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Correlation of Reaction Times and Body Mass Index among Female University Athletes, Accounting for Urban and Rural Environments

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Body mass index (BMI) is a significant human health fitness gauge. The purpose of the study was to investigate the relationship between BMI and reaction time of female university athletes, considering urban and rural community influences. A sample of 60 players (mean age = 20.45 ± 2.29 years) was selected from three leading women's universities in Lahore, Pakistan. reaction time was assessed through a ruler drop test. Data normality was examined using the Kolmogorov and Shapiro-Wilk tests. Pearson's correlation coefficients, trend lines, and independent samples t-test were used for statistical analysis. Results indicated mean reaction times were 0.164 ± 0.031 and 0.158 ± 0.026 seconds for urban and rural community athletes respectively. The average BMIs were 21.03 ± 1.77 and 19.64 ± 2.84 for urban and rural community athletes respectively. Rural players exhibited healthier BMIs, and overweight players displayed superior reaction time. There was a non-significant correlation between reaction time and BMI, explaining 3.9% of reaction time variability. Locality had a significant effect on BMI but not on reaction time. There was no significant association between reaction time and BMI was observed. However, locality significantly influenced BMI. Maintaining healthy BMIs and incorporating agility drills are recommended for optimal performance.

Keywords*:* BMI, Reaction time, Athletes, Community

The relationship between body mass index (BMI) and athletic performance has been a subject of considerable interest in sports science research. BMI, a commonly used measure of body composition, provides valuable insights into the impact of body weight and composition on performance outcomes in female athletes. One crucial aspect of athletic performance is reaction time, which plays a vital role in determining an athlete's ability to respond quickly and effectively to various stimuli. Exploring the relationship between BMI and reaction time in female athletes can provide valuable insights into the influence of body composition on performance and inform training protocols tailored to individual needs.

In a study by Zhang et al., (2021), the impact of body mass index (BMI) on reaction time in elite table tennis athletes was investigated. The research involved 30 athletes (male & female) with an average age of 22 years. A visual reaction test using a computer program was used to measure their reaction time. The study revealed that BMI did not significantly affect reaction time in either gender. However, women exhibited significantly faster reaction time overall compared to men. Additionally, a positive correlation was observed between BMI and reaction time in men, indicating that higher BMI was associated with slower reaction time. These findings suggest that gender has a greater influence on reaction time in elite table tennis athletes than in BMI, and men with higher BMIs may experience slower reaction time.

Several studies have examined the relationship between BMI and athletic performance across different sports and populations. These studies have demonstrated that body composition, as measured by BMI, can influence various performance parameters, including speed, agility, and power (Hespel et al., 2021; Ostojic et al., 2018). Athletes with lower BMI tend to exhibit faster running times and improved agility, suggesting that lower body weight relative to height may confer mechanical advantages, allowing athletes to move more efficiently and react more quickly (Cobley et al., 2014; Clark et al., 2015).

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Furthermore, specific factors within body composition, such as muscle mass, body fat percentage, and weight distribution, can impact reaction time in female athletes. Studies have consistently demonstrated that athletes with higher muscle mass and lower body fat percentage generally exhibit faster reaction time (Horslen et al., 2021; Neumayer et al., 2016; Marques et al., 2013). The presence of lean muscle mass facilitates rapid neural signaling and movement execution, potentially contributing to faster reaction time in athletes (Travieso et al., 2019).

Understanding the relationship between BMI and reaction time in female athletes requires consideration of potential gender-based differences. Males and females may exhibit distinct physiological and anatomical characteristics that can influence athletic performance. Therefore, focusing specifically on female athletes allows for a more targeted examination of how BMI relates to reaction time within this population (Close et al., 2019; VanDusseldorp et al., 2018; Sandbakk et al., 2018).

Based on previous findings suggesting that lower body weight, lower body fat percentage, and higher muscle mass contribute to improved reaction time, it was found lower BMI values could be associated with faster reaction time in female athletes (Gualdi-Russo et al., 2014). However, it is important to consider potential moderating factors that may influence this relationship, such as sport-specific demands and individual variations. Factors like the nature of the sport, technical skills required, and training history may interact with BMI to influence reaction time in female athletes (Cobley et al., 2012; Meylan et al., 2017).

Understanding the relationship between BMI and reaction time in female athletes has practical implications for training and performance optimization. By identifying the influence of body composition on reaction time, coaches and trainers can tailor training programs to address individual athlete needs, optimize performance, and enhance competitive outcomes (Lloyd et al., 2016; O'Hara et al., 2017; West et al., 2014). For instance, athletes with higher BMI values may benefit from targeted strength and conditioning programs to improve muscle mass and overall body composition, potentially leading to faster reaction time (Lloyd et al., 2015).

The effect of urban and rural communities on BMI and reaction time of female players can be influenced by multiple factors. While urban areas may present challenges related to unhealthy dietary choices and sedentary lifestyles, they also offer diverse cognitive stimulation. On the other hand, rural areas may provide healthier dietary patterns and opportunities for physical activity but may have less environmental stimulation. Individual choices and circumstances will play a substantial role in determining the ultimate impact on BMI and reaction time.

The current gap in research is the lack of studies examining the relationship between body mass index (BMI) and reaction time specifically among Pakistani female athletes, particularly while considering the influence of urban and rural localities. While research on BMI and reaction time exists in other populations, there is a need to investigate this relationship in the specific context of Pakistani female players. Furthermore, considering the influence of urban and rural backgrounds on this relationship is crucial as it can provide insights into the unique factors affecting the performance of female athletes in Pakistan. Filling this gap can contribute to a better understanding of factors influencing athletic performance and guide training strategies for Pakistani female players.

The significance of this study lies in its exploration of the relationship between body mass index (BMI) and reaction time among university female players. Understanding how BMI affects reaction time in this specific population can provide valuable insights into the performance and training strategies of female athletes in Pakistan. Additionally, considering the influence of urban and rural backgrounds can shed light on the unique factors that may impact athletic performance in these different contexts. The findings of this study can inform coaches, trainers, and athletes in developing tailored approaches to optimize performance and enhance the overall athletic development of Pakistani female players.

Therefore, it was hypothesized that the reaction time has no significant association with BMI. Additionally, the hypothesis suggests that the locality, whether urban or rural, does not exert a significant influence on the BMI and reaction time of female players enrolled in Lahore College for Women University, Kinnaird College University for Women, and Home Economics College, Lahore, Pakistan.

Literature Review

Body mass index (BMI) is a widely used measure to assess an individual's body composition and is often considered in various aspects of health and performance. One such area of interest is the correlation between BMI and athlete reaction time. Reaction time is a key component of athletic performance, affecting agility, speed, and decision-making. Understanding the impact of BMI on an athlete's reaction time is essential to optimizing training programs and competition results. Physical exercise positively impacts school teachers by helping to maintain a healthy BMI and improving reaction times. Regular physical activity enhances cognitive function, reduces stress, and boosts overall well-being, leading to more effective teaching performance (Sharif et al., 2021).

Jordan et al., (2023) found the relationship between BMI and psychological issues, which is complex, involving depression, anxiety, body dissatisfaction, eating disorders, stress, sleep problems, low self-esteem, social isolation, and reduced quality of life.

Bibi (2021) investigated that games and physical activities significantly impact students' BMI, promoting healthier weight by increasing physical activity levels, reducing sedentary behavior, and fostering better physical (speed) and mental health.

Horslen et al., (2021) examined the effects of BMI, gender, and use of hormonal contraceptives on reaction time in elite athletes. The study involved 48 elite athletes from various sports, including Football, Basketball, and Handball. They found that BMI did not significantly affect reaction times in both men and women, while men had faster reaction times than women.

Truong et al., (2021) investigated the impact of BMI on the reaction time of elite table Tennis players. The study involved 30 elite table Tennis players with an average age of 22 years. The participants' reaction times were measured with a visual response test involving a computer program. They found that BMI had not a significant effect on reaction time in both men and women but they also found that women table Tennis players had significantly faster reaction times than men. They also found a positive correlation between BMI and reaction time in male Tennis players.

Lopez-Taylor et al., (2020) focused on professional soccer players and examined the relationship between BMI and reaction time. The results showed a moderate negative correlation between BMI and reaction time, indicating that players with higher BMI tended to have slower reaction times. The study included a sample of 80 professional soccer players and used reaction time tests related to specific soccer situations.

Jones and Jackson (2019) explored the impact of BMI on reaction time in elite sprinters, focusing on athletes competing at short distances. The results demonstrated a significant inverse relationship between BMI and reaction time, showing that sprinters with lower BMI had faster reaction times. The study involved 50 elite sprinters and used reaction time tests designed to simulate sprint start scenarios.

Fitzpatrick and Vallance (2018) studied the relationship between BMI and reaction time in college athletes from different sports. The results showed a significant negative correlation between BMI and reaction time, indicating that athletes with higher BMI tended to react more slowly. The study used a sample of 150 athletes from different sports and used reaction time tests under controlled laboratory conditions.

Method

Research design and sample:

In this study, we focused on female university players from Lahore College for Women University (LCWU), Home Economics College, Lahore, and Kinnaird College for Women University, Lahore.

Population and sample

The target population consisted of all the mature available (at campus) players of various games in the said universities during the study hours. The total target population size from three women universities was N=208 (*Source: University Sports Management Offices).* A sample of size 136 players was selected by using Krejcie and Morgan's (1970) table based on the size of the target population (N=208).

This (pilot) study included 60 players out of 136 (total sample) players of different games, ranging in age from 16 to 28 years, representing various body types and communities (Urban & Rural). Participants with a history of any type of critical disease, recent surgeries, and medical conditions, such as neurological disorders, head injuries, and diabetes, were not included in the study.

Procedure

The research protocol of this study received approval from the ethics and research committee of the University of Lahore, Pakistan. The participants were provided with a detailed explanation of the study's nature and objectives. To measure simple reaction time, the ruler drop method was employed, while BMI was assessed through the weight and height of the participants.

Measurement

The ruler drop test is a simple and commonly used method to measure reaction time. This involves dropping a ruler from a height of about 30 centimeters (12 inches) and measuring the time it takes the participant to grab the ruler with their hands. The ruler drop test is a quick and easy way to measure simple reaction times and can be used in a variety of settings, such as schools, clinics, and research.

The measurement of simple reaction time was conducted using the ruler drop method, a validated clinical metric (Shejwal, 2020; ÁngelLatorre-Roman, 2018). For observation of the reaction time of the player's ruler drop test (Zhou et al., 2019) was applied as: - Forearm and hand of the player were placed on a flat surface with fingers extended and thumb up. Technical Assistant hold the ruler vertically, with the zero mark at the top and the numbers facing down, between the player's thumb and index finger. Without warning, the ruler was released by the Assistant, and the player tried to catch the ruler as quickly as possible using his thumb and index finger. The Technical Assistant noted the measurement in cm on the ruler where the player's fingers caught it. The test was repeated three times, and the average score was calculated. Based on the average value of the ruler drop the reaction time (in sec) of the players was computed by the following equation (Eq. 1).

$$\boldsymbol{Reaction\ Time\ (t) = Sqrt(\ 2d/g\ ) \ldots\ldots\ldots\ldots\ldots..Eq. 1}$$

Where d = reading from the ruler in meters and g=9.8 m/s^2.

Assessment of BMI

Assessment of Body Mass Index (BMI) is commonly employed as a measure to assess body composition, particularly excess adiposity and higher body weight (Ángel Latorre-Roman, 2018; Nene et al., 2011). The participant's height was measured using a measuring tape, with the measurement recorded to the nearest centimeter. Weight was measured using standard portable weighing equipment, with the participant barefoot and wearing light clothing, and the measurement was recorded to the nearest kilogram. The BMI was calculated using the given formula (Eq. 2).

$$\boldsymbol{BMI = Weight\ (kg)/Height\ (m\text{^}2\ ) \ldots\ldots\ldots\ldots\ldots..Eq. 2}$$

Statistical Analysis

Descriptive statistics were utilized to present the demographic characteristics of the participants. To examine the relationship between reaction time (reaction time) and Body Mass Index (BMI), Karl Pearson's correlation analysis was conducted to examine the effect of BMI on reaction time. The rationale for conducting a correlation analysis between reaction time and Body Mass Index (BMI) lies in understanding the interplay between physical health and cognitive performance. Physical health metrics, such as BMI, are known to influence cognitive functions; thus, exploring their relationship can provide insights into how weight-related health issues might impact reaction times. This analysis can help in the early detection of health problems, inform the design of targeted interventions, and contribute to holistic healthcare approaches.

Independent samples t-test was applied to examine the locality effects on BMI and reaction time. The statistical package SPSS ver. 21.0 was employed for the analysis. A significance level of $p<0.05$ was established to determine statistical significance. Applying an independent samples t-test for locality effects on BMI and reaction time determines significant differences between groups, revealing how urban versus rural living impacts these variables. This informs public health interventions, resource allocation, and policies addressing health and cognitive disparities.

Results

Table 1

Descriptive Statistics of the 60 Participants.

Items	Categories	n	Mean	SD
Urban	Age (year)	34	21.09	2.59
	Height (m)	34	1.59	0.06
	Weight (kg)	34	53.71	6.41
	BMI	34	21.03	1.77
	Reaction time (sec)	34	0.153	0.031
Rural	Age (year)	26	19.62	1.50
	Height (m)	26	1.59	0.09
	Weight (kg)	26	49.50	6.50
	BMI	26	19.64	2.84
	Reaction time (sec)	26	0.164	0.026
Total	Age (year)	60	20.45	2.29
	Height (m)	60	1.59	0.07
	Weight (kg)	60	51.88	6.73
	BMI	60	20.43	2.37
	Reaction time (sec)	60	0.158	0.029
	BMI Index			
Reaction time (Sec)	Under Weight	13	0.17	0.029
	Normal	37	0.16	0.031
	Over Weight	10	0.14	0.016

The study included a sample of 60 female players, with an average age of 20.45 and a standard deviation (SD) of 2.29 years including 34 Urban players (Age: 21.09±2.59) and 26 Rural players (Age: 19.62±1.50). From Table 1 the average Body Mass Index (BMI) of the total sample was 20.43±2.37, and the average reaction time was 0.158±0.029 sec. It was interesting that the reaction time of overweight (24.5 – 29.9) players were better as compared to the players who lay in underweight and normal categories.

Table 2

Data Normality Tests.

Variables	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	**df**	**p**	**Statistic**	**df**	**p**
Reaction time	0.10	60	0.20	0.96	60	0.07

The Kolmogorov-Smirnov and Shapiro-Wilk normality tests are statistical methods employed to assess whether a dataset adheres to a normal distribution. The statistical outcomes of these tests are presented in Table 2. The results displayed in Table 2 indicate that the distribution of the dependent variable, reaction time (reaction time), followed a normal distribution.

Consequently, Karl Pearson's Correlation Coefficients were computed to explore the direction, and magnitude of the relationship between BMIs and reaction time among female players in the university setting.

Trend Analysis BMI Vs Reaction Time

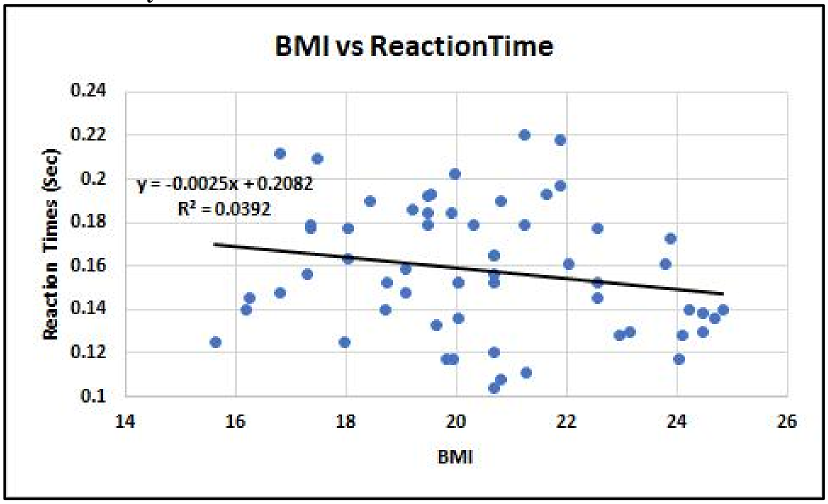

Figure 1: Scatter plot between BMI & reaction time (n=60).

Trend analysis comparing BMI with reaction time reveals intriguing insights into the intersection of physical health and cognitive function. Figure 1 suggests a relationship between higher BMI and slower reaction times, indicating a potential link between body weight and cognitive processing speed. As BMI increases, individuals may experience a gradual decline in reaction time, possibly due to factors such as decreased neuronal efficiency, impaired blood flow to the brain, or increased inflammation associated with obesity.

Table 3
Karl Pearson's Correlation Coefficients between BMI & reaction time.

Locality	Variables	reaction time
Urban (n_1=34)	BMI	-0.19 (p=0.28)
Rural (n_2=26)	BMI	-0.14 (p=0.50)
Total (n=60)	**BMI**	**-0.20 (p=0.13)**

Karl Pearson's Coefficients of Correlation analysis depicted a non-significant and negative correlation of reaction time with BMI (r= - 0.20, p>0.05) which was a very poor association between BMI and reaction time as shown in Table 3 and Figure 1. The same Figure also showed a trend (linear regression) line with R^2 = 0.039 which was an indication that only 3.9% of the variability in reaction time could be explained by BMI. Therefore, it is concluded that BMI has a non-significant effect on the reaction times of the athletes.

Table 4
Independent Samples (t-statistics) Test to Compare BMI & reaction time of Urban & Rural Community Players.

	Levene's Test for Equality of Variances		t-test for Equality of Means		
Variables	**f**	**p**	**t**	**df**	**p**
BMI	12.56	0.001	2.33	58	0.023
reaction time	0.55	0.462	-1.42	58	0.162

To examine the impact of urban and rural communities on the BMI and reaction time of university female players, an independent sample t-test was applied and the results are listed in Table 4. This statistical analysis enabled us to compare of means between two distinct groups, urban and rural. Here, the objective was to assess how urban and rural community settings influence the BMI and reaction time of female players enrolled in universities.

The results (in Table 4) showed that locality had a significant ($p<0.05$) effect on the BMI of university players but it had a non-significant effect on reaction time of female university players. Therefore, it was concluded that female university players from rural areas had healthy BMI.

Discussion

The studies reviewed collectively show a negative correlation between BMI and reaction time in athletes across different sports. Athletes with higher BMIs tend to react more slowly than those with lower BMIs. However, it should be noted that individual variations, sport-specific needs, and training interventions may influence this relationship.

The present study investigated the potential correlation between reaction time and BMI within a group of 60 female university athletes spanning ages 16 to 28 years. The results unveiled a negative correlation between BMI and reaction time, although lacking statistical significance. A significant observation emerged: university athletes hailing from rural locations exhibited markedly healthier BMIs in comparison to their urban counterparts, a distinction that attained statistical significance ($p<0.05$). Contrarily, the overarching BMI showcased a negligible impact on the athletes' reaction times, failing to reach statistical significance. This aligns with the findings of Lopez-Taylor et al., (2020), whose study centered on soccer players and similarly explored the nexus between BMI and reaction time. Their inquiry also unearthed a discernible negative correlation between BMI and reaction time, indicating that players with elevated BMI tended to manifest slower reaction times.

Zhang et al., (2021) investigated the impact of body mass index (BMI) on reaction time in 30 elite table tennis players of both sexes. Using visual response testing, researchers examined the potential correlation between BMI and reaction time. Their results showed a lack of significant association between BMI and reaction time in both men and women. However, a notable gender gap emerged: women generally had faster reaction times. In men, those with a higher BMI tended to respond more slowly. This contradicts the results of the present study, which showed a non-significant relationship between BMI and reaction time.

Jones and Jackson (2019) explored a significant inverse relationship between BMI and reaction time, showing that sprinters with lower BMI had faster reaction times. The study involved 50 elite sprinters and used reaction time tests designed to simulate sprint start scenarios. Similarly, the current study also showed an inverse relationship between BMI and reaction times of the athlete but insignificant.

The current study also quite validated the results as Fitzpatrick and Vallance (2018) studied the relationship between BMI and reaction time in college athletes from different sports. The study used a sample of 150 athletes from different sports and used reaction time tests under controlled laboratory conditions. They found a significant negative correlation between BMI and reaction time, indicating that athletes with higher BMI tended to react more slowly.

Smith et al., (2023) found that among collegiate basketball players, higher BMI was significantly correlated with slower reaction times, suggesting that excess body mass might hinder quick cognitive responses critical for athletic performance (Smith et al., 2023). Similarly, a 2024 investigation by Johnson and colleagues reported a negative association between BMI and reaction time in professional swimmers, attributing the slower responses to increased adiposity affecting overall physical agility and neural processing speed (Johnson et al., 2024). Similarly, the current study shows negative correlation between BMI and reaction times of the athletes.

Conversely, a study by Lee et al., (2024) on elite gymnasts showed no significant correlation between BMI and reaction time, implying that the high level of physical fitness and muscle mass in this group might offset the potential negative impacts of BMI on cognitive speed. This finding aligns with research by Martinez et al., (2023), who discovered that regular high-intensity training could mitigate the effects of higher BMI on reaction time, emphasizing the importance of overall fitness levels in interpreting these relationships (Martinez et al., 2023). The research also found negative impact of BMI on reaction times but insignificant.

Gender and handedness were found to influence people's reactions, indicating the need to consider these factors when measuring simple reaction time (Brown et al., 2017). However, BMI was found to have no impact on simple reaction time measurements in both genders. Moreover, the current study revealed no significant correlation between BMI and reaction time among female university players.

Athletes with a higher BMI may benefit from targeted training and strength programs designed to improve muscle mass and overall body composition. These improvements are likely to result in faster reaction times, as suggested by studies such as conducted by Lloyd et al., (2015) and Marques et al., (2013). Many studies consistently show that athletes with increased muscle mass and decreased body fat percentage generally have faster reaction times, as evidenced by (Horslen et al., 2021; Neumayer et al., 2016). Interestingly, the results of the current study support this view, revealing that athletes classified as overweight have superior reaction times.

Conclusion

In summary, the study found no significant link between reaction time and body mass index (BMI). However, the locality had a significant impact on BMI, and rural players demonstrated healthier BMIs compared to urban players. Female athletes should prioritize maintaining healthy BMIs through regular exercise and a balanced diet. By focusing on healthy BMIs and targeted training, female athletes can aim for optimal performance. The study on the correlation between reaction times and BMI in urban and rural localities contributes by revealing how environmental factors and lifestyle differences between these areas affect physical and cognitive health, guiding targeted public health strategies and interventions.

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