International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 • Website: www.ijfmr.com • Email: editor@ijfmr.com

Association Between Body Mass Index and Physical Fitness of Normal Weight & Overweight University Students

Dr Shalini Singh Chouhan

Physiotherapist/Assistant Professor, School Of Paramedical Sciences, Renaissance University

Abstract

Background: University students face unique lifestyle challenges that can impact their health, physical fitness, and body composition. While Body Mass Index (BMI) is commonly used to assess weight status, it has significant limitations, particularly in distinguishing between muscle and fat mass. This can lead to misclassification, especially among individuals with athletic builds or those with metabolically healthy obesity.

Objective: This study aims to investigate the relationship between BMI and physical fitness among university students, considering the moderating role of body type.

Methods: The study evaluates key components of physical fitness, including cardiorespiratory endurance, muscular strength, and body composition. Body types are categorized using somatotype analysis (ectomorph, mesomorph, endomorph) and detailed body composition measurements. Lifestyle factors such as diet, physical activity, sleep, and stress levels are also considered.

Results: Preliminary findings suggest that BMI alone is not a sufficient indicator of physical fitness. Individuals with the same BMI but different body types show significant variation in physical fitness measures. For example, mesomorphic individuals often display higher muscular strength and cardiovascular fitness compared to others with similar BMIs but differing body compositions.

Conclusion: The study highlights the importance of incorporating body type and lifestyle factors into health assessments for university students. A more comprehensive approach beyond BMI is necessary to accurately evaluate physical fitness and design effective, individualized health interventions.

Keywords: Body Mass Index, Physical Fitness, University Students, Body Type, Somatotype, Health Assessment, Lifestyle Factors

Introduction

The global prevalence of obesity in adolescents is increasing due to a faster rate of unhealthy eating habits and insufficient physical activity, which has turned into a public health concern. High school represents a critical transition from adolescence to adulthood, making it essential for cultivating healthy lifestyles and behaviors. Recently, there has been a notable decrease in physical activity levels among high school students. Research indicates that a reduction in physical activity can result in weight gain and a higher prevalence of obesity in adolescents. The incidence of being overweight is rising among high school students, while their physical fitness is deteriorating. Additionally, the aspiration to be thin is prevalent among young individuals in Asia. These regions are grappling with the dual challenge of having both underweight and overweight adolescents. Consequently, it is vital for high school students to engage in weight monitoring to ensure their health remains optimal.

Body Mass Index (BMI) is the most widely used measure for evaluating weight status in both individuals and population studies. It is calculated by taking weight in kilograms (kg) and dividing it by height in square meters (m2). In 2004, the World Health Organization (WHO) established several classifications for BMI: underweight <18.5 kg/m2, normal weight 18.5-22.9 kg/m2, overweight 23.0-24.9kg/m2, and obese >25 kg/m2, based on revised guidelines for Asian Indians. As the rates of overweight and obesity among young people increase, along with their impact on fitness and movement abilities, research has increasingly contrasted overweight and obese individuals with those of normal weight, indicating that the former generally demonstrate lower levels of physical fitness. Physical fitness includes a variety of physical characteristics that are directly associated with an individual's ability to participate in physical activities and exercise, acting as an indirect measure of a person's health condition. Assessments of physical fitness gauge the performance of both muscular and cardiovascular systems. Muscular endurance is defined as the ability to maintain exercise of muscle groups over extended periods at moderate intensity, utilizing aerobic energy while resisting fatigue. Sit-ups and push- ups are frequently used clinical assessments designed to improve upper body strength and evaluate treatment outcomes. These assessments are commonly employed to measure muscular endurance and various aspects of physical performance. Modified push-up variations are utilized for females, as they typically have less upper body strength than males and display different weight distributions.

Unhealthy behavioral changes, such as an increase in sedentary lifestyles and a decrease in physical activity, are common during the transition from secondary school to university, with 40 to 50% of college students being physically inactive. Excessive sedentary behavior is associated with a greater risk of obesity, adverse health outcomes, increased vulnerability to depression, and reduced cognitive function. Elevation

Review of Literature

1. Normal Weight a Physical Fitness

Normal-weight individuals (BMI 18.5–24.9 kg/m²) consistently show **better physical fitness** across multiple domains, including aerobic capacity, muscular endurance, and agility.

Zhang et al. (2023) conducted a study involving 7,541 Chinese college freshmen and found that students with normal BMI had significantly higher Physical Fitness Index (PFI) scores than those who were underweight or overweight. The study confirmed an **inverted U-shaped** relationship between BMI and fitness performance. *[Source: Zhang et al., BMC Public Health, 2023]*

Qin et al. (2022) conducted a study involving 176,655 Chinese high school students and found that students with a normal BMI had significantly higher Physical Fitness Index (PFI) scores compared to those who were underweight or overweight. The study confirmed an **inverted U-shaped** relationship between BMI and fitness performance. *[Source: Qin et al., Frontiers in Public Health, 2022]*

Liu et al. (2024) analyzed data from 27,973 Chinese university students and observed that standing long jump performance peaked at a BMI of 26.25 kg/m², after which performance declined. This suggests that muscle strength and explosive power are optimal at mid-range BMI levels. *[Source: Liu et al., American Journal of Human Biology, 2024]*

2. Underweight and Physical Fitness

Underweight individuals (BMI < 18.5 kg/m²) often have **lower physical fitness**, mainly due to insufficient muscle mass and energy availability.

Li et al. (2024) analyzed data from 29,371 university students in China and found that underweight participants scored lower in key fitness indicators such as **vital capacity, pull-ups, long jump, and 800m/1000m runs**. The effect was more pronounced in males. *[Source: Li et al., BMC Sports Science, Medicine and Rehabilitation, 2024]*

Gulati et al. (2024) studied Indian doctors and found a significant inverse relationship between BMI and hamstring flexibility. Underweight individuals exhibited reduced flexibility, highlighting the impact of low muscle mass on physical performance. *[Source: Gulati et al., Journal of Medical Academics, 2024]*

Chen et al. (2022) studied children and adolescents in Xinjiang, China, and found that underweight individuals performed poorly in physical fitness tests, including grip strength, standing long jump, and endurance running. The study highlighted that individuals with a BMI above or below the normal range performed poorly in physical fitness. *[Source: Chen et al., BMC Public Health, 2022]*

3. Overweight and Obese Individuals and Physical Fitness

Overweight (BMI 25–29.9 kg/m²) and obese (BMI ≥ 30 kg/m²) individuals tend to experience a **decline in physical fitness**, particularly in endurance and weight-bearing tasks.

Zhang et al. (2023), in the same large-scale study, observed that overweight and obese college freshmen had lower overall PFI scores. The decreased fitness was primarily associated with **excess fat mass**, which limits mobility and increases fatigue.*[Source: Zhang et al., BMC Public Health, 2023]*

Liu et al. (2024) observed that both muscle strength and cardiorespiratory fitness declined with increasing BMI among Chinese university students. The study highlighted that excess body fat impairs both aerobic capacity and muscular performance.*[Source: Liu et al., American Journal of Human Biology, 2024]*

Qin et al. (2022) observed that both overweight and obese students had lower overall PFI scores compared to normal-weight students. The decreased fitness was primarily associated with **excess fat mass**, which limits mobility and increases fatigue.*[Source: Qin et al., Frontiers in Public Health, 2022]*

4. Normal Weight Obesity (NWO) and Physical Fitness

Normal Weight Obesity (NWO) describes individuals with normal BMI but high body fat percentage. Despite being "normal weight," these individuals may perform poorly in physical fitness tasks.

Ignasiak et al. (2023) investigated Polish children and adolescents and found that those with NWO had significantly **lower explosive strength, abdominal muscle endurance, and agility** compared to peers with healthy body composition.*[Source: Ignasiak et al., International Journal of Environmental Research and Public Health, 2023]*

Li et al. (2022) investigated Chinese medical students and found that individuals with high body fat percentage, despite having a normal BMI, exhibited lower physical fitness levels. The study emphasized the importance of considering body composition in health assessments.*[Source: Li et al., BMC Public Health, 2022]*

5. Sex-Based Differences in BMI-Fitness Relationship

Recent studies show that the relationship between BMI and physical fitness may differ by gender due to hormonal, physiological, and body composition factors.

Wang et al. (2022) studied 30,497 Chinese college students and found the **inverted U-shaped trend** between BMI and physical fitness existed in both males and females, though males showed a **stronger correlation**.*[Source: Wang et al., Frontiers in Physiology, 2022]*

Chen et al. (2022) found that the impact of BMI on physical fitness was more evident among boys than girls. The study suggested that BMI has a stronger influence on physical fitness in males, particularly in grip strength and standing long jump performance.*[Source: Chen et al., BMC Public Health, 2022]*

- **Materials And Methods**
- **Hypotheses:**

H1: There will be a negative correlation between BMI and cardiorespiratory fitness across all body types. (Higher BMI, lower fitness)

H2: Mesomorphic body types will demonstrate higher levels ofmuscular strength and endurance compared to ectomorphic and endomorphic body types, regardless of BMI.

H3: There will be a positive correlation between physical fitness and perceived social well-being. (Higher fitness, higher social well-being) H4: The relationship between BMI, physical fitness, and social well-being will be moderated by body type. For example, individuals with higher BMI within a mesomorphic body type may report higher social well-being compared to individuals with similar BMI within an endomorphic body type, if they maintain a higher level of fitness.

Study Design:

Type: Cross-sectional, correlational study. (Could also consider a longitudinal study for a more in-depth understanding of changes over time, but this is more complex).

Setting: University campus (e.g., gymnasium, health centre, student union). Participants:

Target Population: University students (undergraduate and graduate).

Sample Size: Calculate using power analysis to determine the appropriate sample size to detect meaningful correlations. Consider stratification to ensure adequate representation of different body types, genders, and academic disciplines. Aim for a sample size that is statistically powerful and representative of the university population. (e.g., n = 30-50).

Recruitment: • Post flyers around campus.

- Send emails to student organizations.
- Offer incentives (e.g., small gift cards, extra credit in participating courses, access to personalized fitness reports). • Utilize university's research participation pool (if available).

Inclusion Criteria:

- Enrolled as a student at the university.
- Age 18 years or older.
- Able to provide informed consent.

Exclusion Criteria:

- Any medical condition that would prevent them from safely participating in physical fitness testing (assessed via self-report questionnaire).
- Pregnancy.
- Currently taking medications that significantly affect metabolism or physical performance (assessed via self-report questionnaire).

Variables and Measures:

Independent Variable:

Body Mass Index (BMI): Calculated from self-reported height and weight. Ideally, measured height and weight would be more accurate. BMI will be treated as a continuous variable.

Body Type:

Self-Identified: Ask participants to select their perceived body type from a list (e.g., ectomorph, mesomorph, endomorph, other, unsure). Provide brief descriptions/images to aid in selection.

Researcher-Defined (Somatotype Assessment): Consider using a more objective somatotype assessment method (e.g., Heath-Carter method) to assign participants to body type categories based on standardized measurements (skinfold thickness, bone breadth, limb girth). This provides more objective data than self-report.

Dependent Variables:

Physical Fitness Components:

Cardiorespiratory Fitness: Measured using a standardized exercise test (e.g., Bruce Protocol treadmill test, Rockport Walk Test, or a cycle ergometer test). Record time to exhaustion, VO2 max (estimated or directly measured if resources allow).

Muscular Strength: Measured using a one-repetition maximum (IRM) test for upper body (e.g., bench press) and lower body (e.g., leg press or squat).

Muscular Endurance: Measured using tests like push-up test (number of repetitions to fatigue) and sit-up test (number of repetitions in a set time).

Flexibility: Measured using a sit-and-reach test.

Body Composition: Measured using bioelectrical impedance analysis (BIA) or skinfold measurements to estimate body fat percentage.

Perceived Social Well-being:

Validated Questionnaire: Use a standardized and validated questionnaire to assess perceived social well-being, such as:

Social Well-being Scale (Keyes): Assesses five dimensions of social well-being: social integration, social acceptance, social contribution, social actualization, and social coherence.

Satisfaction with Life Scale (SWLS): Although not directly social well-being, it captures overall life satisfaction, which can be influenced by social factors.

Perceived Social Support: Use a scale like the Multidimensional Scale of Perceived Social Support (MSPSS) to measure perceived support from family, friends, and significant others.

Covariates (Potential Confounding Variables):

Collect data on these variables to control for their influence in the analysis.

Age Gender

Ethnicity/Race

Socioeconomic Status (SES): Measured using indicators like parental education level or self-reported financial situation.

Physical Activity Level: Measured using a validated physical activity questionnaire (e.g., International Physical Activity Questionnaire —IPAQ) to assess habitual physical activity levels.

Dietary Habits: Collect data on dietary habits using a food frequency questionnaire (FFQ) or a short dietary assessment tool.
Sleep Quality: Assess sleep quality using a questionnaire such as the Pittsburgh Sleep Quality Index (PSQI).
Mental Health: Assess symptoms of anxiety and depression using standardized questionnaires like the Generalized Anxiety Disorder 7-item (GAD-7) scale and the Patient Health Questionnaire-9 (PHQ-9).
calculation:
Sample size was calculated by using formula:
n=Z2X(1-r2)/r2
where, Z=va1ue from normal tab1e=2.802 r=corre1ation coefficient=0.3 Thus, n=79.36=79

Procedure
Informed consent in writing was acquired from individuals who agreed to participate, and they were provided with a participant information sheet. Students who met the inclusion criteria were selected for the study,
A stadiometer was utilized to assess the height of the subjects in centimeters they were in a standing position. Each participant stood with their back, buttocks, and heels against the stadiometer, having removed their shoes. The height was measured by firmly placing the headboard down to the vertex while the subject maintained a forward gaze. Body weight was determined using a weighing scale, ensuring no support was used, with weight evenly distributed across both feet and hands positioned at their sides. Shoes and excess clothing were taken off, the weight was recorded, and the Body Mass Index (BMI) was calculated.

BMI Calculation
The Body Mass Index (BMI) was determined using the formula: BMI = weight (kg)/height (m)2. Students were categorized into four groups based on their BMI values, following the guidelines set by the World Health Organization (WHO): < 18.5 kg/m2 for underweight, 18.5-23.9 kg/m2 for average weight, 24-27.9 kg/m2 for overweight, and >28 kg/m2 for obese individuals, respectively.
Physical Fitness Test
The physical fitness assessments included Sit-up test, Push-up test, 50 m sprints, sit and reach, standing long jump, 800/1,000 m runs,
Sit-up test (evaluating abdominal strength)
The sit-up test demonstrates a very high reliability (R-va1ue=0.98). Students began in a supine position with their backs flat on the mat, knees bent at 90 degrees, feet securely placed on the mat, and hands positioned at the sides of their heads with elbows directed forward. To perform a proper sit- up, the elbows must make contact with the knees before returning so that the shoulders touch the floor. Once the therapist activated the stopwatch and announced 'GO', the student commenced the sit-ups. The student's feet were secured to prevent them from lifting, which facilitated the sit-up. The total number of sit-ups completed by the students within one minute was recorded. The test was concluded if two consecutive attempts were unsuccessful or if the participant ant could no longer continue.
Push-up test (evaluating upper body strength)
The push-up test demonstrates high reliability (R-value=0.98). The Minimal Detectable Change (MDC) was established at two repetitions. Students positioned themselves prone on the floor, with their hands

placed shoulder- width apart, fingers directed forward, and elbows angled backward. From this starting position, the student pushed up to achieve full arm extension while maintaining a straight body alignment, allowing for a straight line to be drawn from the shoulder joint to the ankle joint (this represented the up position). Subsequently, the students lowered their bodies until the chest to thighs made contact with the floor. The student then pushed backup to full arm extension, ensuring the body remained straight. A push-up was counted when the student reached the up position. The number of repetitions completed by participants within 1 minute was recorded. No rest intervals were permitted between repetitions. The test was concluded if the pace of push-ups altered. For male participants, the test was conducted with legs extended, while for female participants, it was performed with bent knees.

50 m Sprint

To measure the speed and explosive strength of students, a 50 m sprint was performed. Students were tested in groups of four. Upon the investigator's command of "go," the participants commenced the sprint, aiming to finish as quickly as possible. The time taken was recorded in minutes and seconds.

Standing Long Jump

The standing long jump was carried out to assess lower-limb strength. Each participant began at the starting line and was instructed to jump forward as far as possible. The distance was measured in meters from the starting line to the heel of the nearest foot. This test was also conducted twice, with the best score being retained.

800/1,000 m Run

Each student started at the designated line and was tasked with completing either the 800 m or 1,000 m run as quickly as possible. The time taken was recorded in minutes and seconds. Female students completed the 800 m run, while male students ran the 1,000 m.

TABLE - 1

s.No	AGE	WEIGHT	HEIGHT	BMI
1	17	60	170	20.74
2	16	85	160	33.2
3	17	45	165	16.15
4	21	68	167	24
5	21	72	172	21
6	22	82	182	24.8
7	22	80	167	28
8	21	68	152	24.1
9	21	43	149	19
10	21	54	158	21
11	21	59	166	21
12	22	75	158	30
13	20	41	167	14
14	21	40	158	16
15	20	54	134	30
16	20	50	155	20.8
17	21	50	155	20

18	23	43	164	16
19	20	39	158	15
20	23	66	170	22.8
21	21	53	158	21.2
22	18	64	167	22.9
23	23	90	180	27.8
24	21	89	175	29.1
25	19	58	170	20.1
26	20	42	160	16.4
27	20	56	170	19.4
28	20	75	180	23.1
29	20	52	163	19.6
30	19	45	157	18.3
31	19	60	175	19.6
32	18	52	165	19.1

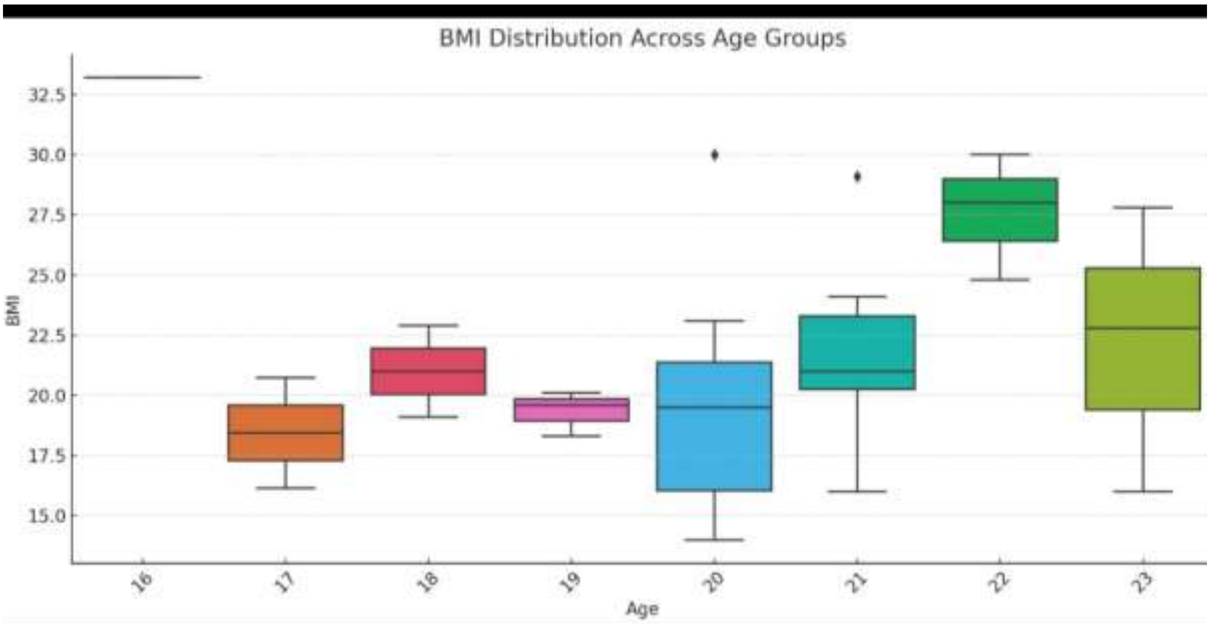
TABLE – 2

N	SIT UPS	PUSH UPS	50 m sprints	standing long jump	800/1,000 m runs
1	17	21	65	110	260
2	20	25	60	100	240
3	22	18	45	83	182
3	20	50	94	200	376
4	18	24	44	104	176
6	21	25	60	83	240
7	25	20	41	68	164
8	30	21	30	87	120
9	26	26	43	89	172
10	15	22	50	40	200
11	12	27	60	90	240
12	11	15	70	70	280
13	14	10	72	54	288
14	13	19	76	53	324
15	13	17	66	65	264
16	9	11	64	45	256
17	15	10	70	50	280
18	17	16	77	30	308
19	10	12	79	40	348
20	14	8	61	130	240
21	25	30	43	124	170
22	22	34	30	111	150
23	20	35	32	110	128

24	21	32	40	115	160
25	24	28	34	120	400
26	30	31	25	120	100
27	18	29	50	119	200
28	22	20	40	118	178
29	19	30	34	116	230
30	21	35	50	125	238

Discussion

ANOVA Summary for BMI Across Age Groups



F-statistic: 2.63

p-value: 0.036

Since the p-value is less than 0.05, we reject the null hypothesis, indicating that there is a statistically significant difference in BMI among at least some age groups.

Summary Statistics by Age Group

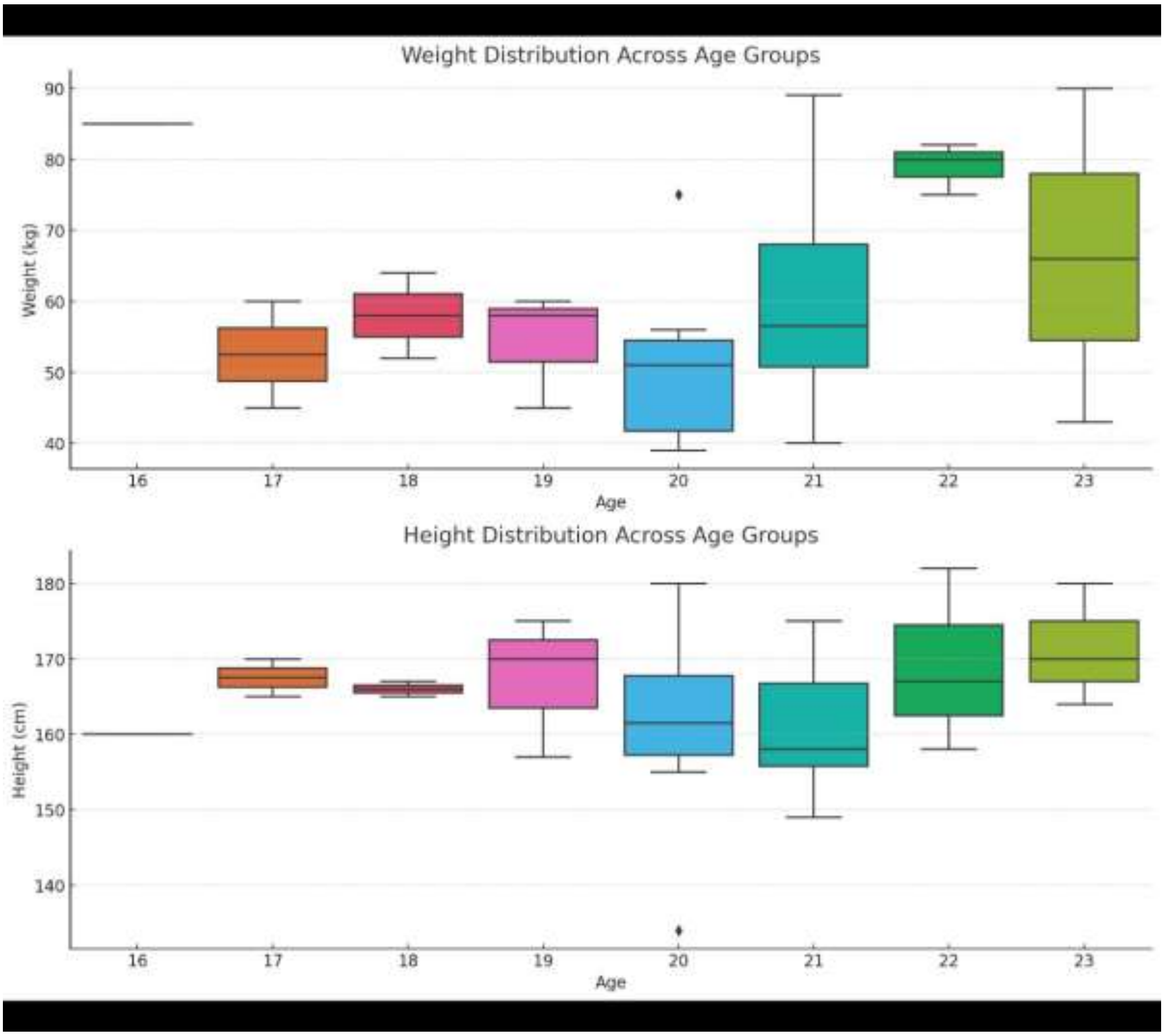
Age	Mean BMI	Std Dev	Count Mean	Weight (kg)	Height (cm)
16	33.20	—	1	85.00	160.00
17	18.44	3.25	2	52.50	167.50
18	21.00	2.69	2	58.00	166.00
19	19.33	0.93	3	54.33	167.33
20	19.79	5.13	8	51.12	160.88
21	21.64	3.50	10	59.60	161.00
22	27.60	2.62	3	79.00	169.00
23	22.20	5.92	3	66.33	171.33

Visualization

The boxplot (displayed above) shows the distribution of BMI values across age groups.

Age 16 has an unusually high BMI (only one sample).
Age 22 shows higher BMI on average.
Most other groups cluster around BMI 18–22.

ANOVA for Weight and Height Across Age Groups



Weight
F-statistic: 2.10
p-value: 0.083
Interpretation: Since the p-value is greater than 0.05, we fail to reject the null hypothesis. This means weight does not significantly vary across age groups in this dataset.
Height
F-statistic: 0.66
p-value: 0.705
Interpretation: Again, the p-value is much greater than 0.05, so height also does not significantly differ between age groups.

Visualization
The Boxplots above show the spread of:

Weight: Slight upward trend with age, but not statistically significant.
Height: Fairly uniform across all age groups.
This research revealed that BMI had a significant impact on PFI for both genders. In comparison to the obese and overweight classifications based on BMI, individuals in the normal-weight category exhibited notably higher PFI scores for both males and females. Our findings indicated that the connection between PFI and BMI was non-linear, displaying an inverted U-shaped relationship. The outcomes of this research suggested that university students classified as normal weight demonstrated superior physical fitness and overall health; as **BMI** increased, physical fitness initially improved before declining.
Participation in sports at the university level is crucial for sustaining physical fitness among students, and there is a need to enhance the quality of physical education programs. Engagement in sports during childhood and adolescence is associated with Health-Related Quality of Life (HRQoL) in young adulthood, whether through individual or team sports, or informal physical activities like backyard games. The objective of school physical education is to motivate students to engage in physical exercise, cultivate a routine of regular activity, and enhance their self-care skills and physical well-being. From a public health standpoint, physical health is vital. Levels of physical fitness are closely linked to health-related outcomes, such as obesity, cardiovascular issues, bone health, mental well-being, and social psychology, all of which have significant implications for physical fitness. University students face considerable academic pressure, contributing to a notable increase in obesity rates and a higher prevalence of overweight individuals. While genetic factors are significant contributors to obesity, environmental and lifestyle elements, including physical activity and dietary habits, are also essential. Prior research indicates that this upward trend may be linked to rapid shifts in eating and exercise behaviors.

Conclusion

To summarize, BMI has an impact on the PFI for both males and females. When comparing the obese and overweight categories determined by BMI, males and females exhibited significantly higher PFI scores. This study, however, has provided initial evidence that BMI influences the PFI in both genders. In comparison to the obese and overweight BMI categories, males and females showed notably higher PFI scores. Therefore, PFI should be prioritized for assessing the physical fitness of university students. Future prospective and longitudinal cohort studies are essential to accurately determine the causal relationships and underlying mechanisms.