









ORIGINAL

Relationship between Cardio-respiratory Capacity and Academic Performance among Medical Female Ex-Students: Body Mass Index Effect

Relación entre la Capacidad Cardiorrespiratoria y el Rendimiento Académico entre Ex-Alumnas de Medicina: Efecto del Índice de Masa Corporal

Samah A. Moawd^{1,2}  , Elsayeda Hamdy Nasr Abdelhalim^{3,4} , M.A. Abdelaziz^{5,6} , Amira Farghaly^{5,7} , Ateya Megahed Ibrahim^{8,9} 

¹Associate Professor, Department of Health and Rehabilitation Sciences, College of Applied Medical Sciences in Alkharje, Prince Sattam bin Abdulaziz University. Alkharj 11942, Saudi Arabia.

²Professor, Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University. Giza, Egypt.

³Associate Professor, College of Nursing, Prince Sattam Bin Abdulaziz University. Alkharj 11942, Saudi Arabia.

⁴Assistant Professor, Department of Maternity, Obstetric and Gynecological Nursing, Faculty of Nursing, Port Said University. Port Said 42526, Egypt.

⁵Basic Medical Sciences Department, College of Medicine, Prince Sattam Bin Abdulaziz University. Alkharj 11942, Kingdom of Saudi Arabia.

⁶Department of Medical Physiology, College of Medicine, Al-Azhar University. Cairo, Egypt.

⁷Medical Education Department, Faculty of Medicine, Suez Canal University. Ismailia, Egypt.

⁸Associate professor, Administration and Nursing Education Department, College of Nursing, Prince Sattam Bin Abdulaziz University, Al-Kharjj, Saudi Arabia.

⁹Assistant Professor, Family and Community Health Nursing Department, Faculty of Nursing, Port Said University, Port Said, Egypt.

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Corresponding author: Samah A. Moawd 

ABSTRACT

Introduction: this study examined the effects of Body Mass Index (BMI) on Cardiorespiratory Capacity (CRC) and explored the relationship between CRC and Academic Performance (AP) among female medical ex-students at Prince Sattam bin Abdul Aziz University (PSAU). Understanding these associations could highlight the role of physical fitness in academic success.

Methods: a sample of 150 female ex-students, aged $23,3 \pm 0,6$ years, was categorized into normal weight (BMI $18,5-24,9$ kg/m²) and overweight (BMI $25-29,9$ kg/m²) groups. BMI was calculated to determine weight status, CRC was assessed using the 20-m shuttle run test (VO₂max), and AP was evaluated through academic grades (AG) and academic abilities (AA) using the Spanish Test of Educational Abilities. Statistical analyses included independent t-tests and Pearson's correlation.

Results: normal-weight participants demonstrated significantly higher CRC (VO₂max = $55,3 \pm 4,9$ mL.kg⁻¹.min⁻¹) than overweight participants ($50,8 \pm 4,2$ mL.kg⁻¹.min⁻¹, $p=0,03$). Additionally, normal-weight participants scored higher in both AA ($58,82 \pm 9,7$ vs. $59,64 \pm 10,04$, $p=0,04$) and AG ($3,4 \pm 0,6$ vs. $3,7 \pm 0,5$, $p=0,032$). BMI negatively correlated with CRC ($r = -0,20$, $p=0,024$), while CRC positively correlated with AA ($r = 0,18$, $p=0,015$) and AG ($r = 0,24$, $p=0,043$).

Conclusions: higher CRC was associated with better academic performance, while increased BMI correlated with lower CRC. The findings suggest that promoting physical fitness may be beneficial for academic success among female medical students at PSAU.

Keywords: Cardiorespiratory Capacity; Academic Performance; Body Mass Index; Medical Students; Physical Activity; Weight Status.

RESUMEN

Introducción: el estudio examinó el efecto del Índice de Masa Corporal (IMC) sobre la Capacidad Cardiorrespiratoria (CCR) y exploró la relación entre la CCR y el Rendimiento Académico (RA) en exalumnas de medicina de la Universidad Prince Sattam bin Abdul Aziz (PSAU). Este análisis busca resaltar el rol del estado físico en el éxito académico.

Métodos: se evaluaron 150 exalumnas (edad media de $23,3 \pm 0,6$ años), categorizadas en dos grupos: peso normal (IMC $18,5-24,9 \text{ kg/m}^2$) y sobrepeso (IMC $25-29,9 \text{ kg/m}^2$). El IMC determinó el estado de peso; la CCR fue medida mediante la prueba de 20 metros (VO₂max), y el RA fue evaluado a través de calificaciones académicas (CA) y habilidades académicas (HA) usando el Test Español de Habilidades Educativas. Se emplearon pruebas t de muestras independientes y coeficientes de correlación de Pearson.

Resultados: las participantes con peso normal presentaron una CCR significativamente mayor (VO₂max = $55,3 \pm 4,9 \text{ mL.kg}^{-1}.\text{min}^{-1}$) que las de sobrepeso ($50,8 \pm 4,2 \text{ mL.kg}^{-1}.\text{min}^{-1}$, $p=0,03$). Además, el grupo de peso normal obtuvo puntajes más altos en HA ($58,82 \pm 9,7$ vs. $59,64 \pm 10,04$, $p=0,04$) y CA ($3,4 \pm 0,6$ vs. $3,7 \pm 0,5$, $p=0,032$). Se observó una correlación negativa entre IMC y CCR ($r = -0,20$, $p=0,024$), y una correlación positiva entre CCR y HA ($r = 0,18$, $p=0,015$) y CA ($r = 0,24$, $p=0,043$).

Conclusiones: la mayor CCR se asoció con mejor rendimiento académico, mientras que el incremento en IMC se correlacionó con menor CCR. Estos hallazgos sugieren que promover el estado físico puede ser beneficioso para el éxito académico de las estudiantes de medicina en PSAU.

Palabras clave: Capacidad Cardiorrespiratoria; Rendimiento Académico; Índice de Masa Corporal; Estudiantes de Medicina; Actividad Física; Estado de Peso.

INTRODUCTION

Cardio-respiratory Capacity (CRC) is related to health outcome, its relationship with Academic Performance (AP) is of great interest. Many factors affect AP such as; fitness, socio-economic condition, prompting, intelligence and sleep pattern.^(1,2) Previous studies stated that there was positive correlation between CRC and AP in children and young teenagers.^(3,4) In university students, there is a decrease in physical activity (PA), this is the main reason for increase in body weight. Moreover, cognitive function is strongly related to CRC, increase CRC leads to improved cognitive function and memory hence, enhancing AP.⁽⁵⁾

Performance in academic life is how to achieve educational goal through attaining the academic abilities (AA) and academic grades (AG). Universities and colleges are very important fields to examine health related conditions to meet the demand of future profession and lifestyle for each student.⁽⁶⁾ There is a close relationship between cardiorespiratory fitness (CRF) and Body Mass Index (BMI). The CRF is presumably regarded as an important element of physical fitness and it is described as the body's ability to perform actively, it involves the exercise of large muscles for a longer period of time with an intensity ranging from moderate to high.^(6,7)

The students from medical college during their transition from adolescence to adulthood experience and unhealthy lifestyle probably because of little or no parental supervision, unhealthy diet habits or routine, no physical activities, less sleep and study related stress.^(8,9) It has been evidently reported that high levels of BMI increase the chances of cardio metabolic disorders which further decreases life expectancy and other types of cancers.

On the other hand, low levels of BMI also bring along a number of other disorders, particularly in females it increases the risk of periodic irregularities, weak immunization and osteoporosis.^(10,11,12) A noticeable rate of obesity in female students are partially because of having a sedentary lifestyle, the socio-economic shift, too much use of screen, unhealthy eating patterns, sleep deprivation and lack of physical activities. Moreover, the shift from adolescence to adulthood, college to university also adds to weight change and a decrease in fitness in terms of cardiovascular and muscular fitness probably because of having an unhealthy lifestyle pattern which leads to negative health outcomes.⁽⁹⁾ In comparison to obesity, the CRF impact on human health has not been taken into consideration although it is one of the most significant determinant of health condition. The term CRF means the capability of the circulatory system to supply oxygen to the muscles during physical activity.

The level of CRF can be measured during different modes of exercises such as exercise on treadmill, step test or cycle ergometer.^(13,14) James and Thomas⁽¹⁵⁾ in their article stated that physical education programmes are designed to involve students physically and at the same time also teaches them fitness as a lifetime activity as it is connected to long-term health benefits. Mo-Suwan et al.⁽¹⁶⁾ in their investigation found out that as much as the BMI level is high or low the GPA of the student is affected. Moreover, they found that high levels of BMI were connected to great risk of scoring a low GPA.

Weight status in students is associated with many factors as fast-food intake and sedentary lifestyle.

Too much intake of fast-food is associated with increase in body weight, that has a negative effect on AP. Additionally, sedentary lifestyle is common in academic life among university students and females were more likely to exhibit a reduced physical activity level, this will be affecting weight status and CRC. ^(17,18) Over weight students feel more strained than normal weight ones, i.e., they are more likely to have low self-esteem, particularly females. ⁽¹⁹⁾ Many other factors affect the academic performance level such as; psychological state and family. Consequently, healthy lifestyle may play important role to enhance AP. ^(20,21)

Medical colleges have a number of courses with a lot of practical application that is required in these courses which takes a long time as compared to non-medical colleges. ⁽²²⁾ Education in medical colleges is more challenging, this is because miscellaneous academic and clinical skills are required in addition to interpersonal skills. Recently students' behaviour in daily life has changed with the development of technology, they have become less active because of too much use of electronic devices for collecting data. ⁽²³⁾

Previous researches reported a positive correlation between physical fitness and AP in school children ⁽²⁴⁾ and adolescents. ⁽²⁵⁾ This correlation seems to be highest in late middle to early high school. ^(26,27) While other studies did not find significant correlation between fitness score and overall AP. ⁽²⁸⁾ Moawd et al. ⁽²⁹⁾ stated that CRC intervenes the correlation between PA and AP in moderate to high activity level and concluded that PA is an important requirement in academic life to achieve better CRC as well as to maintain healthy academic life and meet the future career requirements. Moreover, findings from Santana et al. ⁽³⁰⁾ showed a positive association between CRC and AP, while further comprehending of the relationship of these key factors and its potential impact on AP is needed.

There is lack of researches that describe the relation of in university students especially in medical colleges, so this study is conducted to determine whether there is a correlation between physical fitness, CRC and AP. In addition to this, understanding of this relationship in medical female ex-students and the effect of weight status is also necessary.

Based on previous knowledge, the study hypothesized that weight status affects CRC which in turn affects AP. This study aims to investigate the effect of body mass index (BMI) on cardiorespiratory capacity (CRC) and the relationship between CRC and academic performance (AP) in medical female ex-students. The findings may assist medical college administrators in developing physical programs that help students maintain a healthy BMI, ultimately leading to improved academic performance.

METHODS

Study Design and Sample

The data of this study was obtained in January 2024 from the ex-students of medical college of Prince Sattam bin Abdulaziz University (PSAU), Saudi Arabia. All of the recruited participants were met the inclusion criteria: born in 1995-1996 and finished their final academic year without any fail or withdrawn, as well as free from any chronic disease. A total of one hundred and eighty five female ex-students were voluntarily engaged in the study, aged $23,3 \pm 0,6$. A written informed consent was taken from students before beginning the study. Volunteers female ex-students were divided according to body mass index (BMI) into two groups; normal weight group (BMI from 18,5-24,9 kg/m²), (NW group; n=85); and overweight group (BMI from 25 to 29,9 kg/m²), (OW group; n=80).

Sample Size

A proper sample size was detected using G-power software (version 3.1.9.2; Dusseldorf, Germany) earlier for data collection. In independent t-test samples, a group-sample of 50 students was required (i.e., a total sample of 150 subjects) to achieve 90% power to detect differences between the means against the alternative of equivalent means using an F test with an alpha level of .05. Based on findings from a pilot study, the size of variation in the means was represented by their Standard Deviation (SD) which was 3.8. The common SD within a group was assumed to be 4,22. We recruited up to 180 subjects expecting that 20% of the student's will be lost.

Outcome measures

A valid data for BMI, CRC, AA, and AG were included in the analysis. Measuring height by standing on a stadiometer (Seca, Hamburg, Germany) facing their back without shoes to nearest 0,5 cm and weight was measured on balance wearing light clothes using an electronic scale (BWB-800; Tanita, Tokyo, Japan) to nearest 0,1kg. BMI calculation by dividing weight (kg) by height (m) square. ⁽³²⁾

Cardio-Respiratory Capacity

The Andersen intermittent shuttle-run test was used to assess CRC by determining the maximal oxygen uptake (VO₂max) which is 10 minutes with a time for running that is 5 minutes. The test was done by running between two parallel lines 20 m apart in time to record beeps. The participants should touch the ground by one

hand and turn and run back. Beginning with slow speed then increase the speed gradually by closing the beeps to 15 seconds and 15 minutes' rest. The test outcome focused on covering the most distance, then calculate maximal oxygen uptake ($VO_{2max} = 18,38 + (0,03301 * \text{distance}) - (5,92 * \text{sex})$ (girls=1) ($r=0,84$). Validity and reliability of this Andersen test were $r=0,64$ and $r=0,84$, respectively.⁽²⁶⁾

Academic Performance

Two components were assessed, AG: final cumulative total of the academic years from (0-5) and AA: verbal ability, numeric ability and reasoning ability, scores of these abilities were taken for every ability, and then calculate overall ability (range, 0-110) by summing the scores of the three abilities using Test of Educational Abilities (Spanish version of the Science Research Associates).⁽³³⁾

Statistical Analysis

Statistical tests were conducted through the windows package of SPSS software, version 24 (SPSS Inc, Chicago, IL), $P < .05$ was the accepted significance level. The Kolmogorov-Smirnov test was used to approve data normality. Descriptive statistic was performed using means \pm standard deviation to assess the sample based on their CRC and AP. Two-tailed independent samples t-test was performed to determine the differences between normal and overweight students in their measures including age, weight, height, BMI, VO_{2max} , and AG & AA. The Pearson's correlation coefficient was performed to assess the strength and direction of the relationship between the CRC and AP.

RESULTS

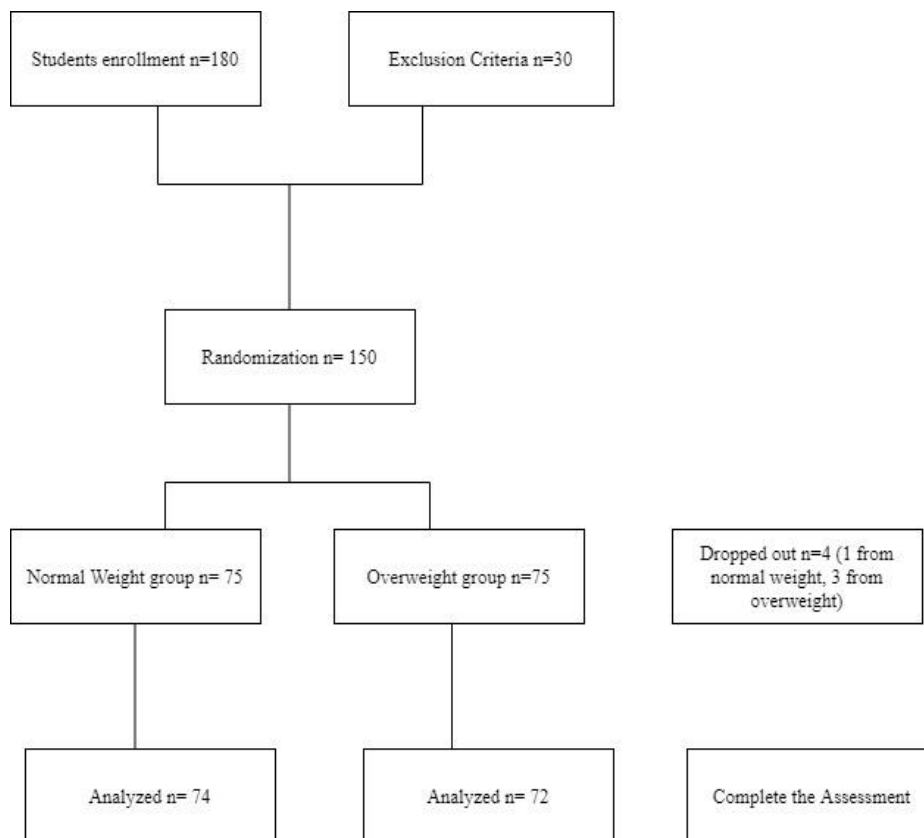


Figure 1. Flow diagram of the study

As presented in Figure 1, the flow diagram of patients is presented. Out of 180 universities female medical ex-students, 30 did not meet the inclusion criteria. 150 students were randomized into normal weight students (75) and overweight students (75) groups, Then, 74 students from the normal weight group and 72 students from the overweight group completed the study and their results were analysed after assessment method.

Demographic data are described in table 1. Show no significant different between normal and overweight students in age, height ($p > 0,05$) while significant difference in weight, BMI, and CRC ($p < 0,05$). Also, academic performance variables including AA and AG had significant differences between normal and overweight students ($p < 0,05$).

Variables	Normal weight (n=74)	Over weight (n=72)	p-value
Age, years	23,6 ±0,33	23,1 ±0,9	0,41
Weight, Kg	54,49 ±3,6	65,97 ±2,1	0,03
Height, cm	161,4 ±1,8	160,1 ± 1,3	0,52
Body mass index kg/m ²	22,92 ±1,6	27,74 ±1,9	0,02*
VO ₂ max, mL.kg-1.min-1	55,3 ±4,9	50,8 ±4,2	0,03*
Academic Abilities (AA)	58,82 ±9,7	59,64 ±10,04	0,04*
Academic Grades (AG)	3,4 ±0,6	3,7 ±0,5	0,032*

Note: BMI, Body Mass Index; CRC, Cardiorespiratory Capacity evaluated by estimated VO₂max; AA, Academic Abilities; AG, Academic Grades. *Significant difference.

Variable	Correlation coefficient	p-value
BMI	-0,20	0,024*
AA	0,18	0,015*
AG	0,24	0,043*

Note: BMI, Body Mass Index; AA, Academic Abilities; AG, Academic Grades. *Significant difference.

Table 2 shows the correlation between CRC and BMI, AG, and AA. A significant correlation was observed between CRC and all other variables (BMI and AP) ($p < 0,05$). Negative correlation between CRC and BMI, while positive correlation between CRC and AP (AG and AA).

DISCUSSION

The results of the present study support the hypothesis that weight status affects CRC which in turn affects AP in medical female ex-students. Previous literature proved that CRC has an influence on AP that is intervened by weight status, these findings suggested that students with higher BMI have lower CRC therefore, lesser AP over time.^(31,32) In addition, it was suggested that there are hurdles to AP that occur between youth with high BMI, and those are moving away from about the normal weight.

Aerobic fitness is positively associated with both inhibitory control and math performance in adolescents, an increase in weight has opposite correlation with inhibitory control in youth. Therefore, the improvements in CRC are associated with BMI reduction along with better AP. The study concludes an inverse relationship between CRC and BMI and direct relationship between CRC and AP (AA and AG). In contrast⁽³³⁾ found no significant association between BMI and performance in school among primary school students. In addition, mental function and self-esteem did not affect the relationship between BMI and performance in school.

Previous studies have documented that high BMI worsen academic performance in students may be due to psychological maladjustment, teasing and feeling of social rejection.⁽³⁴⁾ Furthermore, it was speculated that improved aerobic fitness and metabolic adaptations by controlling weight status could enhance cognitive function and self-esteem, thereby performance in academic life⁽³⁵⁾ These results could support the outcomes of the present study and support the importance of modifying lifestyle in university students for better AP and future career.

A study by Kantomaa et al.⁽³⁶⁾ documented that high AP was related to PA, while low AP was related to obesity. Besides, childhood motor function affected the AP negatively in adolescents due to physical inactivity, and so childhood motor function and adolescents' AP were related to physical activity and obesity. Also, a systematic review presented by Donnelly et al.⁽³⁷⁾ suggested a positive correlation between PA, CRC, cognitive function, and AP, they concluded that PA positively affect cognition other than brain construction and function, however, no data regulate the mechanisms and long-term effect.

The results of the current study showed a positive association between CRC and AP, while further comprehending of the relationship of these key factors and its potential impact on AP is needed. Furthermore, Beltran-Valls et al.⁽²³⁾ investigated the intervention consequence of weight status on the relationship between CRC and AP in adolescents, opposite correlation between CRC and weight status was detected, which may affect AG and reasoning ability Cognitive function affects memory functioning, attention, planning and behaviour. CRC and motor skills may be inversely related to cognitive function and AP among children. Cognitive performance and physical fitness are greatly related to each other. Also, PA has an important role on cognitive and brain function due to a flow of neurological changes that affect the memory and skills.⁽³⁸⁾ Likewise, a review about CRC and motor skills with regard to cognitive function and AP in Children suggested that high CRC and motor skills may enhance cognitive function and AP but these suggestions depend principally on cross-sectional studies.⁽³⁸⁾ Moreover, the association between weight status and cognitive function and AP in children was investigated and

the results stated that higher BMI and greater adiposity were associated with lesser cognitive function, along with poorer AP. In contrast, Ruiz et al.⁽³⁹⁾ concluded that PA improves cognitive performance with no regard to CRC and BMI, they noticed that cognitive function was similar across CRC and muscular strength and body weight categories.

Study Limitations and Implications

The limitation of this study was not comparing different gender to show the difference between them in fitness and AP. A lack of data testing the AP after routine PA in university students or alumni of medical colleges was experienced. The findings of the study may have significant implications on AP that is importance to students, families, and society due to its connection with future career especially medical students and their employability and health. Data of the present study reveals that lifestyles modification and regular PA are of great concern and will help students, to successfully assist in the development of their society. Finally, developing educational programs for health promotion in academic life including regular physical activity are of great concern.

CONCLUSION

The BMI affects the CRC and there is a positive relation between CRC and AP noted in medical collage female ex-students. The findings showed a significant difference between normal and overweight groups regarding CRC, AA, and AG. Also, there were a negative correlation between CRC and BMI, however the correlation between CRC and AP (AA and AG) were positive. Thus, the data presented in this study highlights that enhancements in CRC can be seen by controlling weight status during academic life, which further leads to improved academic performance. Future direction regarding the comparison between medical with non-medical students, alumni and further investigation should be done by taking large sample data.

RECOMMENDATION

Based on the findings of this study, it is recommended that universities implement comprehensive physical activity programs and educational initiatives aimed at improving cardiorespiratory capacity (CRC) and managing body mass index (BMI) among students. Given the significant correlation between CRC and academic performance (AP), promoting regular exercise and healthy weight management can enhance both physical fitness and academic outcomes. Additionally, institutions should consider regular health screenings and provide support services to assist students in maintaining a healthy lifestyle. Future research should explore the effects of these interventions across diverse student populations to further understand their impact on long-term academic and health outcomes.

REFERENCES

1. de Abreu, Raphael Martins et al. "On the significance of estimating cardiorespiratory coupling strength in sports medicine." *Frontiers in network physiology* vol. 2 1114733. 4 Jan. 2023, <https://doi.org/10.3389/fnetp.2022.1114733>
2. Wshah, Adnan et al. "Factors related to the implementation of pulmonary rehabilitation in Jordan: Perspective of healthcare professionals." *Respiratory medicine* vol. 231 (2024): 107728. <https://doi.org/10.1016/j.rmed.2024.107728>
3. Páez-Maldonado, José A., et al. "Physical fitness, selective attention and academic performance in a pre-adolescent sample." *International journal of environmental research and public health* 17.17 (2020): 6216. <https://doi.org/10.3390/ijerph17176216>
4. de Almeida Fragoso, Miguel Pedro Fernandes. *Health-Related Cardiorespiratory Fitness in the School Context*. Diss. Universidade de Lisboa (Portugal), 2021.
5. Edelmann, Dennis, et al. "Physical activity and sedentary behavior in university students-the role of gender, age, field of study, targeted degree, and study semester." *Frontiers in public health* 10 (2022): 821703. <https://doi.org/10.3389/fpubh.2022.821703>
6. Singh, Ekamdeep, Prihana Vasishta, and Anju Singla. "AI-enhanced education: exploring the impact of AI literacy on generation Z's academic performance in Northern India." *Quality Assurance in Education* (2024). <https://doi.org/10.1108/QAE-02-2024-0037>
7. Singh, Hardeep, et al. "Relationship between body mass index and cardiorespiratory fitness to interpret

health risks among sedentary university students from Northern India: A correlation study.” *Clinical Epidemiology and Global Health* 20 (2023): 101254. □ <https://doi.org/10.1016/j.cegh.2023.101254>

8. Cena, Hellas, et al. “How healthy are health-related behaviors in university students: The HOLISTic study.” *Nutrients* 13.2 (2021): 675. □ <https://doi.org/10.3390/nu13020675>

9. Al-Qahtani, Awad Mohammed. “Lifestyle habits among Najran University students, Najran, Saudi Arabia.” *Frontiers in Public Health* 10 (2022): 938062. □ <https://doi.org/10.3389/fpubh.2022.938062>

10. Singh, Hari. *Public Health: A Global Perspective*. CRC Press, 2024. □

11. Cash, Jill C., ed. *Family practice guidelines*. Springer Publishing Company, 2023. □

12. Song, Y., & Li, R. (2021). Effects of environment and lifestyle factors on anovulatory disorder. *Environment and Female Reproductive Health*, 113-136. □

13. Nguyen, Vienna. Exercise testing in preventative health populations: predictors of achieving maximal exercise capacity. Diss. University of British Columbia, 2024. □ https://link.springer.com/chapter/10.1007/978-981-33-4187-6_5

14. James F., and Thomas L. McKenzie. “Physical education’s role in public health.” *Research quarterly for exercise and sport* (1991): 62, no. 2 124-137. <https://doi.org/10.1080/02701367.1991.10608701>

15. Mo-suwan, Ladda, Louis Lebel, Areeruk Puetpaiboon, and Chaon Junjana. “School performance and weight status of children and young adolescents in a transitional society in Thailand.” *International Journal of Obesity* (1999): 23, no. 3 272-277. <https://doi.org/10.1038/sj.ijo.0800808>

16. Benaich, Souad, et al. “Weight status, dietary habits, physical activity, screen time and sleep duration among university students.” *Nutrition and Health* 27.1 (2021): 69-78. □ <https://doi.org/10.1177/02601060209608>

17. Sajjad, Maryam, et al. “Using the theory of planned behavior to predict factors influencing fast-food consumption among college students.” *BMC Public Health* 23.1 (2023): 987. □ <https://doi.org/10.1186/s12889-023-15923-1>

18. Eriksson, Anna, and Paul Horton. “‘How can you be friends with that fatty?’: The othered body in narratives on weight-based bullying.” *Children & Society* (2024). □ <https://doi.org/10.1111/chso.12900>

19. Tafuri, Francesco, et al. “Physically Active Lifestyles within the School context: Morpho-Physiological and Functional Aspects.” (2024). □ <https://doi.org/10.47197/retos.v58.106154>

20. Tran, Thao Vi, et al. “Academic stress among students in Vietnam: a three-year longitudinal study on the impact of family, lifestyle, and academic factors.” *Journal of Rural Medicine* 19.4 (2024): 279-290. □ <https://doi.org/10.2185/jrm.2024-012>

21. Ghosh, Kanjaksha. “Undergraduate medical education in India: need for total modification.” *Journal of Hematology and Allied Sciences* 2.3 (2022): 62-70. □ https://doi.org/10.25259/JHAS_28_2022

22. Beltran-Valls, M.R.; Adelantado-Renau, M.; Castro-Piñero, J.; Sánchez-López, M.; Moliner-Urdiales, D. Cardiorespiratory fitness and academic performance association is mediated by weight status in adolescents: DADOS study. *Eur. J. Pediatr.* 2018, 177, 1037-1043. <https://doi.org/10.1007/s00431-018-3159-1>

23. Van Dusen DP, Kelder SH, Kohl HW, Ranjit N, Perry CL. Associations of Physical Fitness and Academic Performance Among Schoolchildren. *Journal of School Health*. 2011;81(12):733-40. <https://doi.org/10.1111/j.1746-1561.2011.00652.x>

24. Santana, CC D. A., et al. “Physical fitness and academic performance in youth: A systematic review.” *Scandinavian journal of medicine & science in sports* 27.6 (2017): 579-603. <https://doi.org/10.1111/sms.12773>

25. Zhai, Xiangyu, et al. “The relationship between physical fitness and academic performance among

Chinese college students.” *Journal of American College Health* 70.2 (2022): 395-403. □, <https://doi.org/10.1080/07448481.2020.1751643>

26. Arabmokhtari R, Khazani A, Bayati M, Barmaki S and Fallah E. Relationship between Body Composition and Cardiorespiratory Fitness in Students at Postgraduate Level. *Zahedan J Res Med Sci.* 2018 ;20(2): e12109. <https://doi.org/10.5812/zjrms.12109>

27. Kyan, Akira, Minoru Takakura, and Masaya Miyagi. “Does physical fitness affect academic achievement among Japanese adolescents? A hybrid approach for decomposing within-person and between-persons effects.” *International journal of environmental research and public health* 15.9 (2018): 1901. □ <https://doi.org/10.3390/ijerph15091901>

28. Moawd S A, Elsayed S H, Abdelbasset W K, Nambi G, Verma A. Impact of different physical activity levels on academic performance of PSAU medical female students. *Arch Pharma Pract* 2020;11(1):100-4

29. Kalka E, Pastuszak A, Buśko K. Secular trends in body height, body weight, BMI and fat percentage in Polish university students in a period of 50 years. *PLoS One.* 2019 Aug 1;14(8):e0220514. <https://doi.org/10.1371/journal.pone.0220514>

30. Thurstone, L. L., and Th G. Thurstone. “TEA, test de aptitudes escolares.” Madrid: TEA Ediciones (2012). □

31. Suchert V, Hanewinkel R, Isensee B. Longitudinal relationships of fitness, physical activity, and weight status with academic achievement in adolescents. *J Sch Health*, 2016;86(10):734-741. <https://doi.org/10.1111/josh.12424>

32. Hsieh PL, Chen ML, Huang CM, Chen WC, Li CH, Chang LC. Physical activity, body mass index, and cardiorespiratory fitness among school children in Taiwan: a cross-sectional study. *Int J Environ Res Public Health.* 2014; 11:7275-85. <https://doi.org/10.3390/ijerph110707275>

33. Mennes J. The Mediating and Moderating Role of Mental Well-being and Self-esteem in the Relationship between BMI and School Performance in Primary School Children in groups 6, 7 and 8 in Suriname. Master Onderwijswetenschappen Open Universiteit Datum: 20-03-2020 Begeleiding: Dr. I van der Wurff

34. Gunnarsdottir, Thrudur, et al. “Teasing and social rejection among obese children enrolling in family-based behavioural treatment: effects on psychological adjustment and academic competencies.” *International Journal of Obesity* 36.1 (2012): 35-44.. <https://doi.org/10.1038/ijo.2011.181>

35. Miller, Alison L., Hannah J. Lee, and Julie C. Lumeng. “Obesity-associated biomarkers and executive function in children.” *Pediatric research* 77.1 (2015): 143-147. □

36. Kantomaa MT, Stamatakis E, Kankaanpää A, Kaakinen M, Rodriguez A, Taanila A, Ahonen T, Järvelin MR, Tammelin T. Physical activity and obesity mediate the association between childhood motor function and adolescents’ academic achievement. *ProcNatlAcadSci USA.* 2013; 110(5):1917-22 <https://doi.org/10.1073/pnas.1214574110>

37. Donnelly, Joseph E., et al. “Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review.” *Medicine and science in sports and exercise* 48.6 (2016): 1197. □ <https://doi.org/10.1249/MSS.0000000000000901>

38. Kamijo K, Khan NA, Pontifex MB, Scudder MR, Drollette ES, Raine LB, Evans EM, Castelli DM, Hillman CH. The relation of adiposity to cognitive control and scholastic achievement in preadolescent children. *Obesity.* 2012a;20(12):2406-2411. <https://doi.org/10.1038/oby.2012.112>

39. Ruiz JR, Ortega FB, Castillo R, Martín-Matillas M, Kwak L, Vicente-Rodríguez G, et al. Physical activity, fitness, weight status, and cognitive performance in adolescents. *The Journal of Pediatrics.* 2010; 157(6): 917-22 <https://doi.org/10.1016/j.jpeds.2010.06.026>

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CONFLICT OF INTEREST

Authors declare that no conflicts of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: Samah A. Moawd, Elsayeda Hamdy Nasr Abdelhalim, M.A. Abdelaziz.

Data curation: Amira Farghaly, Ateya Megahed Ibrahim.

Formal analysis: Samah A. Moawd, M.A. Abdelaziz.

Research: Elsayeda Hamdy Nasr Abdelhalim, Amira Farghaly.

Methodology: Samah A. Moawd, Elsayeda Hamdy Nasr Abdelhalim.

Project management: Samah A. Moawd, Elsayeda Hamdy Nasr Abdelhalim, M.A. Abdelaziz, Amira Farghaly, Ateya Megahed Ibrahim.

Resources: Amira Farghaly, Ateya Megahed Ibrahim.

Software: M.A. Abdelaziz.

Supervision: Samah A. Moawd.

Validation: Elsayeda Hamdy Nasr Abdelhalim, M.A. Abdelaziz.

Display: Ateya Megahed Ibrahim.

Drafting - original draft: Samah A. Moawd, Elsayeda Hamdy Nasr Abdelhalim, Amira Farghaly.