exclusive.

Kantomaa et al. 2013). In the present study, significant association was found between high-GPA and performing PA at least 30 minutes/day for 5 days a week. However, it was reported that the students performing PA for 30 minutes/day for 3 days a week obtained high GPA than the physically inactive students (Reed et al. 2010). In addition, it was reported that the vigorous PA for 20 minutes/day for at least 3 days/ week was significantly correlated with better academic performance as compared to moderate PA for 30 minutes/ day at least 5 days/week (Coe et al. 2006).

The present study results showed significant association between BMI and GPA; therefore, most of the high achievers were normal-weight students. This finding is consistent with the previous studies that reported overweight and obesity students to have low academic performance (London & Castrechini 2011; Barrigas & Fragoso 2012; Heshmat et al. 2014). In addition, previous reports showed a positive link between increased BMI and high-fat mass and deficits of cognitive function in preadolescent children (Kamijo et al. 2012). However, our result was inconsistent with few studies which did not find a significant correlation of obesity and low academic achievement (Chen et al. 2012; LeBlanc et al. 2012). Moreover, researchers have shown that a high fatty diet decreases hippocampal brain-derived neurotrophic factor levels and affect hippocampus-dependent cognitive functions (Molteni et al. 2004; Tozuka et al. 2010). Therefore, weight loss was associated with significant improvements in cognitive function (Siervo et al. 2012). Furthermore, it has been reported that aerobic exercise increased gray and white matter volume in older adults, which helped to enhance central nervous system (CNS) health and cognitive function (Colcombe et al. 2006). Similarly, it has been reported that hippocampal and medial temporal lobe volume was increased in physically fit older adults with improvements in memory (Erickson et al. 2011).

This study documented that walking is the preferred PA modality among Saudi medical students. Similarly, it was reported in a local study that the participants preferred walking as the best modality of PA (Taha 2008; Al-Eisa & Al-Sobayel 2012). In addition, a systematic review reported that walking is a well-accepted mode of PA in the population (Hillsdon & Thorogood 1996).

This study explored the obstacles that could prevent medical students from being physically active. The major obstacles reported by the participants were lack of time as an external barrier and laziness as an internal barrier. Similarly, a report from India showed that physical inactivity among medical students was due to laziness and lack of time (Rao et al. 2012). In addition, a local study from the Al-Hassa Medical College (KSA) reported time limitation due to a busy study schedule as the major barrier to perform PA (El-Gilany & El-Masry 2011). Furthermore, it was reported that the internal barriers leading to physical inactivity will increased the risk of adopting sedentary behavior (Tammelin et al. 2003). Self-motivation was reported to add enjoyment in doing PA and to increase the chance of participating in future PA (Shen et al. 2007). The major motivating factors for students to perform PA were found to be mood improvement and staying in shape. A previous local study also reported motivating factors to be to stay in shape and for psychological well-being (El-Gilany & El-Masry, 2011).

Few previous studies suggested that the peer social support, helpful relationships, encouragement and educational environment promote high PA levels (Eather et al. 2011; Frank et al. 2008). In addition, our results showed the beneficial effects of PA on the students' academic achievement in a Saudi medical school. Therefore, we recommend that the medical students need to adapt a healthy PA habits, which will positively reflect on their health and academic achievement. In addition, medical schools could encourage healthy PA habits among students by including such topic in their curricula and providing necessary facilities within the schools.

Limitation of the study

The current study is cross-sectional based on a convenient sampling method and the self-reported data of PA. In addition, the results are limited to one institution and a small population sample, although, we have reached the calculated sample size. Other future studies may be needed to prove or disapprove our results.

Conclusion

The present study found positive associations between PA and academic achievement among the medical students. In addition, a negative association was found between obesity with inactivity and academic achievement. The present study results provide evidence that supports the need for establishment of educational and public health programs to promote importance of healthy PA habits for improving health and academic achievement.

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Acknowledgments

References

Abdulghani HM, Al-Drees AA, Khalil MS, Ahmad F, Ponnamperuma GG, Amin Z. 2014b. What factors determine academic achievement in high achieving undergraduate medical students? A qualitative study. Med Teach 1(Supl):S43–S48.

Abdulghani HM, AlKanhal AA, Mahmoud ES, Ponnamperuma GG, Alfaris EA. 2011. Stress and its effects on medical students: A cross-sectional study at a college of medicine in Saudi Arabia. J Health Popul Nutr 29: 516–522.

Abdulghani HM, Irshad M, Al Zunitan MA, Al Sulihem AA, Al Dehaim MA, Al Esefir WA, Al Rabiah AM, Kameshki RN, Alrowais NA, Sebiany A, et al. 2014a. Prevalence of stress in junior doctors during their internship training: A cross-sectional study of three Saudi medical colleges' hospitals. Neuropsychiatr Dis Treat 10:1879–1886.

Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, Leon AS. 2000. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 32:S498–S504.

Al-Eisa ES, Al-Sobayel HI. 2012. Physical activity and health beliefs among Saudi women. J Nutr Metab 2:642187. DOI: 10.1155/2012/642187.

Al-Hazzaa HM. 2004. Prevalence of physical inactivity in Saudi Arabia: A brief review. East Mediterr Health J 10:663–670.

Al-Nozha MM, Al-Hazzaa HM, Arafah MR. 2007. Prevalence of physical activity and inactivity among Saudis aged 30–70 years: A population-based cross-sectional study. Saudi Med J 28:559–568.

Al-Shehri FS, Moqbel MM, Al-Shahrani AM, Al-Khaldi YM, Abu-Melha WS. 2013. Management of obesity: Saudi clinical guideline. Saudi J Obes 1: 18–30.

Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. 2008. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. Cochrane Database Syst Rev 16(2):CD005381. DOI: 10.1002/14651858.

Ardoy DN, Fernandez-Rodriguez JM, Jimenez-Pavon D, Castillo R, Ruiz JR, Ortega FB. 2014. A physical education trial improves adolescents' cognitive performance and academic achievement: The EDUFIT study. Scandinavian J Med Sci Sports 24:e52–e61.

Barrigas C, Fragoso I. 2012. Obesity, academic performance and reasoning ability in Portuguese students between 6 and 12 years old. J Biosoc Sci 44:165–179.

Benjamin K, Donnelly TT. 2013. Barriers and facilitators influencing the physical activity of Arabic adults: A literature review. Avicenna 8: 1–8.

Biddle SJ, Asare M. 2011. Physical activity and mental health in children and adolescents: A review of reviews. Br J Sports Med 45: 886–895.

Booth FW, Laye MJ, Lees SJ, Rector RS, Thyfault JP. 2008. Reduced physical activity and risk of chronic disease: The biology behind the consequences. Eur J Appl Physiol 102:381–390.

Bye D, Pushkar D, Conway M. 2007. Motivation, interest, and positive affect in traditional and nontraditional undergraduate students. Adult Educ Q 57:141–158.

Chen LJ, Fox KR, Ku PW, Wang CH. 2012. A longitudinal study of childhood obesity, weight status change, and subsequent academic performance in Taiwanese children. J Sch Health 82: 424–431.

Coe DP, Pivarnik JM, Womack CJ, Reeves MJ, Malina RM. 2006. Effect of physical education and activity levels on academic achievement in children. Med Sci Sports Exerc. 38:1515–1519.

Colcombe SJ, Erickson KI, Scalf PE, Kim JS, Prakash R, McAuley E, Elavsky S, Marquez DX, Hu L, Kramer AF. 2006. Aerobic exercise training increases brain volume in aging humans. J Gerontol A Biol Scie Med Sci 61:1166–1170.

Davis CL, Tomporowski PD, McDowell JE, Austin BP, Miller PH, Yanasak NE, Allison JD, Naglieri JA. 2011. Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. Health Psychol 30:91–98.

Donnelly JE, Greene JL, Gibson CA, Sullivan DK, Hansen DM, Hillman CH, Poggio J, Mayo MS, Smith BK, Lambourne K, et al. 2013. Physical activity and academic achievement across the curriculum (A + PAAC): rationale and design of a 3-year, cluster-randomized trial. BMC Public Health 13:307.doi: 10.1186/1471-2458-13-307.

Durstine JL, Gordon B, Wang Z, Luo X. 2013. Chronic disease and the link to physical activity. J Sport Health Sci 2:3–11.

Eather N, Morgan PJ, Lubans DR. 2011. Improving health-related fitness in children?: The fit-4-fun randomized controlled trial study protocol. BMC Public Health 11(1):902. Available from: http://www.biomedcentral.com/1471-2458/11/902.

Eather N, Morgan PJ, Lubans DR. 2013. Social support from teachers mediates physical activity behavior change in children participating in the Fit-4-Fun intervention. Int J Behav Nutr Phys Act 10:1–15.

Edwards JU, Mauch L, Winkelman MR. 2011. Relationship of nutrition and physical activity behaviors and fitness measures to academic performance for sixth graders in a Midwest city school district. J Sch Health 81: 65–73.

El-Gilany AH, El-Masry R. 2011. Physical inactivity among Egyptian and Saudi medical students. TAF Prev Med Bull 10:35–44.

Erickson KI, Voss MW, Prakash RS, Basak C, Szabo A, Chaddock L, Kim JS, Heo S, Alves H, White SM, et al. 2011. Exercise training increases size of hippocampus and improves memory. Proc Natl Acad Sci 108: 3017–3022.

Frank E, Tong E, Lobelo F, Carrera J, Duperly J. 2008. Physical activity levels and counseling practices of U.S. medical students. Med Sci Sports Exerc 40:413–421.

Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. 2000. Healthy percentage body fat ranges: An approach for developing guidelines based on body mass index. Am J Clin Nutr 72: 694–701.

Heshmat R, Larijani FA, Pourabbasi A, Pourabbasi A. 2014. Do overweight students have lower academic performance than their classmates? A pilot cross sectional study in a middle school in Tehran. J Diabetes Metab Disord 13:87.

Hillman CH, Erickson KI, Kramer AF. 2008. Be smart, exercise your heart: Exercise effects on brain and cognition. Nat Rev Neurosci 9:58–65.

Hillsdon M, Thorogood MA. 1996. A systematic review of physical activity promotion strategies. Br J Sports Med 30:84–89.

Howley ET. 2001. Type of activity: Resistance, aerobic and leisure versus occupational physical activity. Med Sci Sports Exerc 33: S364–S369.

Ignarro LJ, Balestrieri ML, Napoli C. 2007. Nutrition, physical activity, and cardiovascular disease: An update. Cardio Res 73:326–340.

Kamijo K, Khan NA, Pontifex MB, Scudder MR, Drollette ES, Raine LB, Evans EM, Castelli DM, Hillman CH. 2012. The relation of adiposity to cognitive control and scholastic achievement in preadolescent children. Obesity 20:2406–2411.

Kantomaa MT, Stamatakis E, Kankaanpaa A, Kaakinen M, Rodriguez A, Taanila A, Ahonen T, Jarvelin MR, Tammelin T. 2013. Physical activity and obesity mediate the association between childhood motor function and adolescents' academic achievement. Proc Natl Acad Sci 110: 1917–1922.

Khalaf A, Ekblom O, Kowalski J, Berggren V, Westergren A, Al-Hazzaa H. 2013. Female university students' physical activity levels and associated factors-A cross-sectional study in Southwestern Saudi Arabia. Int J Environ Res Public Health 10:3502–3517.

Konen JC, Fromm BS. 1992. Changes in personal health behaviors of medical students. Med Teach 14:321–325.

LeBlanc MM, Martin CK, Han H, Newton Jr R, Sothern M, Webber LS, Davis AB, Williamson DA. 2012. Adiposity and physical activity are not related to academic achievement in school-aged children. J Dev Behav Pediatr 33:486–494.

Lees C, Hopkins J. 2013. Effect of aerobic exercise on cognition, academic achievement, and psychosocial function in children: A systematic review of randomized control trials. Prev Chronic Dis 10: 1–13.

London RA, Castrechini S. 2011. A longitudinal examination of the link between youth physical fitness and academic achievement. J Sch Health 81:400–408.

Molteni R, Wu A, Vaynman S, Ying Z, Barnard RJ, Gómez-Pinilla F. 2004. Exercise reverses the harmful effects of consumption of a high-fat diet on synaptic and behavioral plasticity associated to the action of brain-derived neurotrophic factor. Neuroscience 123: 429–440.

Rao CR, Darshan BB, Das N, Rajan V, Bhogun M, Gupta A. 2012. Practice of physical activity among future doctors: A cross sectional analysis. Int J Prev Med 3:365–369.

Reed JA, Einstein G, Hahn E, Hooker SP, Gross VP, Kravitz J. 2010. Examining the impact of integrating physical activity on fluid intelligence and academic performance in an elementary school setting: A preliminary investigation. J Phys Act Health 7: 343–351.

Sallis JF. 2010. We do not have to sacrifice children's health to achieve academic goals. J Pediatr 156:711–718.

Shen B, McCaughtry N, Martin J. 2007. The influence of self-determination in physical education on leisure-time physical activity behavior. Res Q Exerc Sport 78:328–338.

Siervo M, Nasti G, Stephan BC, Papa A, Muscariello E, Wells JC, Prado CM, Colantuoni A. 2012. Effects of intentional weight loss on physical and cognitive function in middle-aged and older obese participants: A pilot study. J Am Coll Nutr 31:79–86.

Stanford FC, Durkin MW, Blair SN, Powell CK, Poston MB, Stallworth JR. 2012. Determining levels of physical activity in attending physicians, resident and fellow physicians and medical students in the USA. Br J Sports Med 46(5):360–364.

Taha AZ. 2008. Self-reported knowledge and pattern of physical activity among school students in Al Khobar, Saudi Arabia. East Mediterr Health J 14:344–355.

Tammelin T, Nayha S, Hills AP, Jarvelin MR. 2003. Adolescent participation in sports and adult physical activity. Am J Prev Med 24:22–28.

Tozuka Y, Kumon M, Wada E, Onodera M, Mochizuki H, Wada K. 2010. Maternal obesity impairs hippocampal BDNF production and spatial learning performance in young mouse offspring. Neurochem Int 57: 235–247.

Warren JM, Ekelund U, Besson H, Mezzani A, Geladas N, Vanhees L. 2010. Experts panel. Assessment of physical activity — A review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European association of cardiovascular prevention and rehabilitation. Eur J Cardiovasc Prev Rehabil 17:127–139.

WHO. 2011. Global recommendations on physical activity for health. Available from: http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/index.html.