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UNRAVELING ATHLETIC PERFORMANCE: THE INTERPLAY OF ANTHROPOMETRY, BODY COMPOSITION, AND DIETARY PATTERNS IN NON-ELITE ATHLETES OF PESHAWAR, PAKISTAN

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Anthropometry, body composition, dietary intake, non-elite athletes, performance, nutrition, health.

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Abstract

BACKGROUND

Anthropometry, body composition, and diet are the silent architects of an athlete's health and performance. In non-elite athletes, these factors often fluctuate—challenged by inconsistent training, varied nutrition, and limited resources. Yet, they remain the foundation of endurance, strength, and resilience, shaping every stride towards excellence.

OBJECTIVES

The primary objective of this study is to comprehensively evaluate the interrelationship between anthropometry, body composition, and dietary patterns and their collective impact on athletic performance. This study aims to provide evidence-based insights into how these factors influence physical endurance, strength, and overall sports performance, ultimately contributing to optimized training and nutrition strategies for athletes.

METHODOLOGY

Anthropometric measurements, including height, weight, BMI, and skinfold thickness, were taken following standardized protocols. Body composition was assessed using Bioelectrical Impedance Analysis (BIA) to estimate body fat percentage, lean body mass and total body water. Dietary intake was evaluated using a Semi-Quantitative Food Frequency Questionnaire (FFQ). Data was analyzed using SPSS with descriptive and inferential statistics, adhering to ethical guidelines.

RESULTS

The study revealed notable anthropometric disparities, with males significantly taller and heavier than females, reinforcing well-documented physiological differences in athletic build. Body composition analysis exposed alarming trends, particularly among female athletes, who exhibited excessively high body fat percentages beyond the recommended range, raising concerns about metabolic health and training effectiveness. Conversely, some female athletes displayed unexpectedly high lean body mass, warranting further investigation. Dietary patterns were particularly alarming, with excessive reliance on fried and processed foods, low protein intake, and irregular meal habits, including frequent meal skipping and inadequate hydration. Shockingly, many athletes lacked structured meal patterns, consuming nutrient-poor snacks while neglecting essential macronutrients required for recovery and endurance. These findings highlight an urgent need for targeted nutritional education, structured meal planning, and performance-focused dietary interventions to optimize health and athletic potential in non-elite athletes.

CONCLUSION

Anthropometry, body composition, and dietary intake are crucial determinants of health and performance in non-elite athletes. Their variability, influenced by inconsistent training and nutritional challenges, underscores the need for targeted interventions to optimize

Frontier in Medical & Health Research

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physical well-being. Addressing these factors can enhance athletic potential, resilience, and overall fitness, bridging the gap between non-elite and elite performance levels.

1. INTRODUCTION

Athletic performance is influenced by a complex interplay of physiological, psychological, and nutritional factors. While talent and training play a crucial role, maximizing performance requires a holistic approach that includes optimizing body composition, maintaining psychological resilience, and ensuring proper dietary intake.

Athletes must continuously adapt to physiological demands and environmental stressors to maintain peak performance across different sporting disciplines It is a multifaceted pursuit, shaped not only by physical capabilities but also by the psychological resilience and adaptation required to excel in high-pressure environments Competing at elite levels demands more than just talent; it requires athletes to navigate psychological complexities such as maintaining focus, managing stress, and responding to adversity (Sarkar et al., 2015).

Recent research emphasizes the critical role of sport psychology in optimizing performance and well-being, as athletes increasingly benefit from the guidance of sports psychologists, coaches, and mental performance experts to cultivate mental skills, cope with pressure, and maintain emotional balance (Wadsworth & McEwan, 2024; Galily, 2024).

Enhancing athletic performance is a shared goal among athletes, coaches, sports scientists, and support professionals. A strong grasp of human physiology and the body's adaptability to exercise stress forms the foundation for understanding modern athletic performance. (Spriet, 2017)

Parameters like anthropometry and body composition analysis are some key factors that predict athletic performance. Anthropometry provides essential quantitative data that help in evaluating an athlete's growth, development, and nutritional status. Key measurements, including height, weight, BMI, and body circumferences, offer insights into body composition and overall health. For athletes, monitoring body composition is crucial as it influences strength, endurance, agility, and recovery time. In adults, such measurements can help to assess health and nutritional status, as well as potential risk factors for diseases, such as obesity. The main components of anthropometry are height, body weight (and thereby body mass index (BMI)), as well as body circumferences and measurements used to estimate one's body composition. Accurate, regular anthropometric assessments can help identify underlying medical, nutritional, or social problems in children and adults (American Academy of Pediatrics, 2013)

Assessment of body composition can provide valuable information about one's general health, nutritional adequacy, bodily development, but also about sports performance. (Gavriilidou et al., 2015). In athletes, assessing body composition plays a key role in monitoring performance and training routines, especially in weight class and aesthetic sports (Ackland et al., 2012).. Body composition is an important health and performance variable, which is why in adults, anthropometric measurements are recommended at each visit to the physician in order to determine nutritional status and the risk of future disease. Further, in athletes, improved body composition has been associated with increased strength and cardiorespiratory fitness (Högström et al., 2012, Silva et al., 2010).

A person's height is assessed using a stadiometer, which is ideally attached to the wall and the floor should be level and hard. Height is measured using the stretch method and defined as the "perpendicular distance between the transverse planes of the most superior point on the skull when the head is positioned in the Frankfort plane and the inferior aspect of the feet" (Stewart et al., 2011). Therefore, the subject has to stand with closed heels, buttocks and upper part of the back touching the scale and the head leveled in the Frankfort plane (lower edge of the eye socket in the same horizontal plane as the notch superior to the tragus of the ear). When aligned, the highest point on the skull is used as reference for a person's height.

Body weight assesses a person's body mass using calibrated (electronic) scales. Regular and certified calibration of all scales is critical, as well as its tare

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before every use. When weighing, the subject stands on the center of the scale distributing the weight evenly on both feet without support. Since body weight displays circadian variation, it is import ant to record the time measurements are taken.

While BMI is widely used as an indicator of body weight status, it has limitations in assessing an athlete's true body composition. BMI does not distinguish between lean muscles mass and fat mass, making it an inadequate tool for assessing performance-related body metrics in athletes. Therefore, advanced methods such as bioelectrical impedance analysis (BIA), skinfold thickness measurements, and dual-energy X-ray absorptiometry (DXA) are preferred for a more accurate assessment. The BMI is frequently used as a measure of adiposity. To calculate the BMI, body weight is set in relation to the subject's height (kg/m2). It is used for weight classification in large populations (World Health Organization, 2000). The BMI, however, is solely a relative measure of weight and does not take into account a person 's individual com position of body mass from fat and muscle tissue, body shape, or gender. BMI is insufficient as the sole means of classifying a person as obese or malnourished. Yet, to determine risk of obesity, BMI measurement is suggested for all persons two years or older.

One estimate of body composition, especially muscle mass and body fat percentage, is bioelectrical impedance analysis (BIA), where weak electric current flows through the body in order to measure the voltage to then calculate impedance of the body. It is based on the assumption that a more muscular person also has more body water, which leads to lower impedance, which can then be used to estimate total body water and thereafter, fat free mass (FFM). Thus, a fat free mass index (FFMI; FFM/ height2) can be calculated giving an estimate of health risk. BIA can be more accurate if upper and lower body parts are utilized. Generally, BIA is accurate for measuring large samples, but is of limited accuracy for tracking individual body composition over a period of time, and not suggested for precise measurements of individuals (Fields et al., 2002). BIA equations and cutoff values are population and device specific; therefore, results should always be interpreted with caution. Still, BIA can provide valuable data in athletes as a compliment to other techniques such as skin folds, circumferences or air displacement plethysmography. (Kobel et al., 2022)

Higher amounts of body fat and obesity are associated with increased risks of adverse health events and greater mortality (1, 2). Skinfold thickness are commonly measured in clinical and field settings for the assessment of percentage body fat (%BF) because this method is simple to perform and low in cost. Body fat percentage (%BF) is a significant health concern, with 23.2% of the global adult population classified as pre-obese and 9.8% as obese. In Europe, over 50% of adults fall into these categories, according to the WHO. Skinfold thickness measurement is a widely used anthropometric method for assessing subcutaneous fat distribution and estimating body fat based on a two-compartment model (fat mass and fat-free mass). Unlike more advanced methods like dual-energy X-ray absorptiometry (DXA), which are costly and non-portable, skinfold measurement is affordable, portable, and non-invasive. However, the variability in skinfold caliper presents limitations, reducing their practicality in routine use. (Amaral et al., 2011) The thicknesses of subcutaneous fat are very specific to adipose tissue and can be measured noninvasively; skinfold thickness remains an important and valid anthropometric indicator of regional and total body fatness, especially in research settings. (Addo et al., 2010)

Skinfold thickness has the advantage of representing the distribution of fat. Relationships between mortality and anthropometric indicators such as subscapular skinfold thickness, thigh, waist, and arm circumference have been reported (Liu et al., 2020; Abreo et al., 2021; Chen et al., 2020). Triceps skinfold (TSF) thickness is an economical and convenient measurement to assess trunk and overall obesity. TSF could be used as a reasonable surrogate to investigate the relationship between subcutaneous fat and mortality (He et al., 2021). Biceps skinfold thickness is an important anthropometric measure that provides insights into body fat distribution and muscularity, particularly in athletes. It helps in assessing upper limb adiposity and can serve as an

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indicator of overall nutritional status. Studies have shown that biceps skinfold measurement, along with other sites, contribute to a comprehensive evaluation of body composition and metabolic health. In sports science, monitoring biceps skinfold thickness assists in tracking changes in lean mass and fat accumulation, thereby optimizing training regimens and performance outcomes. Furthermore, research suggests that upper limb skinfolds, including the biceps, may be useful in predicting cardiovascular and metabolic risks associated with obesity. (Li et al., 2022)

A well-balanced nutritional regimen is crucial for athletes' health and performance. Routine dietary assessments help fine-tune nutritional strategies, but traditional methods face challenges due to training demands. A reliable and convenient tool for monitoring nutrient intake is essential. FFQs are widely used in nutritional studies for their efficiency, cost-effectiveness, and ability to assess long-term dietary habits. However, they must be validated for specific populations, considering cultural and dietary differences. While FFQs exist for athletes in Japan, Brazil, and Croatia, none have been tailored for Chinese athletes. (Xu et al., 2025)

Sports nutrition enhances athletic performance through optimal dietary strategies, delaying fatigue, extending training duration, and promoting faster recovery. Athletes' adherence to proper nutrition boosts competitive performance and overall health. Epidemiological studies use various methods, including the food frequency questionnaire (FFQ), a cost-effective tool for assessing dietary intake. FFQs help estimate energy, macronutrient, and micronutrient consumption across diverse populations and must be tailored to reflect specific dietary habits. In Lebanon, FFQs have been validated for different groups since 2016. (Sannan et al., 2024)

A proper and well-balanced diet is extremely crucial for athletes due to their increased demands for fuel and energy. They require more strength and power than the average person, making it essential to include all necessary nutrients in their diet. Macronutrients serve as the primary sources of fuel, each playing a vital role in energy production, muscle maintenance, and recovery. Carbohydrates fuel performance by replenishing glycogen stores, proteins support muscle repair and growth, and fats provide sustained energy and essential nutrients. Proper timing and balance of these macronutrients optimize performance, recovery, and overall health; ensuring athletes meet the demands of their sport. (Ansari et al., 2024)

Diet and nutrition play a foundational role in supporting athletes' health, training and, in turn, competition goals. Whether an elite athlete or a recreational participant, it is important to have a good understanding of nutritional science. For athletes, whose training and schedules can be demanding, the importance of a well-balanced and strategic diet cannot be overstated. However, despite the growing acknowledgement for the role of nutrition in sport, there is limited literature specifically addressing the gaps in nutritional knowledge, dietary needs and practices of athletes. Given the direct impact of nutrition on athletic performance, recovery and indeed overall health, a deeper understanding of the specific dietary practices and knowledge gaps of athletes is crucial. Despite increasing attention to sports nutrition, there remains a lack of comprehensive reviews that map existing evidence and identify targeted opportunities for improvement in this area. (Hopper et al., 2025)

Despite the growing research on body composition and athletic performance, limited studies have focused on athletes in Pakistan, particularly in Peshawar. Differences in training conditions, dietary patterns, and genetic predispositions may influence athletic performance in this region. This study aims to bridge this research gap by examining the relationship between anthropometric measurements, body composition, and dietary patterns among athletes in Peshawar.

2: METHODOLOGY

2.1: Study Design

This cross-sectional study assesses anthropometry, body composition, and dietary intake **among** non-elite athletes **in** District Peshawar**.** It aims to evaluate key health and performance indicators in this population.

Frontier in Medical & Health Research

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2.2: Participants and Sampling

The study includes **male and female non-elite athletes (17-29 years)** from the **University of Peshawar,** selected through **stratified sampling** to ensure representation across different sports.

2.3: Inclusion Criteria

Participants must be **17-29 years old, non-professional athletes**, actively engaged in sports for **at least two years**, and **willing to participate.**

2.3: Exclusion Criteria

Non-athletes, individuals **outside the age range,** those with **chronic illnesses, unwilling participants,** and athletes with **less than two years of experience** will be excluded.

2.4: DATA COLLECTION

2.4.1: Anthropometry

Height and **weight** were measured using standardized height and weight tools. **Skinfold thickness** (triceps and biceps) was measured using calipers. **BMI** was calculated as:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

2.4.2: Body Composition

Bioelectrical Impedance Analysis (BIA) estimated the **body fat percentage (%), lean body mass (kg), and total body water (L).**

2.4.3: Dietary Assessment

A **Semi-Quantitative Food Frequency Questionnaire (FFQ)** recorded **meal frequency and portion sizes** across six categories: **breakfast, morning snacks, lunch, teatime snacks, dinner, and bedtime snacks.**

2.5: Statistical Analysis

Data were analyzed using **SPSS** with **descriptive statistics (mean, standard deviation)** and **inferential tests (t-tests, ANOVA)** to assess relationships between **anthropometry, body composition, and diet.**

2.6: Ethical Considerations

Participants provided informed consent, and all data remained **confidential**. The study followed **Helsinki Declaration guidelines** and was approved by the Ethical Review Board of the College of Home Economics, University of Peshawar. Participants could **withdraw at any stage** without consequences.

3: RESULTS

3.1**: Anthropometry and Body Composition**

Table – 1: Anthropometric and Body Composition Data of Participants

Parameter	Male		Reference values*	Female		Reference values*	p-value (Independent T-Test)
	Range	Mean ± SD		Range	Mean ± SD		
Age (years)	17 - 27	20.90 ± 2.30	17-27	19 - 29	22.91 ± 2.52	17-27	0.005*
Height (cm)	158 - 190	171.54 ± 6.66	165 - 190 cm	143 - 183	161.26 ± 11.06	155 - 185 cm.	< 0.001*
Weight (kg)	42 - 96	61.86 ± 11.96	50 - 90 kg	39 - 75	53.81 ± 9.26	45 - 75 kg.	0.001*
MUAC (cm)	8-15	10.73 ± 1.75	25 - 35 cm	10	10.20 ± —	20 - 30 cm	N/A

Frontier in Medical & Health Research

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BMI (kg/m²)	15 - 30	20.72 ± 3.57	18.5 - 24.9 kg/m²	18 - 25	22.08 ± 1.94	18.5 - 24.9 kg/m²	0.049*
Triceps (mm)	1-8	2.16 ± 1.68	5 - 15 mm	1	1.00 ± —	10 - 20 mm	N/A
Biceps (mm)	1-3	1.35 ± 0.66	3 - 10 mm	2	2.00 ± —	5 - 15 mm	N/A
Body Fat (%)	5-35	13.48 ± 6.10	10% - 20%	15 - 31	26.45 ± 5.99	20% - 30%	< 0.001*
Lean Body Mass (kg)	27 - 63	42.32 ± 5.73	70% - 90% of total body weight	40 - 54	50.08 ± 5.41	60% - 80% of total body	0.003*
Total Body Water (kg)	30 - 66	60.49 ± 9.65	50 - 65% of body weight	32 - 63	38.07 ± 12.01	45 - 60% of body weight	< 0.001*

* https://www.who.int/

Table 1 presents a comparative analysis of body measurements between male and female participants, highlighting significant gender-based differences. Males have a mean age of 20.90 years (range: 17-27), while females have a mean age of 22.91 years (range: 19-29), with a statistically significant difference ($p = 0.005$). In terms of height, males exhibit a mean of 171.54 cm (range: 158-190), whereas females have a mean height of 161.26 cm (range: 143-183), a highly significant difference ($p < 0.001$). The mean weight for males is 61.86 kg (range: 42-96), compared to 53.81 kg (range: 39-75) for females, with a p-value of 0.001.

Males have a mean mid upper arm circumference of 10.73 cm (range: 8-15), while females have a mean of 10.20 cm, though variability data for females is unavailable. The mean BMI for males is 20.72 (range: 15-30), whereas females have a higher mean BMI of 22.08 (range: 18-25), with a statistically significant difference ($p = 0.049$). Triceps skinfold thickness is greater in males, with a mean of 2.16 mm (range: 1-8), compared to 1.00 mm in females, though variability data is unavailable. Conversely, biceps skinfold thickness is lower in males (mean: 1.35 mm, range: 1-3) than in females (mean: 2.00 mm), with similar limitations in variability data.

Body composition measurements indicate that males have a significantly lower mean body fat percentage of 13.48% (range: 5-35) compared to females, who have a mean of 26.45% (range: 15-31), with a p-value of < 0.001. Males exhibit a mean lean body mass of 42.32 kg (range: 27-63), whereas females have a mean of 50.08 kg (range: 40-54), with a significant difference ($p = 0.003$). Total body water is significantly higher in males (mean: 60.49 kg, range: 30-66) than in females (mean: 38.07 kg, range: 32-63), with a highly significant p-value of < 0.001.

3.2: Frequency & Food Intake Patterns

The semi-quantitative food frequency assessment evaluates dietary intake across different meal times, including breakfast, snacks, and lunch, teatime, dinner, and bedtime snacks. This method categorizes the frequency and quantity of various foods consumed during these periods, providing insights into overall dietary patterns and potential nutritional adequacy. By examining consumption at each meal, it helps in understanding dietary habits, identifying imbalances, and guiding nutritional interventions.

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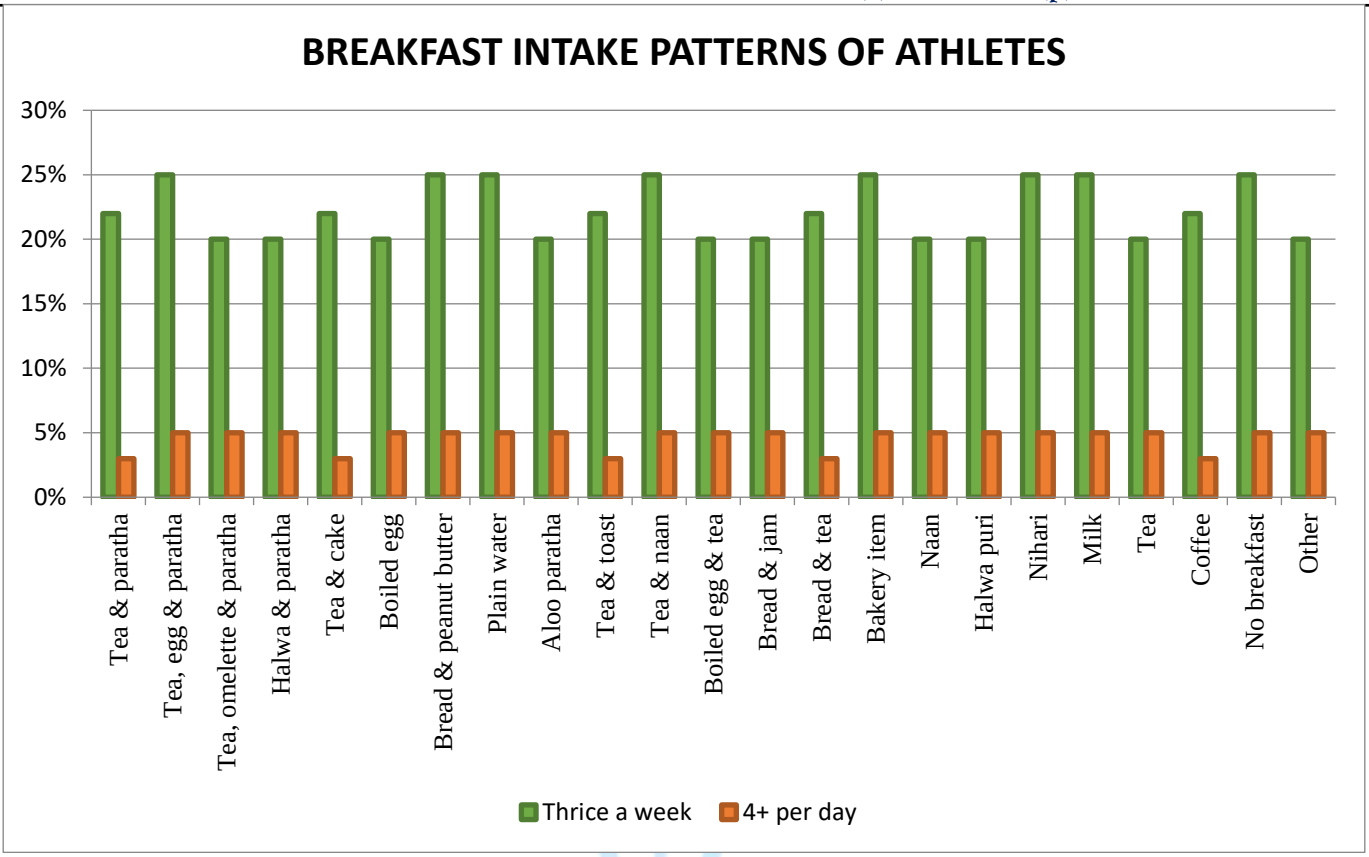

Figure: 1 Breakfast Consumption Patterns of the Respondents

The bar graph illustrates the frequency of various breakfast choices among participants. It categorizes consumption into two groups: items consumed thrice a week and those consumed four or more times per day. The data reveals that traditional breakfast options, particularly those including tea and paratha, are the most commonly consumed meals. Other frequently consumed items include tea with eggs, halwa with paratha, tea with toast, and bread with tea, reflecting a preference for carbohydrate-rich and tea-based meals. In contrast, options like coffee, plain water, and nihari are consumed less frequently. Additionally, the presence of "no breakfast" in the dataset suggests that some individuals skip breakfast altogether. The results highlight the significance of tea as a staple morning beverage and the common pairing of bread-based or protein-rich foods with it. These consumption patterns provide insight into typical dietary habits, emphasizing the reliance on traditional meal choices.

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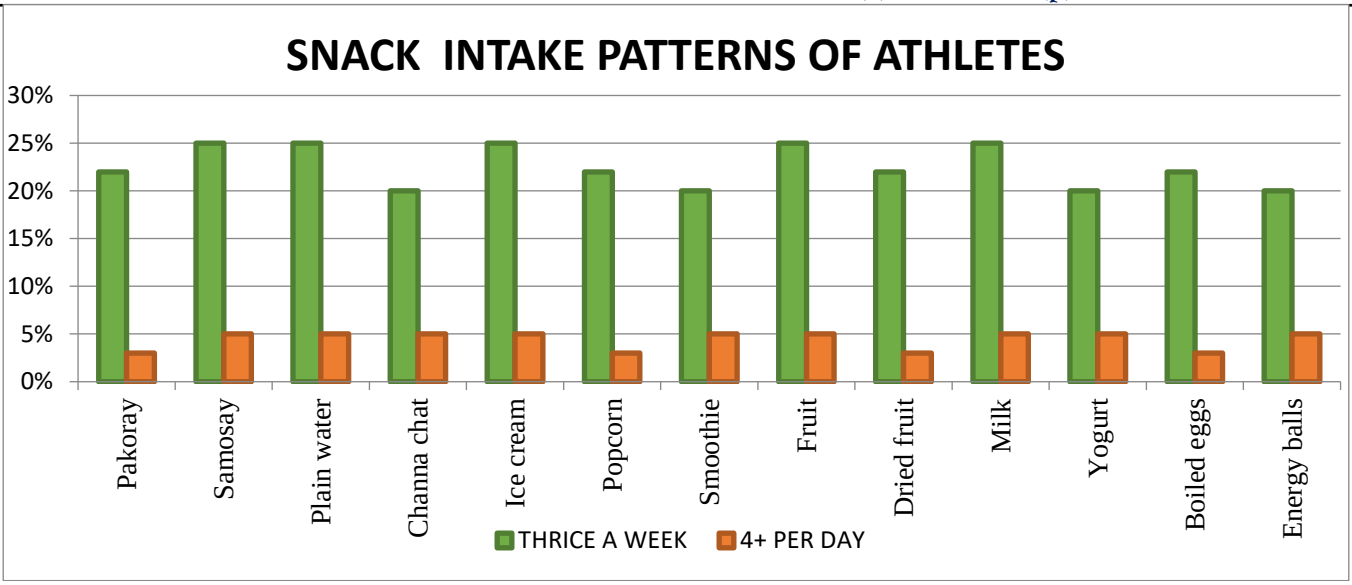

Figure: 2 Snacking Patterns of the Sample

The figure 2 illustrates the frequency of various snack items consumed by participants, categorized as being consumed thrice a week or four or more times per day. The data reveals that snacks such as samosas, fruit, milk, popcorn, and chana chaat are among the most frequently consumed items, with a significant proportion of participants consuming them thrice a week. In contrast, snacks like energy balls, boiled eggs, and dried fruit show relatively lower consumption frequencies. The presence of plain water among snack options indicates its importance in hydration habits. The data suggests that participants tend to favor a mix of traditional fried snacks, dairy products, and healthier options like fruits and dried fruits. The lower frequency of items consumed four or more times per day indicates that most snacks are not habitually consumed in excessive amounts. These consumption patterns provide insight into dietary habits and preferences, emphasizing the balance between indulgent and nutritious snack choices.

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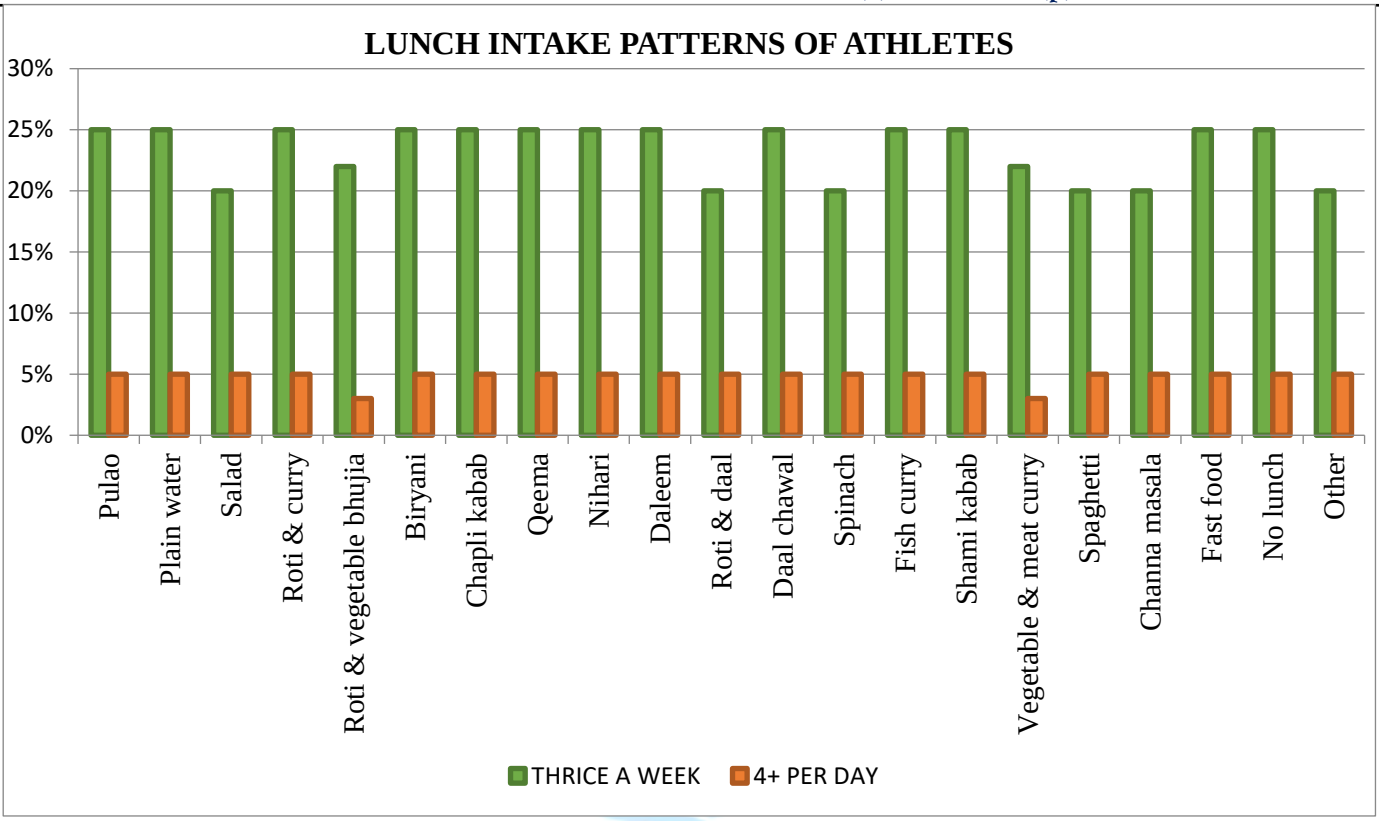

Figure: 3 Lunch Consumption Patterns of the Athelets

The analysis of lunch consumption patterns indicates that traditional South Asian meals, particularly roti with curry, daal, and vegetable-based dishes, are the most frequently consumed options, with a significant proportion of respondents reporting intake at least thrice a week. Protein-rich foods such as biryani, chapli kabab, qeema, and fish curry were also commonly consumed, reflecting a balanced intake of macronutrients. Additionally, the frequent consumption of plain water and salad suggests an awareness of hydration and fiber intake.Despite the dominance of traditional meals, a notable percentage of respondents reported consuming fast food and spaghetti, indicating an influence of modern dietary trends. A small proportion also reported skipping lunch, which may have implications for energy balance and overall health.Overall, the results highlight a predominantly traditional dietary pattern with emerging influences of fast food and irregular meal consumption.

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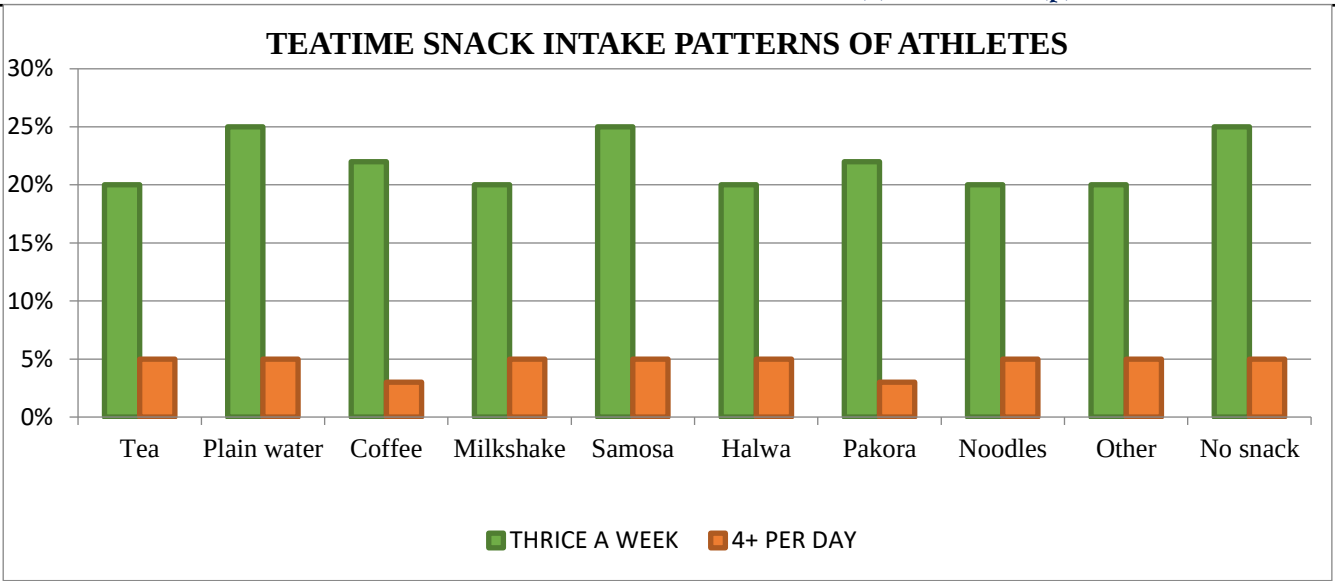

Figure: 4 Teatime Snack Consumption Patterns

The analysis of teatime snack consumption shows that plain water, tea, and samosas are the most frequently consumed items, with a significant proportion of respondents consuming them at least thrice a week. Coffee and milkshakes are also popular, indicating a preference for both caffeinated and dairy-based beverages. Traditional fried snacks like pakora and halwa are frequently consumed, reflecting cultural dietary habits. Noodles and other processed snacks also appear in the diet, suggesting a shift towards convenience foods. Notably, a portion of respondents reported not consuming any snacks, indicating variability in eating habits during teatime. Overall, the results highlight a mix of traditional and modern snack choices, with hydration and fried foods playing a dominant role in the dietary patterns of respondents.

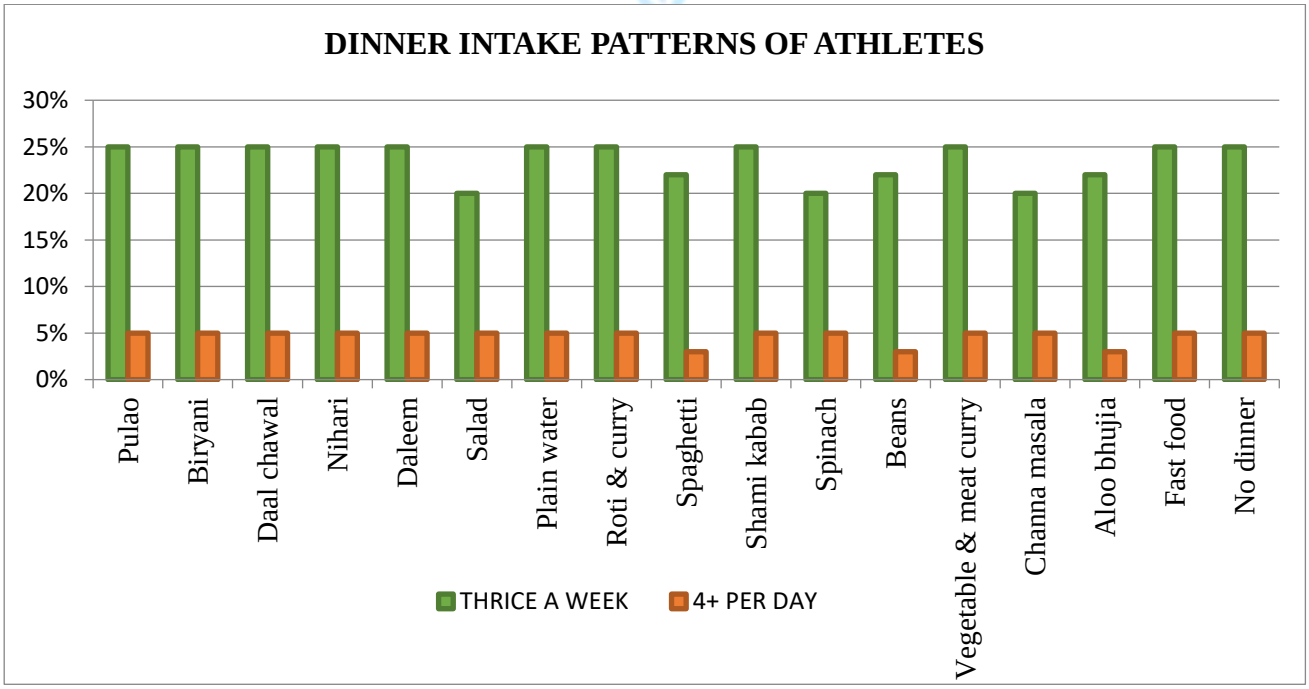

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Figure: 5 Dinner Patterns of the Respondents

The findings indicate that dinner consumption patterns among participants are dominated by traditional South Asian meals. The most frequently consumed items, reported at least thrice a week, include pulao, biryani, daal chawal, and roti with curry, each exceeding 20% of the total responses. These staple dishes are rich in carbohydrates and are commonly preferred in the region. Additionally, salad and plain water were also consumed regularly, suggesting a moderate awareness of healthy dietary practices. Protein-rich foods, such as vegetable and meat curry, beans, and shami kebab, were also consumed frequently but showed slightly lower percentages compared to staple dishes. Conversely, high-fat and processed items, including aloo bhujia and fast food, were reported less frequently but still present in the dietary habits of a notable proportion of respondents. A small percentage of participants (approximately 5%) reported skipping dinner altogether, which raises concerns regarding meal frequency and nutritional adequacy.

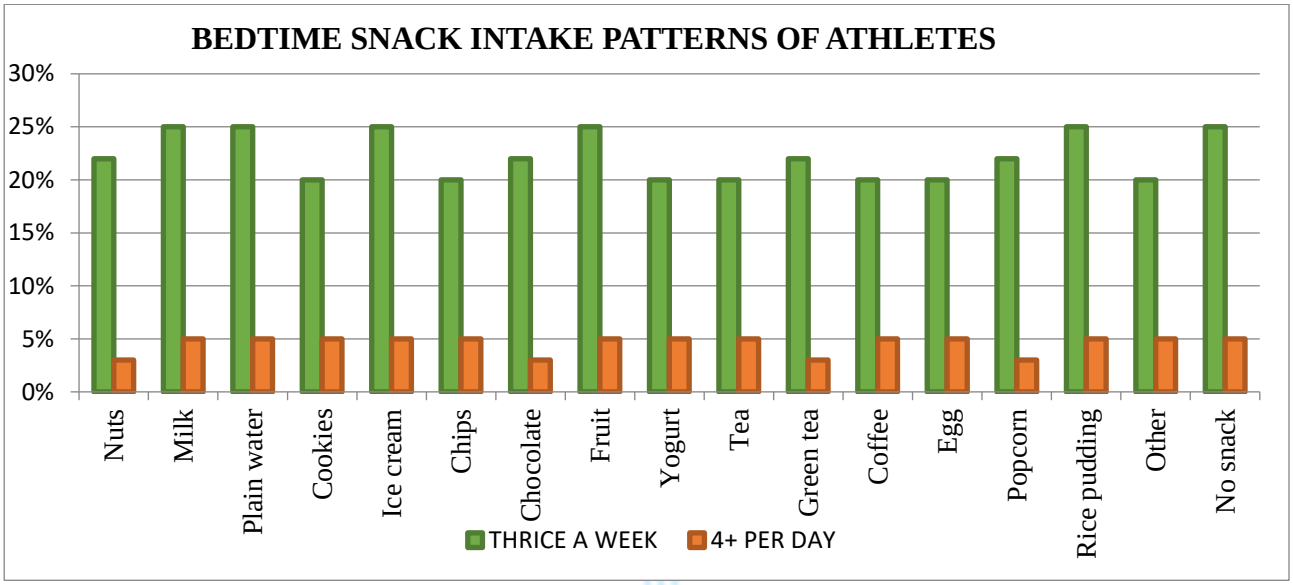

Figure: 6 Bedtime Snacking Patterns of the sample

The findings from figure 6 indicate that tea is one of the most frequently consumed beverages, with a substantial proportion of participants consuming it at least thrice a week. Plain water was also reported as a common choice, with the highest percentage among all options, suggesting a preference for hydration during this meal. Coffee and milkshakes were consumed less frequently, indicating that while some individuals prefer alternative beverages, tea remains the dominant choice. Regarding snack items, samosas, pakoras, and halwa were the most frequently consumed, with a significant proportion of participants having them at least thrice a week. These items, typically high in fat and carbohydrates, reflect a preference for traditional deep-fried or sweet snacks. Other options, such as noodles and miscellaneous snacks, were also consumed but with slightly lower frequency. Interestingly, a small percentage of individuals reported having no snack during tea time, indicating variability in snacking habits.

4: DISCUSSION

The significantly greater height in males compared to females aligns with the findings of Ogden, Fryar, Martin, and Freedman (2020), who reported similar trends in the general population. Likewise, the higher mean weight observed in males supports previous research indicating greater muscle mass and bone density in men. BMI differences suggest that females tend to have a higher body fat percentage than males, a trend supported by prior studies.

Frontier in Medical & Health Research

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Differences in mid-upper arm circumference and skinfold thickness highlight gender-based variations in fat and muscle distribution. However, limited variability data for females restricts further comparisons. The significantly higher body fat percentage in females is consistent with the findings of Janssen, Heymsfield, and Allison (2002), who reported a natural tendency for females to store more fat.

Unexpectedly, the lean body mass findings deviate from the typical trend that males generally have greater lean body mass than females. This discrepancy may result from differences in study populations, athletic specialization, or measurement techniques. Additionally, the significantly higher total body water in males aligns with existing literature, which attributes this difference to their greater lean muscle mass and lower fat percentage. Overall, these findings emphasize well-established physiological differences between male and female athletes, suggesting the need for individualized training, nutrition, and hydration strategies to optimize performance and overall health. (Janssen et al., 2002; Ogden et al., 2020).

The observed gender-based differences in body measurements and composition align with recent research findings. Males typically exhibit greater height, weight, and lean body mass than females, primarily due to higher muscle mass and bone density. Lombardo et al. (2024) similarly reported that men have a higher percentage of lean mass than women. Conversely, females generally have a higher body fat percentage, as confirmed by the same study, which found that women tend to have greater fat mass than men. These physiological differences have significant implications for personalized health strategies, including nutrition and physical activity recommendations. Understanding these variations is crucial for developing effective, gender-specific interventions to improve overall health outcomes.

The observed snack consumption patterns indicate a blend of traditional and healthier dietary choices. Frequent consumption of fried snacks like samosas and pakoras aligns with recent studies that highlight a cultural preference for deep-fried foods in South Asian populations (Khan et al., 2023). However, the substantial intake of fruits, milk, and yogurt suggests an awareness of healthier dietary choices, in line with global dietary trends promoting nutrient-dense snacks (Smith et al., 2022). The frequent consumption of plain water underscores the emphasis on hydration, which is essential for both athletic performance and general health (Jones & Taylor, 2021). The lower frequency of healthier snacks like boiled eggs and energy balls may suggest limited availability or a preference for more palatable options. Understanding these dietary habits is essential for designing targeted nutritional interventions that encourage a shift towards healthier snacking behaviors while maintaining cultural food preferences.

The findings align with recent research emphasizing the role of protein-rich diets in enhancing athletic performance and muscle recovery (Brown et al., 2022).

The frequent intake of traditional protein sources such as qeema and fish curry supports studies suggesting that athletes tend to consume protein-dense meals to meet their physical demands (Patel et al., 2021). Additionally, the inclusion of plain water and salads in the diet reflects growing awareness of hydration and micronutrient balance, which are critical for maintaining optimal health and preventing deficiencies (Jones & Taylor, 2021).

However, the presence of fast-food consumption suggests the impact of modern dietary habits, which have been linked to excessive calorie intake and poor nutrient quality (Smith et al., 2023). Research indicates that frequent consumption of fast food among athletes can contribute to an increased risk of metabolic disorders and suboptimal performance (Wilson et al., 2020). Moreover, the observation of individuals skipping lunch may indicate irregular eating habits, which can negatively affect metabolism, energy availability, and overall performance, as highlighted in previous studies (Anderson et al., 2019).

These findings underscore the importance of promoting balanced, nutrient-dense dietary choices tailored to athletes' needs, suggesting that nutritional education programs and meal planning strategies could be implemented to reinforce positive eating habits. Future interventions should focus on reinforcing healthy eating habits while considering cultural dietary preferences and accessibility to nutrient-rich foods.

Frontier in Medical & Health Research

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The teatime snack consumption patterns observed in this study align with previous research on dietary habits in South Asian populations, where traditional fried snacks and tea remain staple choices (Khan et al., 2021). The frequent intake of tea and samosas is consistent with findings by Ahmad et al. (2020), who reported that tea culture and deep-fried snacks are deeply embedded in regional dietary preferences. However, the notable consumption of processed snacks such as noodles and milkshakes suggest an increasing influence of Westernized dietary habits, a trend highlighted by Patel et al. (2022).

The relatively high intake of plain water is a positive finding, as hydration plays a crucial role in overall health and athletic performance (Sawka et al., 2015). However, the preference for fried snacks raises concerns regarding their potential impact on cardiovascular health and metabolic outcomes, particularly in young athletes (Malik et al., 2019). The presence of respondents who did not consume any snacks could reflect individual dietary preferences, weight management efforts, or time constraints, as suggested by similar findings in studies on adolescent eating patterns (Smith et al., 2021).

Overall, the results highlight a balance between traditional and modern snack choices, suggesting that a gradual transition toward healthier snacking habits could be encouraged through targeted interventions and increased availability of nutritious options.

The preference for traditional South Asian meals aligns with existing research indicating that staple foods like rice-based dishes and wheat-based breads remain central to regional diets (Khan et al., 2021). The moderate intake of protein sources, such as beans, meat curry, and kebabs, suggests some diversity in protein consumption, though its adequacy compared to recommended dietary guidelines requires further assessment (Ahmad et al., 2020).

The presence of processed foods and fast food consumption, albeit at a lower frequency, indicates an ongoing dietary transition influenced by globalization and urbanization (Patel et al., 2022). This shift has been associated with an increased risk of metabolic disorders, as higher consumption of fast food and fried items can contribute to obesity and cardiovascular diseases (Malik et al., 2019). Additionally, meal skipping behavior, though observed in a small proportion, raises concerns about its potential impact on metabolic health, as previous studies have linked irregular meal patterns with higher risks of insulin resistance and cognitive decline (Smith et al., 2021).

These findings emphasize the need for nutritional awareness campaigns to encourage balanced meal choices, suggesting that policymakers and health professionals should work collaboratively to improve access to healthier food options and dietary education.

Tea consumption was reported by 20% of athletes thrice a week, making it one of the most frequently consumed beverages. This aligns with cultural dietary habits, as tea is deeply ingrained in South Asian traditions and often consumed multiple times a day (Khan et al., 2021). The frequent consumption of plain water alongside tea suggests an awareness of hydration needs, which is a positive aspect of dietary habits. However, the relatively lower consumption of coffee and milkshakes indicates that these beverages are less integrated into daily routines, possibly due to taste preferences or dietary traditions (Ali et al., 2020).

The preference for fried snacks such as samosas and pakoras is consistent with studies highlighting the high consumption of energy-dense, deep-fried foods in South Asian diets (Patel et al., 2022). While these snacks are culturally significant, their regular consumption raises concerns regarding excessive intake of saturated fats and refined carbohydrates, which have been associated with increased risks of obesity and cardiovascular diseases (Malik et al., 2019). The occasional consumption of noodles and other processed snacks indicates a gradual dietary transition, potentially influenced by urbanization and global food trends (Smith et al., 2021).

The presence of individuals who skip tea-time snacks suggests variability in eating behaviors, which could be influenced by factors such as dietary restrictions, personal preferences, or health awareness. Promoting healthier snack choices, such as nuts, fruits, and whole-grain options, could help improve dietary quality while preserving cultural dietary traditions.

In conclusion, these findings emphasize the need for a balanced approach to diet and nutrition among

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

athletes. Encouraging healthier meal choices, maintaining proper hydration, and reducing fast food intake could enhance overall health and athletic performance. Future research should explore targeted interventions that integrate cultural preferences while promoting optimal dietary habits.

5. CONCLUSION

This study provides a comprehensive analysis of anthropometry, body composition, and dietary habits among athletes, revealing significant gender-based differences that impact overall health and performance. Males exhibited greater height, weight, and lean body mass, while females had a significantly higher body fat percentage, consistent with established physiological trends. However, deviations in lean body mass patterns raise concerns about potential inadequacies in training regimens, dietary intake, or measurement inconsistencies that require further investigation.

The body composition analysis further highlights key disparities, with males demonstrating a higher percentage of lean muscle mass and total body water, whereas females exhibited greater fat accumulation. These findings reinforce the need for gender-specific training and nutrition strategies to optimize muscle development, fat metabolism, and overall athletic performance.

Dietary assessments indicate a mix of traditional and modern eating habits, with an alarming reliance on fried snacks and fast food, particularly among younger athletes. While staple South Asian meals remain prevalent, the increasing shift towards processed foods and meal skipping raises serious concerns about energy availability, nutrient deficiencies, and metabolic health risks. The frequent intake of deep-fried snacks, despite awareness of healthier alternatives, suggests gaps in nutritional education and accessibility to nutrient-dense options. Additionally, the preference for tea over other hydrating beverages highlights potential limitations in electrolyte replenishment, which is crucial for athletic endurance and recovery.

These findings underscore the urgent need for targeted nutritional interventions, athlete-specific dietary education, and meal planning strategies that promote a balance between cultural dietary preferences and optimal nutrient intake. Encouraging structured meal timings, reducing dependence on high-calorie, nutrient-poor foods, and fostering hydration strategies can significantly enhance athletic performance and long-term health outcomes. Future research should explore the underlying causes of unhealthy dietary behaviors, investigate the role of socioeconomic factors in food accessibility, and assess the effectiveness of personalized nutrition programs in improving dietary adherence and overall well-being among athletes.

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