

Cardiovascular response of students to physical exertion using the 'Trunk Flexion Test'

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Abstract

Background and Study Aim Multiple factors affect the health condition of students. In this regard, a key preventative measure is observing the students' level of physical preparedness. The aim of the study is to assess the cardiovascular system response of students to physical exercise using the 'Trunk Flexion Test'.

Material and Methods This study included 77 students from the physical education faculties of three universities in Ukraine, comprising 34 males and 43 females. The cardiovascular system's response was gauged using the 'Trunk Forward Flexion Test'. Data on participants were compiled through Google Form. Statistical evaluation was conducted using PyCharm CE and Python programming libraries. ANOVA was utilized to determine the differences in cardiovascular responses among students, and Pearson's correlation coefficient explored the relationship between body mass index and cardiovascular function.

Results Research findings show gender-based disparities in cardiovascular system responses (CVSR). Women outperformed men in achieving 'Excellent' ratings. Women also led in 'Good' and 'Average' evaluations, while men were more likely to be in 'Undesirable' and 'Hazardous' categories. Differences were noted in body mass index. The proportion of students with normal weight differed by university. The prevalence of overweight varied among universities. The occurrence of 'Underweight' and 'Obese' also varied by university. An elevation in body mass index was correlated with a decline in CVSR in men.

Conclusions Variations in CVSR highlight the importance of implementing wellness initiatives and encouraging students to enhance their physical activity levels.

Keywords: health, quality life, monitoring, exercise stress, body mass index

Introduction

In areas impacted by armed conflicts, pervasive stress and adversities influence both students' mental health and their physical welfare and abilities. College students confront extra hurdles that may impact their physical readiness and proficiency in executing certain physical tasks. The onset of the COVID-19 pandemic in 2020 brought about unparalleled limitations in everyday life, markedly influencing their physical engagement and general health [1, 2, 3].

The pandemic's influence was notably harsh in sectors that require extensive physical activity, such as physical education. Moving to online teaching platforms was vital for maintaining health and safety. However, this move inadvertently caused a decline in the practical training quality needed by these students [4, 5, 6], subsequently lowering the physical readiness of university students,

particularly those training to be physical education instructors [7, 8].

The outbreak of war in the students' residential regions intensified these challenges. The war disrupted their regular physical schedules and significantly transformed their educational settings, vocational training, and led to a decline in physical activity [9, 10, 11, 12]. This era of hardship emphasized the urgent necessity to monitor the students' physical well-being.

Apart from the difficulties associated with military conflicts, the COVID-19 pandemic and the move to virtual learning further aggravated the physical health situation of students [13, 14]. The pandemic reduced opportunities for physical activities and interactions, and online learning limited the practical elements of physical training. These shifts created a demand for various assessments to evaluate students' physical health. The most straightforward tests for monitoring the evaluation of the cardiovascular system responses (CVSR) under physical load. The 'Trunk Flexion

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Test' is notable for its ease of use and efficiency in measuring key physical metrics [15, 16, 17, 18, 19]. Researchers evaluate the test's effects from different angles. González-Carbonell et al. [20] propose assessing outcomes using a bending-stretching ratio index. Mitsuda et al. [21] examine how bending influences spinal flexibility in healthy college students. Another study discovered notable enhancements in trunk bending with the application of vibration techniques [17]. In Colloca and Hinrichs' overview [16], they emphasize that tests for spinal bending and relaxation are crucial objective tools in clinical practice for patient diagnosis and therapy. Research involving 18 female students from 18 to 26 years old advised concentrating on personal initial flexibility [15], with the author advocating that this tactic significantly improves the students' flexibility.

These researches highlight the importance of routine physical assessments of students in conflict areas to fully grasp the impact of such a stressful setting on their physical health. The 'Trunk Flexion Test' acts as an easy-to-use measure to gauge the effects of stressors from the environment on students' physical condition.

The aim of the study is to assess the cardiovascular system response of students to physical exercise using the 'Trunk Flexion Test'.

Materials and Methods

Participants

Participants in the study were students from three Ukrainian universities specializing in physical education: two in the east (Kharkiv - *University1 and University2*, a region of active military conflict) and one in the west (Ivano-Frankivsk - *University3*, frequently under shelling threat) areas. In total, 77 students (34 males and 43 females) took part. They were instructed to adhere to safety protocols during air raid alarms and to use the 'AirAlert' mobile app for missile attack warnings.

Research Design

The 'Trunk Flexion Test' aims to evaluate the reaction of the cardiovascular system (CVSR) to physical load and the individual's adaptability to physical activity changes. A Google Form questionnaire and a dedicated webpage (Figure 1) detailing the test's execution have been set up. Participants are encouraged to independently conduct the test and then log their outcomes in the Google Form. The participation is confidential, with all data being used solely for research.

The 'Trunk Flexion Test' procedure [22, 23, 24, 25].

Prior to the test, participants should relax for 5 minutes before beginning. The webpage includes a timer and control buttons for tracking time. Participants are advised to measure their pulse for

10 seconds, then complete 20 forward bends of the trunk within 90 seconds. After bending, measure the pulse again for 10 seconds, followed by a 1-minute rest. After resting, measure the pulse once more for 10 seconds. These results should be entered into the designated data input field on the website.

After the test is done and data fields are completed, the results will show up. Participants can save their results for future analysis (by clicking 'Save as CSV'). They are recommended to use 'Copy Results' and 'Return to Google Form' buttons, and then paste the results in the Google Form. Next, they should fill out the rest of the necessary fields (nickname, age, height, weight, year of study, university affiliation) and send it by hitting the 'Submit' button.

Statistical Analysis

For the statistical evaluation, the PyCharm CE environment and a range of Python libraries were employed. Variance analysis (ANOVA) was carried out to examine possible disparities in students' CVSR. The Pearson correlation coefficient was utilized to explore the link between BMI and CVSR. Furthermore, calculations for average and standard deviation were made. A significance level of 0.05 was adopted.

Results

Table 1 illustrates the experimental participant group – 77 people (34 men and 43 women). This group of students cohort adequately varies in age, height and weight, making it apt for research. Standard CVSR metrics are given in Table 2 [22, 23], which outlines suggested CVSR level ranges for trunk forward flexion. The levels of response are divided into five classifications.



Table 1. Aggregate profile of experimental participants

Characteristic	Value	
	Female	Male
Age (years)	19.4 ± 4.6	20.3 ± 3.0
Height (cm)	165.3 ± 6.8	179.4 ± 6.6
Mass (kg)	59.1 ± 8.6	76.1 ± 14.7
BMI (kg/m ²)	21.6 ± 2.4	23.5 ± 3.7
Number of Respondents	43	34

Table 2. Cardiovascular system response to forward trunk incline

Level Ranges	Assessment
0 - 0.3	Excellent
0.31 - 0.6	Good
0.61 - 0.9	Average
0.91 - 1.2	Undesirable
More than 1.2	Hazardous

The reaction of the cardiovascular system to forward body tilt

The method of performing the test

1. Wait quietly for 5 minutes before starting the test.
2. To count the time, use the stopwatch and timers by pressing the appropriate buttons below.
3. Count the pulse in 10 seconds and enter the result in the appropriate window.
4. Perform 20 forward body bends in 90 seconds and enter the result in the appropriate window
5. Immediately after the inclines, count the pulse again for 10 seconds and enter the result in the appropriate window
6. Rest for 1 minute.
7. 1 minute after rest, count the pulse again for 10 seconds - and enter the result in the appropriate window
8. At the end of the test, click the **Copy results** button and paste them into the Google form - click the **Return to Google form** button

For detailed instructions and evaluation table, [click here](#) .

We wish you success!

Stopwatch "Pulse in 10 seconds" 10 seconds

Start Slope Timer 90 seconds

Rest Timer 60 seconds

Add results:

heart rate in 10 seconds at rest:

pulse in 10 seconds after 20 inclines:

pulse in 10 seconds after 1 minute of rest:

CALCULATE

Result:

Cast

RESULTS:

Heart condition:

Save as CSV

Results:

Copy the results **Return to Google Form**

Figure 1. The webpage for the 'Trunk Bend Test'

Table 3 displays the categorization of students based on CVSR. The table's data shows trends like at University 1, where a significant number of female students are in the less favorable CVSR categories ('Hazardous' and 'Average'), while most male students are in the 'Excellent' category. The total count of male and female students at this university is relatively low.

In University 2, a significant proportion of women fall into the 'Hazardous' category of CVSR, indicating poor cardiovascular responses. The male students also show a variety in CVSR levels. This university stands out for its highest student count and a varied gender ratio.

University 3 sees a considerable number of its female students categorized under unfavorable

CVSR, mainly in the 'Hazardous' category. There is also a diversity in CVSR among male students.

Consolidated data from all three universities reveal:

- Women show a higher percentage of students in the 'Hazardous' and 'Undesirable' categories compared to men, which may indicate a higher level of risk for the female group.

- The level of students in the 'Excellent' category among women is much lower compared to men.

- The average CVSR and standard deviation of students in this group of universities are 2.53 and 4.58 respectively, indicating diversity and spread in the data.

Special attention should be given to the female group of students, as it demonstrates a higher

Table 3. Classification of students according to CVSR categories

University	Gender	Heart condition category	Percentage, %	Student count	Mean	Std Dev	Total student count
1	Female	Hazardous	42.86	3	1.27	0.74	7
		Average	42.86	3	1.27	0.74	7
		Good	14.29	1	1.27	0.74	7
	Male	Excellent	50.0	1	0.35	0.21	2
		Good	50.0	1	0.35	0.21	2
2	Female	Hazardous	63.64	14	3.77	6.2	22
		Undesirable	18.18	4	3.77	6.2	22
		Good	9.09	2	3.77	6.2	22
		Average	4.55	1	3.77	6.2	22
		Excellent	4.55	1	3.77	6.2	22
	Male	Excellent	33.33	4	2.32	5.81	12
		Hazardous	25.0	3	2.32	5.81	12
		Good	16.67	2	2.32	5.81	12
		Average	16.67	2	2.32	5.81	12
		Undesirable	8.33	1	2.32	5.81	12
3	Female	Hazardous	42.86	6	1.19	0.44	14
		Undesirable	28.57	4	1.19	0.44	14
		Average	14.29	2	1.19	0.44	14
		Good	14.29	2	1.19	0.44	14
	Male	Hazardous	35.0	7	1.11	0.95	20
		Good	30.0	6	1.11	0.95	20
		Undesirable	20.0	4	1.11	0.95	20
		Excellent	10.0	2	1.11	0.95	20
1, 2, 3	Female	Average	5.0	1	1.11	0.95	20
		Hazardous	53.49	23	2.53	4.58	43
		Undesirable	18.6	8	2.53	4.58	43
		Average	13.95	6	2.53	4.58	43
		Good	11.63	5	2.53	4.58	43
	Male	Excellent	2.33	1	2.53	4.58	43
		Hazardous	29.41	10	1.49	3.49	34
		Good	26.47	9	1.49	3.49	34
		Excellent	20.59	7	1.49	3.49	34
		Undesirable	14.71	5	1.49	3.49	34
		Average	8.82	3	1.49	3.49	34

percentage of students with unfavorable heart conditions.

A comparative analysis using the one-way Analysis of Variance (ANOVA) method was conducted to assess potential differences in CVSR among students. The ANOVA results showed that there are no statistically significant differences in CVSR in either women or men depending on their university affiliation. For both groups (women and men), the p-value exceeds the significance level alpha (0.05), indicating that based on the available data, it cannot be concluded that there are statistically significant differences in CVSR among students between universities.

Table 4 consists of the suggested BMI categorization as recommended by the 'Centers for Disease Control and Prevention' [Zierle-Ghosh2023]. Table 5 categorizes students based on their BMI. The insights from Table 5 are as follows:

- University 1 – a predominance of normal-

weight female students, with a smaller male student population.

- University 2 – a significant number of women are of normal weight, but there are also cases of underweight, overweight, and obesity. Men are primarily normal or overweight.

- University 3 – most women have a normal weight, though some are underweight. Men are generally normal or overweight, with an instance of underweight.

The analysis of results using a one-way Analysis of Variance (ANOVA) with a significance level (alpha = 0.05) indicates the following. The ANOVA results for the female group showed a statistic value of 1.7251, with a corresponding p-value of 0.1911. Similarly, for the male group, the statistic value was 0.5451, with a p-value of 0.5852. In this case, for both groups, the statistic value is not high, which may suggest that the differences in BMI values are not statistically significant.

Table 4. Suggested BMI category values as per Centers for Disease Control and Prevention Guidelines [26]

Weight Category	BMI Range, kg/m ²
Underweight	≤ 18.4
Normal weight	18.5 - 24.9
Overweight	25.0 - 39.9
Obese	>40.0

Table 5. Distribution of students by BMI category

University	Gender	BMI Category	Percentage, %	BMI, kg/m ²	Student Count
1	Female	Normal weight	71.43	23.28	5
		Overweight	28.57	23.28	2
	Male	Normal weight	50.0	26.38	1
		Overweight	50.0	26.38	1
2	Female	Normal weight	86.36	21.83	19
		Underweight	4.55	21.83	1
		Obesity	4.55	21.83	1
		Overweight	4.55	21.83	1
	Male	Normal weight	66.67	23.73	8
		Overweight	33.33	23.73	4
3	Female	Normal weight	85.71	20.28	12
		Underweight	14.29	20.28	2
	Male	Normal weight	70.0	23.15	14
		Overweight	25.0	23.15	5
		Underweight	5.0	23.15	1
1, 2, 3	Female	Normal weight	83.72	21.56	36
		Underweight	6.98	21.56	3
		Overweight	6.98	21.56	3
		Obesity	2.33	21.56	1
	Male	Normal weight	67.65	23.54	23
		Overweight	23.53	23.54	8
		Obesity	5.88	23.54	2
		Underweight	2.94	23.54	1

In this study, the p-values for both groups exceed 0.05, indicating that the differences in BMI values are not statistically confirmed. Therefore, the ANOVA results suggest that there are no statistically significant differences in BMI values between the groups of women and men at the 0.05 significance level. It should be noted that the ANOVA results assess the differences in BMI among all possible pairs of universities (1-2, 1-3, and 2-3) for women and men separately.

The study examined the correlations between BMI and CVSR in men and women, using the Pearson correlation coefficient. BMI served as a marker of physical health, and CVSR was characterized through the 'Heart condition' category. The results showed a faint negative association between BMI and CVSR in men (Pearson correlation coefficient = -0.0447), pointing to a possible relationship of rising BMI with declining CVSR in men. For women, a slight positive association was noted between BMI and CVSR (Pearson correlation coefficient = 0.1776), indicating a potential correlation between higher BMI and enhanced CVSR in this demographic.

A more comprehensive explanation of the connection is accessible from the data shown in Figure 2. The evaluation of the graph for women, focusing on 'Heart condition Category' and 'IMT Category', enables the discovery of the following regular patterns:

- In the 'Hazardous' CVSR level among women, most are classified as having a 'Healthy weight' BMI. This suggests that 'Healthy weight' could be the predominant BMI category for women in

this CVSR group.

- The 'Undesirable' CVSR category shows a range of BMI categories, from 'Underweight' to 'Overweight' and 'Obesity'. This could imply that BMI is a more variable factor for women within this CVSR category.
- The 'Hazardous' category is notably prevalent in CVSR levels among women. Irrespective of their BMI classification, a significant number of women in this category maintain a 'Healthy weight', highlighting the need for careful CVSR management in women.

Figure 3 provides a more comprehensive explanation of the interconnection for men. From the graph analysis for males, we can extract the subsequent observations and deductions:

- On the chart, it's evident that most men classified as 'Undesirable' in CVSR levels are in the 'Healthy weight' BMI range. This suggests a possible stronger link between CVSR levels and BMI in men of this group.
- Within the 'Hazardous' category of CVSR for men, many are in the 'Healthy weight' BMI range. However, there are also men categorized as 'Overweight' and 'Obese'. This could imply a more varied influence of CVSR levels on men with distinct BMI classifications.

It's crucial to recognize that the 'Hazardous' CVSR level predominates among men, irrespective of their BMI classification. This could indicate the necessity for enhanced CVSR level surveillance in men.

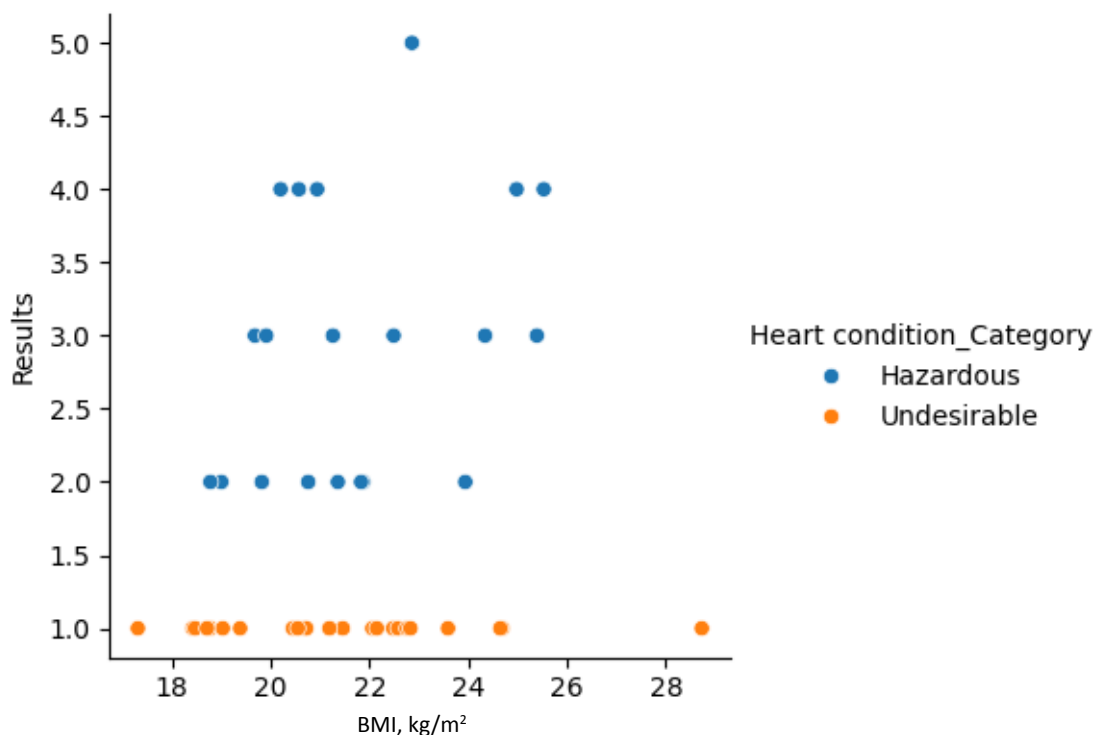


Figure 2. Relationship of BMI categories with CVSR category in women.

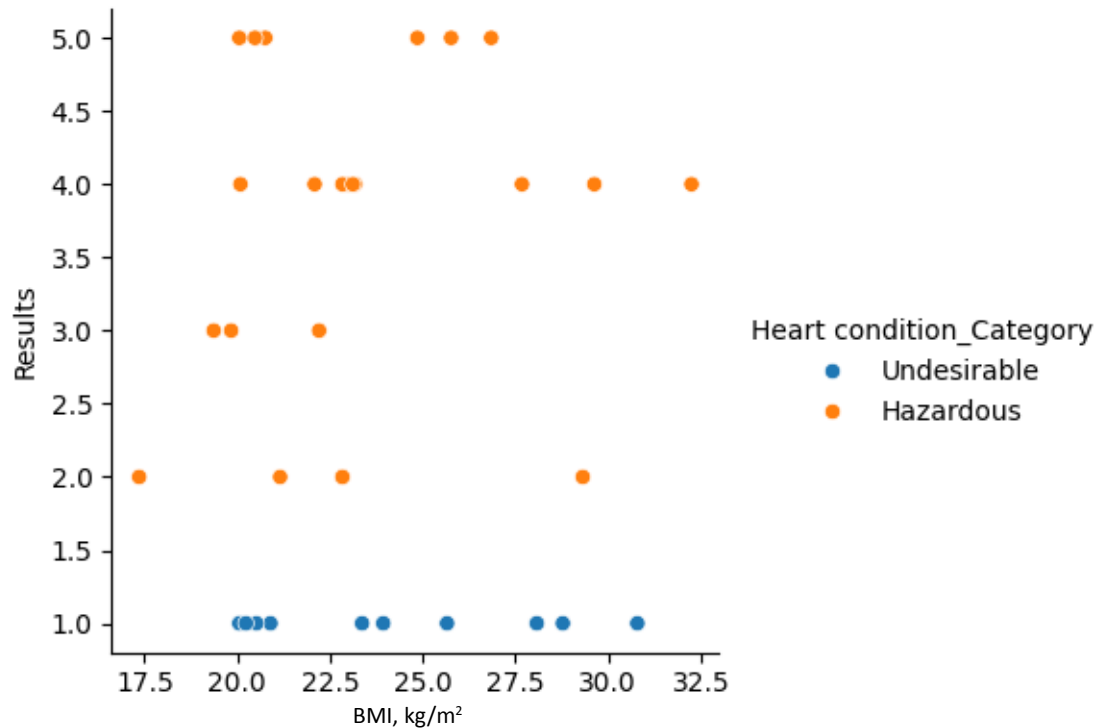


Figure 3. Relationship of BMI categories with CVSR category in men

Discussion

The aim of the study is to assess the cardiovascular system response of students to physical exercise using the 'Trunk Flexion Test'. The importance of choosing an appropriate test to evaluate trunk characteristics is emphasized in the study by Martínez-Romero [27]. Among many studies [19, 27, 28], tests using various trunk positions are the most accessible method for assessing CVSR under load. The body of research on trunk flexion and extension provides important insights for spine health and functionality [16, 18, 20, 28].

We also adopted similar positions in choosing an appropriate test for university students. The 'Trunk Flexion Test' was selected as the test. We found several publications demonstrating the capabilities of this test [22, 23, 24, 25].

The results of our study revealed the following trends in CVSR among students of different genders. A higher percentage (53.49%) of women were found to have a CVSR level classified as 'Hazardous'. This may indicate a more pronounced CVSR in women during physical exercises of this type. Among men, more than a quarter of cases (26.47%) fell into the 'Good' category, which may indicate a higher adaptability and ease of tolerating this exercise. The results of the one-way Analysis of Variance (ANOVA) did not show statistically significant differences in CVSR in either women or men depending on their university affiliation, indicating no differences in CVSR response to load.

Other authors' research showed roughly the same dependencies and trends as in our study [22, 23, 24, 25]. Sokolova and Dvornikov [25] present

data on a biathlete with a score of 0.3 (excellent). Chizhinskaia [24] found that the level of physical activity of female biology students affects the CVSR indicators on trunk forward flexion. Arinchin [29] and Erdonov et al. [30] found that female students had a CVSR on trunk forward flexion of 0.31–0.6 (Good). Our study results differ slightly:

- Men (Hazardous - 29.41%, Good - 26.47%, Excellent - 20.59%, Undesirable - 14.71%, Average - 8.82%);
- Women (Hazardous - 53.49%, Undesirable - 18.6%, Average - 13.95%, Good - 11.63%, Excellent - 2.33%).

Equally important is the relationship between BMI and CVSR in response to physical exercise. In this context, Aires et al. [31] emphasized the close link between low levels of cardiorespiratory fitness and obesity. The authors highlighted the importance of improving cardiorespiratory fitness even at a young age.

In our study, the relationship between BMI and CVSR is presented as follows:

- The 'Hazardous' CVSR level in women often corresponds to the 'Healthy weight' BMI category, which may indicate a connection between these two parameters. However, in the 'Undesirable' CVSR category, the level is accompanied by a variety of BMI categories, including 'Underweight', 'Overweight', and 'Obesity'. The 'Hazardous' group predominates among women in the CVSR level, regardless of their BMI category.

- Most men in the 'Undesirable' CVSR category fall within the 'Healthy weight' BMI range, which may indicate a stronger connection between CVSR level and BMI for men in this category. Among

men in the 'Hazardous' CVSR category, many also have a 'Healthy weight' BMI. However, there are also men with 'Overweight' and 'Obesity' BMI. This may suggest a more diverse impact of CVSR level on men with different BMI categories. It is important to note that 'Hazardous' is the dominant CVSR category among men, regardless of their BMI category, emphasizing the need for more thorough monitoring of CVSR levels among men.

The study results of Dimkpa and Oji [32] confirmed the usefulness of BMI for predicting obesity-related risks, especially among young people. Ivonne Bojorquez-Diaz et al. [33] conducted to assess BMI among college students and to identify the prevalence of obesity and hypertension as metabolic risk factors. Joshi et al. [34] focused on studying the relationship between BMI and various cardiovascular disease risk factors.

Zafar et al. [35] indicated a potential risk of hypertension and cardiovascular diseases among students with higher BMI or central obesity distribution. These studies emphasize the need for active prevention and attention to health at a young age. Additionally, we also determined a measure such as BMI. In this context, BMI is a good criterion that characterizes the health level of students, as evidenced by the studies of Markowitz [36] and Nuttall [37].

Our study allowed us to determine such important health indicators for students as body mass index. This led to the following conclusions: the majority of men (67.65%) and women (83.72%) have a body mass index corresponding to the 'Normal weight' category, indicating healthy weight. Nevertheless, there is a proportion of participants with overweight and obesity among both men (23.53% and 5.88% respectively) and women (6.98% and 2.33% respectively).

Other studies, similar to ours, note the following. Aires [31] revealed a close link between low levels

of Cardiorespiratory Fitness (CRF) and obesity. However, no associations were found between physical activity and BMI. The findings of Ivonne Bojorquez-Diaz [33] indicate that the average BMI values for women and men were 24.0 ± 5.5 kg/m² and 25.2 ± 5.2 kg/m² respectively. Joshi [34] showed a high prevalence of BMI risk among male students (53.50%) and female students (48.10%). Nicoteri [38] noted an increase in the proportion of students with overweight and obesity from the first to the senior (or graduate) year of study, from 25.6% to 32%. Parekh [39] showed that among 180 students, 26.1% were underweight and 32.2% were of normal weight, with an average BMI of 21.9 ± 5.14 kg/m². Zafar [35] presented data on the average BMI (23.24 ± 4.31) and the distribution of weight categories in the sample, including underweight (21.3%), normal weight (52%), overweight (20.5%), and obesity (6.2%).

Overall, the results of our study differ slightly from other similar studies. It should be noted that we used the 'Trunk Flexion Test', while other researchers used trunk tilt tests in other modifications and poses.

Conclusions

Our study results show the potential of assessing the CVSR of students to physical exercise using a simple and accessible test like the 'Trunk Flexion Test'. The differences in CVSR between men and women highlight the importance of considering gender differences in developing physical activity programs and assessing student health. The relationship between body mass index and CVSR points to the need for a more individualized approach to evaluating and managing the physical condition of students based on their body mass. Further research could be directed towards a deeper investigation of the factors influencing students' CVSR and evaluating the effectiveness of measures to improve physical activity and health among the student population.

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