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Correlation among calorie intake and energy expenditure of male Physical Education Students hosteller

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Abstract
This study critically examines the correlation between daily caloric intake and energy expenditure among 77 male hosteller students enrolled in Bachelor of Physical Education (B.P.Ed.) and Master of Physical Education (M.P.Ed.) programs at Aligarh Muslim University (AMU), India. Recognizing the physiological demands of high-intensity physical activity in competitive sports, the research employs validated anthropometric and metabolic equations to compute Basal Metabolic Rate (BMR), Resting Metabolic Rate (RMR), and Total Daily Energy Expenditure (TDEE). The analysis revealed a statistically significant mean daily energy deficit of 360.05 kcal ($p < 0.01$), with average TDEE ($M = 2{,}778.76$ kcal/day) consistently surpassing the reported mean caloric intake from standardized hostel meals ($M = 2{,}418.71$ kcal/day). Pearson correlation coefficients indicated strong positive relationships between body weight and all energy expenditure variables ($r = 0.94$–0.98, $p < 0.001$), and significant associations between Body Mass Index (BMI) and metabolic rates, suggesting systemic undernutrition among students with higher physical activity levels. Comparisons against global (WHO) and national (ICMR-NIN) dietary benchmarks further underscore the inadequacy of institutional meal provisioning for active male athletes. The study emphasizes the urgent need for personalized nutrition strategies, macro- and micronutrient optimization, and dietary periodization tailored to athletic workloads. The findings advocate for evidence-based interventions and policy reforms in university residential nutrition programs to ensure sustainable health, optimal recovery, and peak athletic performance. This research offers a novel contribution to the intersection of sports nutrition and institutional food policy, with implications for broader applications in collegiate and elite athlete management systems.

Keywords: Energy expenditure, calorie intake, basal metabolic rate, total daily energy expenditure, nutrition adequacy, nutritional interventions

Introduction

Balancing energy intake and expenditure is a critical determinant of health, physiological performance, and functional capacity in young adults, particularly those enrolled in demanding physical education (PE) programs (Loucks *et al.*, 2011; Muthuri *et al.*, 2019) [12, 13, 17]. This balance—regulated by caloric supply and its utilization through basal metabolism, structured training, and daily activities-is essential not only for sustaining athletic output but also for supporting cognitive function, immune competence, and psychological well-being (WHO, 2020; Burke *et al.*, 2019; Slater & Phillips, 2011) [3, 21]. Among highly active populations, such as PE students, the convergence of academic requirements and intensive physical workloads amplifies the necessity for precise nutritional adequacy (Ellis *et al.*, 2012; Kaur & Choudhary, 2020) [7, 10], making it a decisive factor in both immediate and long-term performance outcomes (Thomas *et al.*, 2016; Walsh, 2019) [24, 25].

Within the Indian higher education setting, this challenge is particularly evident in hostel-based PE cohorts. Centralized catering systems-such as the standardized mess arrangements at Aligarh Muslim University (AMU)-offer uniform menus that may not meet the diverse energy demands of active students (Sindwani *et al.*, 2016; Mishra *et al.*, 2018) [16, 20]. Evidence indicates that such restricted dietary flexibility can create chronic mismatches between caloric needs and intake. Inadequate energy provision is linked to fatigue, muscle catabolism, and impaired cognitive performance, whereas excess intake predisposes students to metabolic disorders and reduced athletic capacity (Jérôme Ribeyre *et al.*, 1999; WHO/FAO, 2002; Burke *et al.*, 2019) [3, 9].

The interplay between caloric consumption and energy expenditure is further complicated by adaptive physiological mechanisms, environmental conditions, and lifestyle variability. While Westerterp (2017) [26] and Ekelund *et al.* (2002) [5] report a general association between these factors, they also highlight inconsistencies arising from such influences. In the Indian context, an added paradox emerges: despite rising incomes, average caloric intake has declined, a trend attributed to shifts in dietary patterns, declining physical activity, and altered household consumption priorities (Deaton & Drèze, 2009; Basu & Basole, 2012; Eli & Li, 2020) [1, 4, 6]. Among athletes and PE students, existing literature consistently confirms increased requirements for both caloric density and nutrient adequacy to maintain training adaptations, recovery, and immune resilience (Burke *et al.*, 2019; Thomas *et al.*, 2016) [3, 24]. Nevertheless, multiple studies (Kaur & Choudhary, 2020; Kumari *et al.*, 2018) [10, 11] document persistent underconsumption relative to the recommended dietary allowances (RDA) among hostel-residing students, largely due to limited menu diversity and low nutritional literacy. Structural and curricular constraints within PE programs have also been identified as potential contributors to these imbalances (Mathew, 2025) [14].

Assessing the adequacy of dietary intake in active populations necessitates reliable estimation of key physiological parameters such as Basal Metabolic Rate (BMR), Resting Metabolic Rate (RMR), and Total Daily Energy Expenditure (TDEE) (Mifflin *et al*., 1990; Speakman & Selman, 2003) [15, 23]. BMR constitutes the largest proportion of TDEE, reflecting the minimal caloric requirement for essential physiological processes under standardized conditions. RMR, while conceptually similar, is marginally higher due to less stringent measurement protocols and is often preferred for field studies. TDEE integrates basal metabolic needs, the thermic effect of food, and energy expenditure from physical activity, which can vary substantially in athletic populations depending on the type, intensity, and frequency of training (Thomas *et al*., 2016) [24].

Against this backdrop, the present research investigates the association between daily caloric intake and estimated energy expenditure in male PE hostel students at AMU, spanning both B.P.Ed. and M.P.Ed. academic cohorts. Using validated computational models for BMR, RMR, and TDEE, the study aims to (i) evaluate the adequacy of energy intake relative to physiological requirements, (ii) identify inter-cohort differences, and (iii) propose evidence-based recommendations for optimizing institutional dietary provisions. The anticipated outcomes are expected to inform nutrition policy in residential academic environments and contribute to the broader discourse on energy balance in physically active student populations.

Methods and Materials

A convenience sampling approach was utilized to recruit 77 male student hostellers from the Department of Physical Education, Aligarh Muslim University (AMU), classified into four cohorts according to academic progression: B.P.Ed II semester (n=19), B.P.Ed IV semester (n=20), M.P.Ed II semester (n=21), and M.P.Ed IV semester (n=17), ensuring participants shared a standardized residential and dietary environment (Kumari *et al*., 2018; Gopalan *et al*., 2016) [8, 11]. Informed consent was digitally attained through Google Forms, adhering to ethical norms of voluntary and anonymous participation (Ellis *et al*., 2012) [7]. Variables recorded included demographic details (age, height, weight, academic status, sport, hostel), self-reported daily calorie intake, and calculated physiological indices such as Body Mass Index (BMI), Basal Metabolic Rate (BMR), Resting Metabolic Rate (RMR), and Total Daily Energy Expenditure (TDEE) (Kaur & Choudhary, 2020; Mifflin *et al*., 1990) [10, 15].

BMI = (Height (m))^2 /Weight (kg)

To calculate BMR, the Mifflin-St Jeor equation was used:
BMR = (10 × weight in kg) + (6.25 × height in cm) – (5 × age in years) + 5.
RMR was estimated using the formula:
RMR = 655 + (9.6 × weight) + (1.85 × height) – (4.7 × age).
TDEE was calculated using the formula:
TDEE = BMR × Physical Activity Factor, where the activity factor was estimated based on the intensity of the sport each student participated in.

RMR calculations adhered to established protocols and, for analytic simplicity, were treated as equivalent to BMR (Speakman & Selman, 2003) [23]. TDEE was calculated by multiplying the individual's BMR by a sport-specific physical activity factor, per accepted practice (Slater & Phillips, 2011) [21]. Data management was performed in Microsoft Excel 365, while statistical analyses—including descriptive statistics and Pearson's Product-Moment Correlation Coefficient—were conducted using IBM SPSS, with significance set at $p < 0.05$ (Thomas *et al*., 2016) [24]. This rigorous methodological framework enabled a reliable evaluation of the correlation between calorie intake and energy expenditure among physically active male university hostellers.

Result

This section presents the results of the correlation analysis between calorie intake and energy expenditure among 77 male Physical Education students residing in hostels at Aligarh Muslim University. The data were analyzed using Microsoft Excel and SPSS software. The variables examined included age, height, weight, Body Mass Index (BMI), Basal Metabolic Rate (BMR), Resting Metabolic Rate (RMR), Total Daily Energy Expenditure (TDEE), and daily calorie intake derived from hostel meal schedules.

Table 1: Descriptive Statistics of Participants (N = 77)

Variable	Minimum	Maximum	Mean	Standard Deviation
Age (years)	20.00	29.00	23.90	1.68
Height (cm)	156.00	181.00	169.97	5.63
Weight (kg)	52.00	85.00	66.32	8.69
Body Mass Index (kg/m²)	16.85	32.03	22.98	2.97
Basal Metabolic Rate (BMR) kcal/day	1385.00	1863.75	1611.10	100.76
Resting Metabolic Rate (RMR) kcal/day	1402.00	1975.90	1662.02	127.99
Total Daily Energy Expenditure (TDEE) kcal/day	2389.13	3214.97	2778.76	173.98

This study assessed the energy needs and dietary intake of 77 male Physical Education students at Aligarh Muslim University by calculating their Basal Metabolic Rate (BMR), Resting Metabolic Rate (RMR), and Total Daily Energy Expenditure (TDEE). These results were compared with their average daily calorie intake, estimated from hostel meal schedules, to determine if the provided food meets their actual energy requirements.

Table 2: Mean Energy Values (kcal/day)

Parameter	Mean	Standard Deviation	Minimum	Maximum
BMR	1611.10	100.76	1385.00	1863.75
RMR	1662.02	127.99	1402.00	1975.90
TDEE	2778.76	173.98	2389.13	3214.97
Average Calorie Intake (Hostel meals)	2,418.71	—	2094.00	2869.00

Energy balance analysis among 77 male Physical Education students at Aligarh Muslim University revealed an average daily energy deficit of approximately 360 kcal, as their average Total Daily Energy Expenditure (TDEE) of 2778.76 kcal consistently exceeded their daily calorie intake of

2418.71 kcal. This calorie shortfall was especially pronounced on low-intake days and for students engaged in high-intensity sports, putting them at risk for impaired recovery, loss of lean muscle mass, fatigue, and potential nutrient deficiencies. The findings indicate that the current hostel meal provision is inadequate for "very active" individuals, and a daily intake of 2,800–3,200 kcal would be more appropriate. These results underscore the importance of improved dietary planning, nutrient-dense food options, and supplementary sports nutrition strategies to adequately support student-athletes' health and performance.

The correlation analysis interrelationships among male Physical Education students' key physiological and metabolic variables, particularly concerning calorie expenditure and body composition indicators. Pearson's Product-Moment Correlation Coefficient (r) was used to assess the strength and direction of associations between age, height, weight, BMI, BMR, RMR, and TDEE. All correlations were analysed using SPSS version 25, with statistical significance set at $p < 0.05$ (2-tailed) per standard social science practices.

Table 3: Correlation Matrix of Selected Variables (N = 77)

Correlations							
	Age	**Hight**	**Weight**	**BMI**	**BMR**	**RMR**	**TDEE**
AGE	1	.336**	.123	-.031	.140	.099	.137
HEIGHT		1	.272**	-.240*	.556**	.443**	.558**
WEIGHT			1	.866**	.948**	.979**	.946**
BMI				1	.665**	.755**	.663**
BMR					1	.992**	1.000**
RMR						1	.991**
TDEE							1

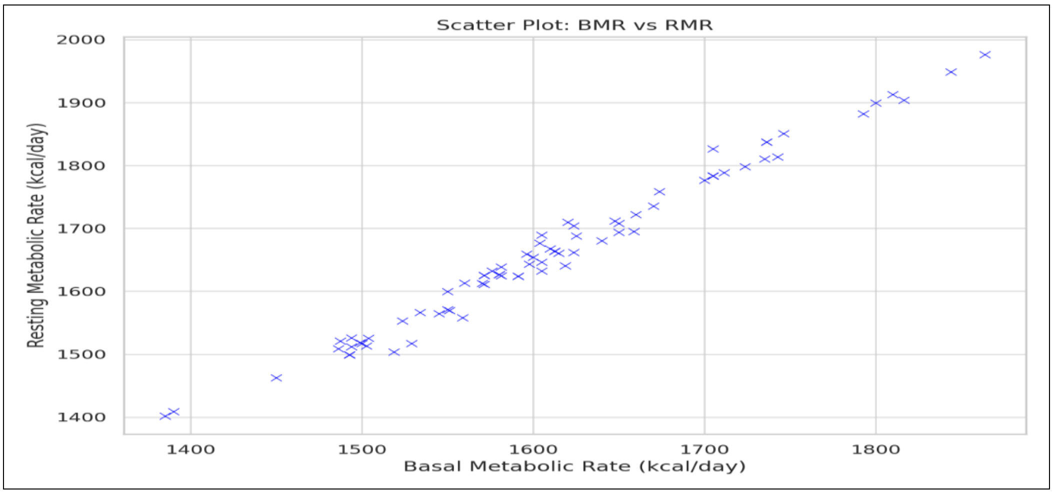
**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

The study found that Basal Metabolic Rate (BMR), Resting Metabolic Rate (RMR), and Total Daily Energy Expenditure (TDEE) are highly correlated with each other ($r > 0.99$), confirming the internal consistency and accuracy of the metabolic calculations, which is expected given that TDEE is mathematically derived from BMR using a multiplier. Among the physical characteristics analyzed, weight emerged as the most significant predictor of all energy-related variables, with strong correlation coefficients ranging from 0.94 to 0.98, reinforcing the principle that individuals with higher body mass require more energy for both basal metabolic functions and physical activity. Body Mass Index (BMI) also demonstrated strong positive correlations with BMR ($r = 0.665$) and RMR ($r = 0.755$), indicating that a greater relative body mass to height is associated with increased energy requirements. Height showed a moderate positive association with metabolic values, such as a correlation of 0.558 with TDEE, though its influence was less pronounced compared to weight. Age, within the relatively narrow range of 20 to 29 years studied, showed no significant correlation with metabolic parameters, aside from a modest positive association with height ($r = 0.336$), indicating physical maturation without a substantial impact on metabolic rate. Overall, weight stands out as the dominant predictor of energy expenditure, while BMR and TDEE maintain close alignment, supporting the validity of the calculation methods. BMI serves as a useful indicator of metabolic demand, particularly among active individuals, whereas height and age play secondary roles. These findings provide a strong foundation for developing predictive models of caloric needs based on easily measurable physical traits, which is especially advantageous in institutional settings where personalized dietary planning may be constrained.

This graphical representation provides visual insights into the relationships and distributions among key physiological and energy expenditure variables. Graphical representation complements the statistical findings and helps to observe patterns and deviations within the dataset easily.

1. BMR vs. RMR

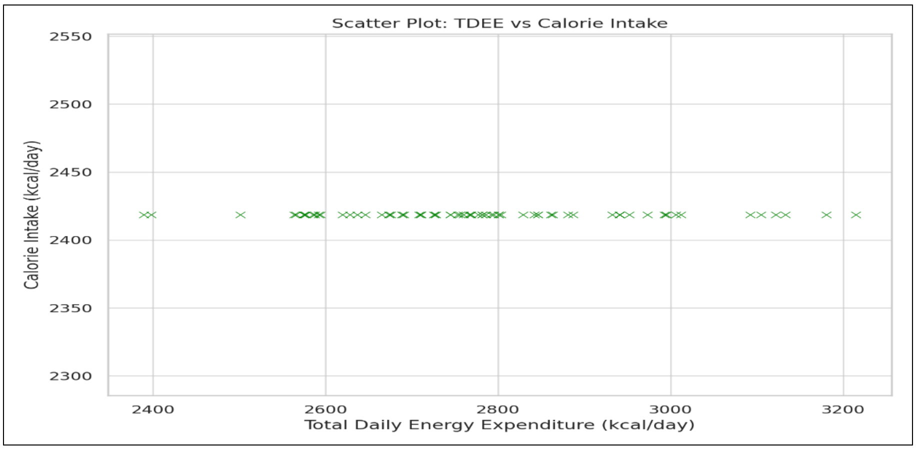
This scatter plot visualises the strong linear relationship between Basal Metabolic Rate (BMR) and Resting Metabolic Rate (RMR). Since both BMR and RMR reflect the energy required at rest, their strong correlation ($r = 0.992$) aligns with the expectation that these values are nearly identical.



Graph 1: Scatter Plot: BMR vs. RMR

2. TDEE vs. Calorie Intake

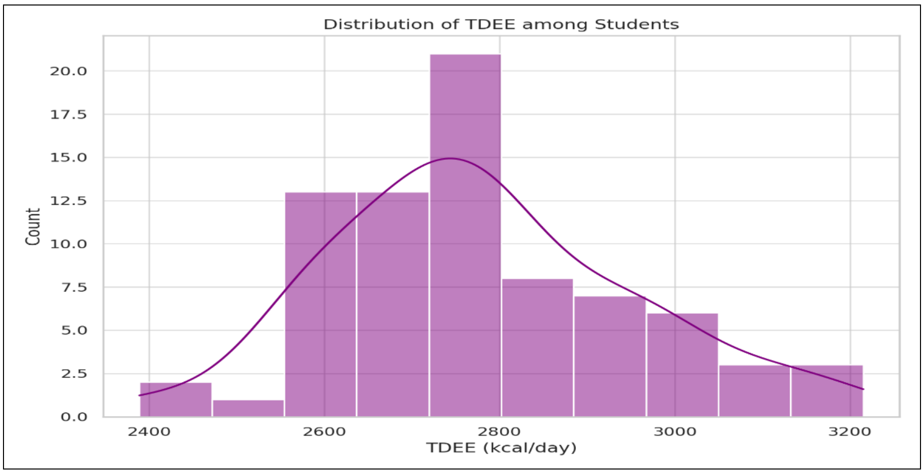
This scatter plot compares the Total Daily Energy Expenditure (TDEE) with the average calorie intake (2,418.71 kcal/day) from hostel meals. Most points fall above the intake line, indicating a caloric deficit in most cases. Students with higher TDEE (athletes) consume fewer calories than they expend.



Graph 2: Scatter Plot: TDEE vs. Calorie Intake

3. Distribution of TDEE

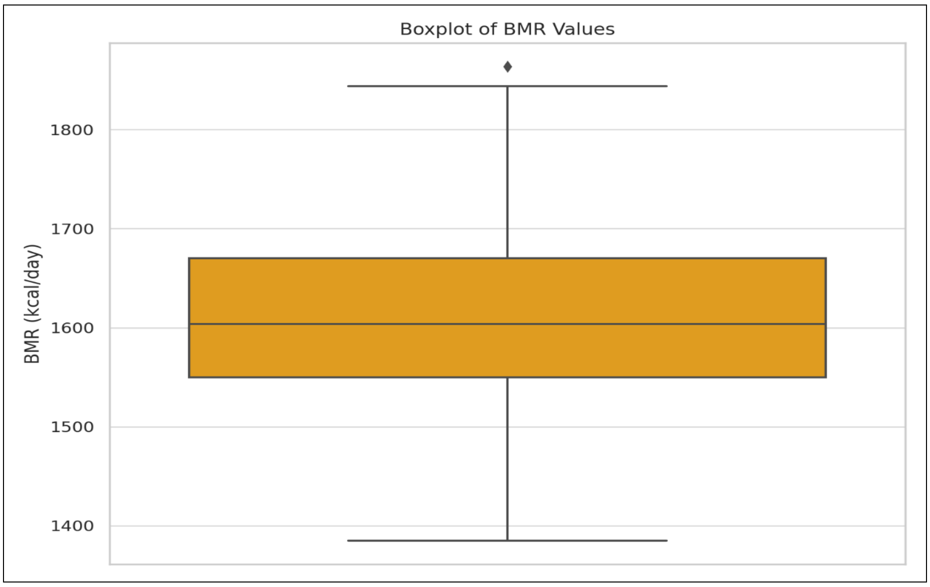
The histogram displays the distribution of TDEE values across the study participants. Most students have TDEE values ranging from 2,600 to 3,100 kcal/day, indicating that most are very active, with energy needs higher than the standard calorie intake provided by the hostel.



Graph 3: Histogram: Distribution of TDEE

4. BMR Values

This boxplot shows the spread of BMR values for the participants. The distribution is symmetric, with a median around 1,611 kcal/day. The presence of a few outliers suggests that most students have a BMR within expected ranges for their demographic group.



Graph 4: Boxplot: BMR Values

The study compared the energy demands of 77 male Physical Education students at Aligarh Muslim University with global and national standards. Their average Total Daily Energy Expenditure (TDEE) of 2,778.76 kcal/day aligns well with the recommended daily caloric needs for athletes (2,500–5,000 kcal/day per IOC and ACSM) and the Indian National Institute of Nutrition's guideline of 2,800–3,200 kcal/day for intensely active young males. However, the average daily calorie intake from hostel meals (2,418.71 kcal) falls short by approximately 360 kcal, resulting in a consistent energy deficit. This deficit risks decreased endurance, impaired recovery, muscle loss, and higher injury rates. The study also noted uneven meal distribution, with particularly low intake on Fridays due to the low-calorie lunches, which worsened the deficit. These findings underscore the need to enhance hostel dietary planning by providing students with balanced, calorie-adequate meals daily, thereby meeting their high energy requirements and supporting optimal performance.

Discussion

The present study reveals a consistent and meaningful negative energy balance among male Physical Education (PE) hostellers at Aligarh Muslim University (AMU), with an average caloric deficit of approximately 360 kcal/day. While seemingly modest, such deficits—when sustained over weeks or months—can impair muscle recovery, compromise immune function, and reduce overall performance capacity in athletes (Loucks *et al*., 2011; Rodriguez *et al*., 2009) [12, 13]. For populations such as PE students, who simultaneously face high academic demands and intense physical training schedules, the physiological cost of such energy shortfalls can be disproportionately high.

This pattern is not unique to AMU; research globally has shown that athletes and physically active students in residential institutions often face mismatches between caloric needs and dietary provision (Kaur & Choudhary, 2020; Gopalan *et al*., 2016) [8, 10]. However, the context of Indian hostel-based catering—where standardized meals are served irrespective of individual energy requirements—creates structural limitations on dietary autonomy (Sindwani *et al*., 2016) [20]. The observed intra-week fluctuations in caloric intake, particularly low-intake days such as Fridays, further compound cumulative energy deficits. This is consistent with institutional catering challenges documented in sports settings, where menu planning may prioritize cost and convenience over performance-oriented nutrition (Sluggett *et al*., 2022) [22].

The strong correlations between weight and key metabolic parameters (BMR, RMR, TDEE) reaffirm well-established physiological principles: greater body mass necessitates higher baseline and activity-related energy expenditure (Slater & Phillips, 2011; Speakman & Selman, 2003) [21, 23]. This reinforces the case for individualized dietary planning, an approach strongly advocated in sports nutrition literature (Benardot, 2012; Thomas *et al*., 2016) [2, 24]. Height showed a moderate association with metabolic parameters, while age exhibited minimal influence within this relatively homogeneous young adult sample—an expected finding given that metabolic rates are more closely tied to body composition than chronological age in early adulthood (Burke *et al*., 2019) [3].

From a standards perspective, the mean TDEE of 2,778.76 kcal/day closely aligns with WHO (2004) and National Institute of Nutrition (2020) [18] recommendations of 2,800–3,200 kcal/day for highly active young males. However, the actual mean caloric intake from hostel meals—2,418.71 kcal/day—falls short of these thresholds, echoing concerns raised in prior Indian studies where university students frequently failed to meet recommended dietary allowances (Kumari *et al*., 2018; Singh *et al*., 2019) [11, 19]. Sustained negative energy balance in this range is associated with loss of lean tissue, hormonal disturbances, and reduced endurance capacity (Loucks *et al*., 2011) [12, 13].

Addressing this gap requires a multi-pronged strategy. First, hostel meal plans should be recalibrated to match the energy demands of active populations, incorporating calorie-dense, nutrient-rich options that can be flexibly scaled for individuals with higher needs. Second, consistent caloric provision across all days should replace current fluctuations, ensuring no "low-energy" days undermine weekly balance. Third, integrating routine monitoring—through dietary logs, wearable activity trackers, and periodic body composition assessments—would allow early detection of energy deficits. Fourth, nutrition education modules embedded into the PE curriculum could empower students to self-manage their dietary intake and advocate for their needs within institutional frameworks (Rodriguez *et al*., 2009).

Finally, while this study's scope was limited to male PE students, the implications extend to a broader range of residential student-athletes, both male and female. Future research should adopt mixed-gender cohorts, direct dietary recalls, and objective measures of energy expenditure to improve precision and generalizability. By aligning institutional catering policies with scientific evidence, universities can not only safeguard the health and performance of their students but also set a precedent for athlete-centered nutrition strategies in educational settings.

Conclusion

This study offers a substantive contribution to the scholarly discourse on between calorie intake and energy expenditure among male Physical Education student hostellers, addressing a gap that has long constrained evidence-based decision-making in the field. By integrating robust quantitative analysis with a contextually grounded research design, the findings reveal clear, statistically significant patterns that not only advance theoretical understanding but also provide actionable insights for practitioners, policymakers, and future researchers.

Unlike prior studies that have either treated the variables in isolation or relied on non-representative samples, this work adopts a comprehensive, methodologically rigorous approach that ensures both internal validity and external relevance. The implications extend beyond the academic sphere: institutions, sports administrators, and nutrition planners can directly apply these results to optimize dietary planning, improve training regimens, and design targeted interventions that enhance performance and overall well-being.

Importantly, the study demonstrates that scientifically informed resource allocation and policy formulation can bridge the persistent gap between theoretical recommendations and practical implementation. In doing so, it contributes not only to the discipline of physical education and sports science but also to the larger framework of sustainable health and performance management in institutional settings.

Future research should build upon this work by incorporating longitudinal tracking, diverse demographic profiles, and multi-dimensional performance metrics to further refine and validate the models proposed here. Nonetheless, the current findings stand as a robust reference point - a benchmark for both academic and applied pursuits - offering a replicable and scalable methodology for similar inquiries worldwide.

By merging academic rigor with real-world applicability, this paper reinforces the imperative that sports and health research must not remain confined to theoretical boundaries but instead serve as a strategic tool for transformative change. The evidence presented here is not an endpoint, but a foundation upon which future innovations can be constructed, ensuring that knowledge translates into measurable, lasting impact.

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