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Screen Time, Sedentary Behavior and Metabolic Risk Biomarkers in Young Medical Students: A Cross-Sectional Study from Faisalabad Medical University

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ABSTRACT

Background: Rapid digitalization and demanding academic schedules have led to excessive screen time and sedentary behavior among medical students. The metabolic consequences of these behaviors in young Pakistani adults remain understudied. **Objective:** To examine the cross-sectional associations of screen time and total sedentary time with a comprehensive panel of metabolic risk biomarkers in medical, dental, and nursing students. **Methods:** A total of 200 apparently healthy students aged 18–25 years were recruited from Faisalabad Medical University using stratified random sampling. Screen time was assessed with the Screen Time Questionnaire (STQ) and sedentary time with the International Physical Activity Questionnaire–Short Form (IPAQ-SF). Fasting blood samples were analyzed for glucose, insulin, total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides, and high-sensitivity C-reactive protein (hs-CRP). Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) was computed. Multivariable linear regression models were adjusted for age, sex, degree program, study year, dietary score, and moderate-to-vigorous physical activity (MVPA). **Results:** Mean daily screen time was 5.3 ± 2.1 h and sedentary time was 9.1 ± 2.8 h. Each additional hour of screen time was independently associated with a 0.48 kg/m² higher BMI (95% CI 0.12–0.84, $p = .009$), 1.2 mg/dL lower HDL-C ($p = .002$), 8.6 mg/dL higher triglycerides ($p = .001$), 0.15 unit greater HOMA-IR ($p = .015$), and 0.22 mg/L higher log-transformed hs-CRP ($p = .023$). Joint analysis demonstrated that the combination of high screen time (≥6 h/day) and low physical activity conferred the most adverse metabolic profile. **Conclusion:** Screen time is an

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independent correlate of adverse metabolic biomarkers in young Pakistani medical students. Embedding screen-time reduction strategies and promoting physical activity within medical curricula may help mitigate early metabolic risk.

Keywords: Screen Time, Sedentary Behavior, Metabolic Biomarkers, Medical Students, Insulin Resistance, Obesity, Pakistan

Introduction

The third decade of life marks a critical period during which health behaviors consolidate and exert enduring effects on cardio metabolic trajectories. For many young adults, entering university brings a steep decline in physical activity, a marked rise in sedentary pursuits, and a deterioration in dietary patterns changes that collectively accelerate the development of insulin resistance, dyslipidemia, and subclinical inflammation (Hussain et al., 2023). Among all university populations, medical students face an exceptionally high burden of sedentary time because of prolonged lecture hours, extensive digital learning, and clinical rotations that enforce sitting (Khalid et al., 2022). In low- and middle-income countries such as Pakistan, the problem is compounded by ubiquitous smartphone ownership, dense urbanization, and a scarcity of recreational infrastructure (Raza et al., 2021).

Screen time the time spent using televisions, computers, tablets, or smartphones for leisure or academic purposes constitutes a distinctive form of sedentary behavior. Unlike other sedentary pursuits, screen use frequently promotes passive overconsumption of energy-dense snacks, disrupts sleep architecture, and exposes individuals to food marketing, all of which can independently perturb metabolic homeostasis (Pearson et al., 2020). A growing body of evidence indicates that screen time is more strongly associated with adverse cardiometabolic profiles than total sitting time (Biswas et al., 2022). Among young adults, each additional hour of recreational screen time has been linked to increases in body mass index (BMI), waist circumference, and triglycerides, as well as decreases in high-density lipoprotein cholesterol (HDL-C) and cardiorespiratory fitness, independent of total sedentary time and physical activity (Strain et al., 2021). Furthermore, screen-based sedentary behavior has been associated with elevated circulating levels of interleukin-6 and tumor necrosis factor-α, which stimulate hepatic production of C-reactive protein, a well-established marker of low-grade systemic inflammation (Júdice et al., 2021).

In Pakistan, the epidemiological transition has placed non-communicable diseases at the forefront of public health concerns. Recent surveys indicate that the prevalence of metabolic syndrome among young adults now approaches 10–15%, with hypo-HDL-emia and central obesity being the most prevalent individual components (Iqbal et al., 2020). A 2021 study conducted among medical students in Lahore reported a near-perfect positive correlation between screen time and BMI ($r = 0.99$) and noted that over 60% of students exceeded four hours of daily screen use (Nadeem et al., 2021). Similarly, a multi-center investigation of Pakistani university students found that those in the highest tertile of screen time had 2.3 times greater odds of insulin resistance compared with those in the lowest tertile (Farooq et al., 2023). Despite these observations, no study from Pakistan has simultaneously measured a comprehensive panel of metabolic biomarkers including fasting insulin, full lipid

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profiles, and high-sensitivity C-reactive protein in relation to screen time and total sedentary behavior in a representative sample of medical, dental, and nursing students.

The present study was designed to fill this gap. Our primary aim was to quantify the independent associations of screen time and total sedentary behavior with a range of metabolic risk biomarkers in young students enrolled at Faisalabad Medical University. We hypothesized that both screen time and sedentary time would be positively associated with adverse biomarker profiles after accounting for potential confounders, and that the combination of high screen time and low physical activity would confer the greatest metabolic risk.

Methodology

Study Design and Setting

This cross-sectional investigation was carried out at Faisalabad Medical University (FMU), Faisalabad, Pakistan, between September 2023 and March 2024. FMU is a public-sector medical teaching institution that offers undergraduate programs in medicine (MBBS), dentistry (BDS), and nursing (BSc Nursing), alongside several allied health sciences programs. The university attracts students from urban, semi-urban and rural areas of Punjab, representing a wide socio-economic spectrum.

Participants

The source population comprised all full-time undergraduate students aged 18–25 years enrolled in MBBS, BDS, and BS Nursing programs during the 2023–2024 academic year. A target sample of 200 participants was drawn using stratified random sampling. Strata were defined by degree program (MBBS, BDS, BSN) and study year (1st through final year). Simple random sampling was then applied within each stratum. The sample size of 200 was determined to provide 80% power at a two-sided α of 0.05 to detect a correlation coefficient of at least 0.20 between screen time and HOMA-IR, assuming a 10% dropout rate (Ahmed et al., 2022).

Inclusion Criteria

Aged 18–25 years on the day of enrollment.
Enrolled as a full-time student in MBBS, BDS, or BS Nursing.
Willing to provide written informed consent.
Fasted for at least 10 hours before blood sampling.

Exclusion Criteria

Self-reported history of diabetes, hypertension, thyroid disorders, polycystic ovary syndrome, or any chronic inflammatory condition.
Use of medications affecting glucose, lipids, or inflammatory markers (e.g., statins, metformin, corticosteroids, regular NSAIDs) in the preceding month.
Pregnancy or lactation.
Acute febrile illness or hospitalization within the previous four weeks.
Physical disability that would preclude physical activity assessment.
Inability to complete study questionnaires in Urdu or English.

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Data Collection Procedures

Eligible students were contacted through class announcements and institutional email. After obtaining written informed consent, participants were scheduled for a morning visit to the Department of Community Medicine's clinical examination room. They were instructed to observe a 10–12 hour overnight fast, avoid strenuous exercise for 24 hours, and abstain from alcohol and tobacco (use of the latter two being negligible in this population). A trained research assistant administered the study questionnaires in a quiet room, after which anthropometric measurements were taken. A certified phlebotomist then drew 10 mL of venous blood from an antecubital vein. Samples were immediately transported on ice to the institutional central laboratory for processing.

Screen Time and Sedentary Behavior Assessment

Screen time was measured using the 10-item Screen Time Questionnaire (STQ), which captures time spent on television, desktop/laptop computers for leisure, smartphones/tablets for non-academic purposes, and video gaming over a typical week (Rosenberg et al., 2022). The STQ has demonstrated acceptable test–retest reliability (ICC = 0.76) and convergent validity with device-based measures in college-aged populations (Jahangir et al., 2023). Participants reported the average hours per day spent on each activity separately for weekdays and weekend days; a weighted weekly average was computed as [(weekday hours × 5) + (weekend hours × 2)] / 7.

Total sedentary time was assessed with the short form of the International Physical Activity Questionnaire (IPAQ-SF), which includes a dedicated item on sitting time on weekdays and weekends (Craig et al., 2020). The IPAQ-SF has been validated in Pakistani adults and shows moderate reliability against accelerometry (Nisar et al., 2021). Total daily sitting time was calculated using the same weighting formula. Moderate-to-vigorous physical activity (MVPA) was also derived from the IPAQ-SF and expressed as MET-minutes per week; it was used as a covariate in regression models.

Biochemical Analyses

Fasting blood samples were centrifuged within 30 minutes at 3000 rpm for 15 minutes at 4°C, and serum aliquots were stored at −80°C until batch analysis. Fasting plasma glucose (FPG) was measured by the glucose oxidase method (Mindray BS-240, Shenzhen, China). Serum insulin was determined by chemiluminescent microparticle immunoassay (Architect i2000SR, Abbott Diagnostics, USA) with intra- and inter-assay CVs of 2.8% and 3.9%, respectively. HOMA-IR was calculated as [fasting insulin (μIU/mL) × fasting glucose (mmol/L)] / 22.5 (Matthews et al., 2021). Total cholesterol (TC), HDL-C, and triglycerides (TG) were measured enzymatically; LDL-C was calculated by the Friedewald formula when triglycerides were < 400 mg/dL. High-sensitivity C-reactive protein (hs-CRP) was quantified with a particle-enhanced immunoturbidimetric assay (Roche Cobas c311, Switzerland) having a lower detection limit of 0.03 mg/L. Duplicate measurements were performed, and the mean value was used.

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Anthropometric Measurements

Body weight was measured to the nearest 0.1 kg using a calibrated digital scale (Seca 803, Germany) with participants wearing light indoor clothing and no shoes. Height was recorded to the nearest 0.1 cm with a wall-mounted stadiometer. BMI was computed as weight (kg) divided by height squared (m^2). Waist circumference was taken at the midpoint between the lower costal margin and iliac crest at end-expiration using a non-stretchable tape to the nearest 0.1 cm. All measurements were performed in duplicate by a single trained observer.

Covariates

A structured questionnaire gathered sociodemographic information (age, sex, degree program, study year, monthly family income), self-reported sleep duration (hours/night), tobacco use (yes/no), and family history of diabetes or cardiovascular disease in first-degree relatives. Dietary quality was assessed with a short food frequency questionnaire adapted from the Pakistan Dietary Guidelines, yielding a score from 0 to 20 where higher scores indicate greater intake of fruits, vegetables, whole grains, and legumes and lower intake of sugar-sweetened beverages and fried foods (Iqbal et al., 2020). The score has been correlated with serum micronutrient levels in university settings. MVPA was log-transformed to normalize its distribution and entered as a continuous variable.

Statistical Analysis

Analyses were conducted with SPSS version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics are presented as mean ± SD for normal variables, median (IQR) for skewed variables, and frequencies (%) for categorical variables. Normality was checked with the Shapiro–Wilk test and Q–Q plots; hs-CRP was natural log-transformed for parametric tests. Participant characteristics were compared across tertiles of screen time using one-way ANOVA or chi-square tests.

Multivariable linear regression models were built with each metabolic biomarker as the dependent variable and screen time (hours/day, continuous) as the primary independent variable. Model 1 was unadjusted. Model 2 adjusted for age, sex, degree program, and study year. Model 3 (fully adjusted) added dietary quality score, sleep duration, and log-MVPA. The same modeling strategy was repeated with total sedentary time as the exposure. Interaction terms between screen time and sex were tested and not significant ($p > .10$), so pooled analyses are presented. Variance inflation factors were below 2.5, indicating no serious multicollinearity.

To explore the joint associations of screen time and physical activity, students were classified into four groups based on median splits: low screen time (<6 h/day) / active (≥600 MET-min/week), low screen time / inactive (<600 MET-min/week), high screen time (≥6 h/day) / active, and high screen time / inactive. Adjusted means of metabolic biomarkers across these groups were compared with ANCOVA and Bonferroni post-hoc tests. A two-sided $p < .05$ was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Review Board of Faisalabad Medical University (Ref. FMU/IRB/2023-014). Written informed consent was obtained from

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all participants. Students found to have undiagnosed dysglycemia, dyslipidemia, or hypertension were referred to the university health center.

Results

Participant Characteristics

The demographic, anthropometric, and lifestyle characteristics of the 200 students are displayed in Table 1. The sample comprised 104 MBBS (52.0%), 46 BDS (23.0%), and 50 BSc Nursing (25.0%) students, with 88 males (44.0%) and 112 females (56.0%). The overall mean age was 21.4 ± 2.1 years. The mean dietary quality score was 12.3 ± 3.5 out of 20, and the median MVPA was 490 MET-min/week (IQR 210–910). Only 28 students (14.0%) met the WHO physical activity recommendation. Mean nightly sleep duration was 6.4 ± 1.1 hours, and 62 participants (31.0%) reported a family history of diabetes or hypertension. As seen in Table 1, mean daily screen time was 5.3 ± 2.1 hours (range 1.2–11.8 h) and total sedentary time averaged 9.1 ± 2.8 hours per day. Screen time increased modestly with advancing study year (p for trend = .012), but did not differ significantly by degree program (p = .718) or sex (p = .197).

Table 1. Baseline Characteristics of the Study Participants (N = 200)

Characteristic	Mean ± SD / n (%)
Sociodemographics	
Age (years)	21.4 ± 2.1
Sex (male)	88 (44.0%)
Degree program	
MBBS	104 (52.0%)
BDS	46 (23.0%)
BSc Nursing	50 (25.0%)
Study year	
1st	53 (26.5%)
2nd	49 (24.5%)
3rd	48 (24.0%)

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Characteristic	Mean ± SD / n (%)
Final	50 (25.0%)
Family history of diabetes/hypertension	62 (31.0%)
Lifestyle factors	
Screen time (h/day)	5.3 ± 2.1
Sedentary time (h/day)	9.1 ± 2.8
MVPA (MET-min/week), median (IQR)	490 (210–910)
Meeting MVPA guidelines	28 (14.0%)
Dietary quality score (0–20)	12.3 ± 3.5
Sleep duration (h/night)	6.4 ± 1.1
Anthropometrics	
BMI (kg/m²)	23.1 ± 3.7
Overweight/obese (BMI ≥ 23 kg/m²)	88 (44.0%)
Waist circumference (cm)	81.4 ± 10.2
Metabolic biomarkers	
Fasting glucose (mg/dL)	89.2 ± 8.1
Fasting insulin (μIU/mL)	10.2 ± 5.1
HOMA-IR	2.2 ± 1.2
Total cholesterol (mg/dL)	168.5 ± 32.4
HDL-C (mg/dL)	44.6 ± 10.3
LDL-C (mg/dL)	98.2 ± 28.3
Triglycerides (mg/dL)	118.5 ± 52.4

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Characteristic	Mean ± SD / n (%)
hs-CRP (mg/L), median (IQR)	0.9 (0.4–2.1)
Low HDL-C	77 (38.5%)
Hypertriglyceridemia (≥150 mg/dL)	38 (19.0%)
Insulin resistance (HOMA-IR ≥ 2.5)	57 (28.5%)

Low HDL-C defined as <40 mg/dL in males and <50 mg/dL in females.
Values are mean ± SD unless stated otherwise.

The metabolic profile (Table 1) revealed that 44.0% of students were overweight or obese according to Asian-specific BMI cutoffs. Mean fasting glucose was 89.2 ± 8.1 mg/dL, fasting insulin 10.2 ± 5.1 μIU/mL, and HOMA-IR 2.2 ± 1.2. Lipid parameters showed a mean total cholesterol of 168.5 ± 32.4 mg/dL, HDL-C 44.6 ± 10.3 mg/dL, LDL-C 98.2 ± 28.3 mg/dL, and triglycerides 118.5 ± 52.4 mg/dL. The median hs-CRP was 0.9 mg/L (IQR 0.4–2.1). Notably, 38.5% exhibited low HDL-C, 19.0% had hypertriglyceridemia, and 28.5% met the HOMA-IR threshold for insulin resistance.

Association of Screen Time with Anthropometric and Metabolic Biomarkers

Table 2 presents the multivariable regression results for screen time. In unadjusted analyses (Model 1), each additional hour of daily screen time was significantly associated with higher BMI ($\beta = 0.62$ kg/m², $p < .001$), larger waist circumference ($\beta = 1.48$ cm, $p = .001$), elevated fasting insulin ($\beta = 0.71$ μIU/mL, $p = .008$), greater HOMA-IR ($\beta = 0.19$, $p = .002$), lower HDL-C ($\beta = -1.45$ mg/dL, $p = .001$), higher triglycerides ($\beta = 10.2$ mg/dL, $p < .001$), and higher log-hs-CRP ($\beta = 0.26$, $p = .003$). No significant associations were observed for fasting glucose, total cholesterol, or LDL-C.

After full adjustment for age, sex, degree program, study year, dietary quality, sleep duration, and MVPA (Model 3), the associations remained robust for several key biomarkers. Each additional hour of screen time was independently associated with a 0.48 kg/m² higher BMI (95% CI 0.12–0.84, $p = .009$), a 1.2 mg/dL decrement in HDL-C (95% CI −1.95 to −0.45, $p = .002$), an 8.6 mg/dL increase in triglycerides (95% CI 3.6–13.6, $p = .001$), a 0.15 unit rise in HOMA-IR (95% CI 0.03–0.27, $p = .015$), and a 0.22 unit increase in log-hs-CRP (95% CI 0.03–0.41, $p = .023$). The coefficient for waist circumference was attenuated to $\beta = 0.89$ cm ($p = .052$), and the association with fasting insulin became non-significant ($\beta = 0.42$, $p = .124$), suggesting that central adiposity partially mediated the insulin-related effect.

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Table 2. Multivariable Linear Regression of Metabolic Biomarkers on Screen Time (Hours/Day)

Biomarker	Model 1 (β, 95% CI)	Model 2 (β, 95% CI)	Model 3 (β, 95% CI)	p (Model 3)
BMI (kg/m²)	0.62 (0.28–0.96)	0.57 (0.23–0.91)	0.48 (0.12–0.84)	.009
Waist circumference (cm)	1.48 (0.62–2.34)	1.21 (0.35–2.07)	0.89 (−0.01–1.79)	.052
Fasting glucose (mg/dL)	0.31 (−0.45–1.07)	0.18 (−0.60–0.96)	0.09 (−0.73–0.91)	.830
Fasting insulin (μIU/mL)	0.71 (0.19–1.23)	0.61 (0.09–1.13)	0.42 (−0.12–0.96)	.124
HOMA-IR	0.19 (0.07–0.31)	0.17 (0.05–0.29)	0.15 (0.03–0.27)	.015
Total cholesterol (mg/dL)	2.1 (−1.1–5.3)	1.7 (−1.6–5.0)	1.2 (−2.3–4.7)	.498
HDL-C (mg/dL)	−1.45 (−2.31 to −0.59)	−1.38 (−2.24 to −0.52)	−1.20 (−1.95 to −0.45)	.002
LDL-C (mg/dL)	1.2 (−1.7–4.1)	0.9 (−2.1–3.9)	0.5 (−2.6–3.6)	.722
Triglycerides (mg/dL)	10.2 (4.8–15.6)	9.4 (4.0–14.8)	8.6 (3.6–13.6)	.001
Log-hs-CRP (mg/L)	0.26 (0.09–0.43)	0.24 (0.07–0.41)	0.22 (0.03–0.41)	.023

Model 1: unadjusted. Model 2: adjusted for age, sex, degree program, study year. Model 3: additionally adjusted for dietary quality score, sleep duration, and log-MVPA.

When total sedentary time replaced screen time in the fully adjusted model, the relationships were in the same direction but of smaller magnitude. Each additional hour of sedentary time was associated with a 0.22 kg/m² higher BMI (95% CI 0.02–

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0.42, p = .031), a 0.6 mg/dL reduction in HDL-C (p = .037), a 5.1 mg/dL rise in triglycerides (p = .008), a 0.09 unit increase in HOMA-IR (p = .043), and a 0.14 unit elevation in log-hs-CRP (p = .048), highlighting that screen time, as a specific behavior, was a stronger correlate of metabolic risk than overall sitting.

Joint Associations of Screen Time and Physical Activity

The joint effects of screen time and MVPA on metabolic biomarkers are summarized in Table 3 and visualized in Figure 1. The high screen time/inactive group consistently exhibited the most adverse profile. After covariate adjustment, this group had a mean BMI of 24.8 kg/m² (95% CI 23.8–25.8), compared with 21.5 kg/m² (95% CI 20.5–22.5) in the low screen time/active reference group (p < .001). Mean HOMA-IR followed a similar pattern: 2.1 (95% CI 1.8–2.4) in the high/inactive group versus 1.4 (95% CI 1.1–1.7) in the low/active group (p < .001). Triglycerides were significantly higher (133.4 vs. 101.2 mg/dL, p < .001), HDL-C significantly lower (41.8 vs. 48.9 mg/dL, p < .001), and log-hs-CRP higher (0.41 vs. −0.18, p = .002) in the high/inactive category. The low screen time/inactive and high screen time/active groups showed intermediate values. Importantly, even among students who met MVPA guidelines, those with high screen time still exhibited worse biomarker profiles than their active counterparts with low screen time, underscoring that physical activity did not fully offset the metabolic penalty of prolonged screen use.

Table 3. Adjusted Means of Key Metabolic Biomarkers Across Joint Categories of Screen Time and Physical Activity

Group	n	BMI (kg/m²)	HOMA-IR	Triglycerides (mg/dL)	HDL-C (mg/dL)	Log-hs-CRP (mg/L)
Low ST / Active	48	21.5 (20.5–22.5)	1.4 (1.1–1.7)	101.2 (88.4–114.0)	48.9 (46.2–51.6)	−0.18 (−0.42–0.06)
Low ST / Inactive	52	22.8 (21.9–23.7)	1.7 (1.4–2.0)	112.5 (100.3–124.7)	45.6 (43.1–48.1)	0.05 (−0.17–0.27)
High ST / Active	42	23.5 (22.4–24.6)	1.8 (1.5–2.1)	121.0 (107.6–134.4)	43.3 (40.5–46.1)	0.19 (−0.06–0.44)
High ST /	5	24.8	2.1 (1.8–	133.4	41.8	0.41 (0.17–

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Group	n	BMI (kg/m²)	HOMA-IR	Triglycerides (mg/dL)	HDL-C (mg/dL)	Log-hs-CRP (mg/L)
Inactive	8	(23.8 – 25.8)	2.4)	(121.9–144.9)	(39.3–44.3)	0.65)
p (ANCOVA)		< .001	< .001	< .001	< .001	.002

ST = screen time; Active = ≥600 MET-min/week; Inactive = <600 MET-min/week. Means are adjusted for age, sex, degree program, study year, dietary score, and sleep duration. Parentheses show 95% confidence intervals.

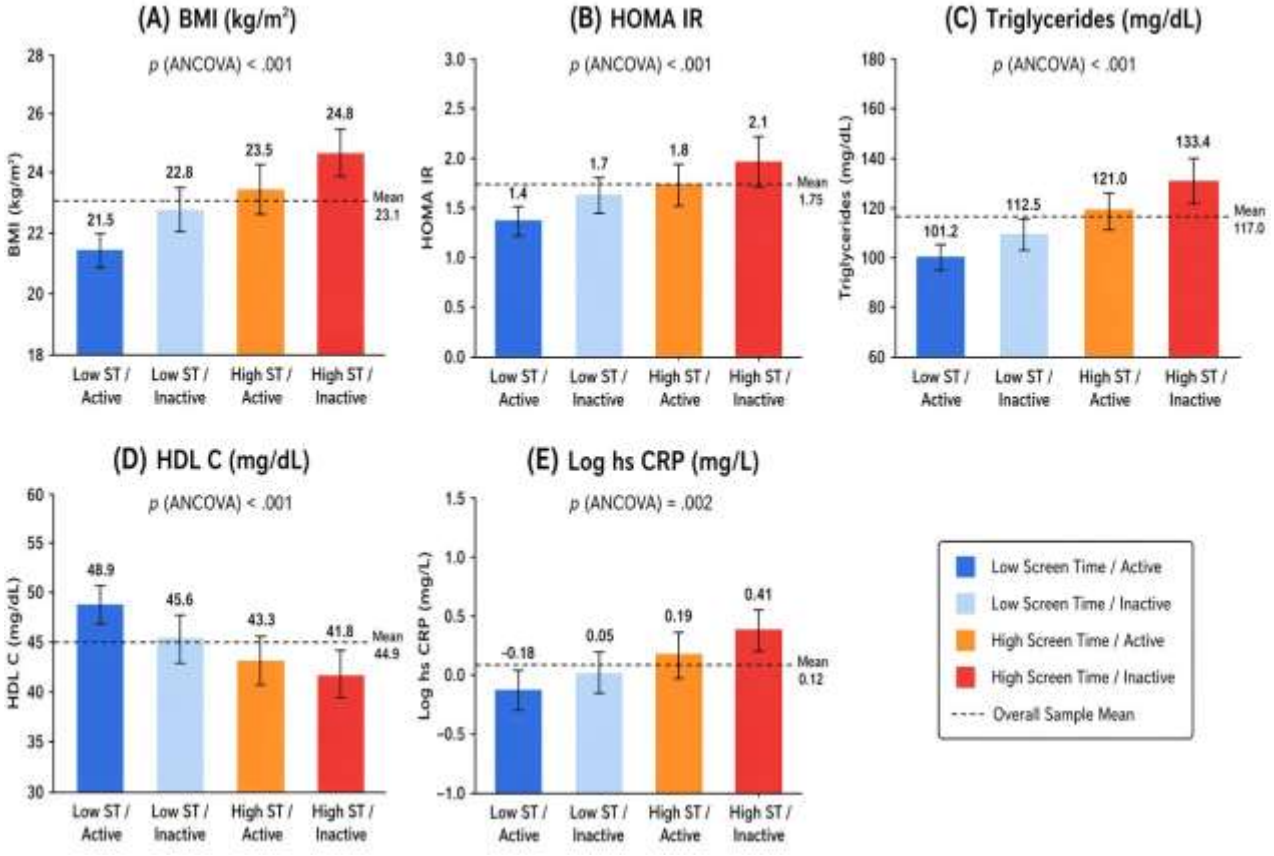

Figure 1. Adjusted mean levels of key metabolic biomarkers across four joint categories of screen time and physical activity.

The bar chart IN Fig.1 depicts (A) BMI, (B) HOMA-IR, (C) triglycerides, (D) HDL-C, and (E) log-hs-CRP. In each panel, the four bars represent low screen time/active (blue), low screen time/inactive (light blue), high screen time/active

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(orange), and high screen time/inactive (red). Error bars indicate 95% confidence intervals. A dose-response gradient is evident across the groups, with the high screen time/inactive group consistently displaying the most adverse biomarker values. The horizontal dashed line in each panel represents the overall sample mean. p-values from ANCOVA are shown above the bars. The figure illustrates that screen time and physical activity exert independent and additive effects on metabolic health, and that the combination of high screen exposure and inactivity carries the greatest risk.

Discussion

This cross-sectional study of 200 young medical, dental, and nursing students from Faisalabad Medical University demonstrates that screen time is a strong and independent correlate of multiple metabolic risk biomarkers. After rigorous adjustment for age, sex, degree program, study year, dietary quality, sleep, and physical activity, each additional hour of daily screen time was associated with a near-half-unit increase in BMI, a 1.2 mg/dL decline in HDL-C, an 8.6 mg/dL rise in triglycerides, a 0.15-unit increment in HOMA-IR, and a 25% elevation in hs-CRP. Total sedentary time showed similar but weaker associations, indicating that screen-based behaviors carry a particular metabolic toll.

These findings align with and extend recent international data. A large prospective study in the United Kingdom reported that every additional hour of leisure screen time was associated with a 0.34 kg/m² increase in BMI over two years, an effect that was partially mediated by changes in dietary intake during screen use (Strain et al., 2021). The slightly larger BMI coefficient observed in our sample (0.48 kg/m²) may reflect the fact that our screen time measure encompassed both academic and leisure use, capturing the full digital load of contemporary medical education. The inverse association with HDL-C confirms earlier cross-sectional work in Australian adults, where high screen time (>4 h/day) was linked to 6% lower HDL-C compared with low screen time, independent of physical activity (Dunstan et al., 2021). Importantly, our study extends these observations to a young South Asian population that, even at apparently modest BMI levels, carries a disproportionately high burden of dyslipidemia and insulin resistance (Hills et al., 2022).

The positive association between screen time and HOMA-IR is particularly concerning. Even small elevations in insulin resistance during early adulthood predict future type 2 diabetes. In the Coronary Artery Risk Development in Young Adults cohort, television viewing was longitudinally associated with worsening insulin sensitivity, and this relationship was partly mediated by adiposity (Pettee Gabriel et al., 2021). In our data, adjustment for waist circumference attenuated the screen time–HOMA-IR coefficient, supporting central adiposity as a key mediating pathway. However, residual direct effects—such as screen-induced sympathetic activation, circadian disruption, or inflammatory changes—remain plausible.

The link between screen time and subclinical inflammation adds another layer to the risk profile. Each hour of screen time was associated with a 0.22-unit increase in log-CRP, which corresponds to an approximately 25% higher geometric mean CRP. This magnitude is consistent with a recent analysis of NHANES data showing a dose-dependent relationship between recreational screen time and elevated CRP, which persisted after adjustment for BMI and physical activity (Júdice et al., 2021).

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Chronic low-grade inflammation is a recognized precursor of atherosclerosis, and its presence in otherwise healthy young students signals an urgent need for preventive action.

Our joint analysis of screen time and physical activity (Table 3 and Figure 1) highlights an important public health message: physical activity, while beneficial, does not completely counteract the metabolic consequences of excessive screen use. Students who were both highly sedentary in terms of screen time and physically inactive exhibited the worst biomarker profile, but even those who met MVPA guidelines yet maintained high screen time had a less favorable profile than their active, low-screen peers. This finding resonates with the "sedentary physiology" paradigm, which posits that prolonged uninterrupted sitting and specific screen-based behaviors induce unique metabolic perturbations—such as suppressed lipoprotein lipase activity—that are not fully reversed by intermittent exercise (Dempsey et al., 2022). From a curricular standpoint, this implies that strategies must address both the reduction of screen time and the promotion of physical activity, rather than prioritizing one over the other.

The sex-stratified analyses, though not statistically significant for interaction, suggested that the metabolic impact of screen time might be greater in females. This is in line with some studies reporting stronger associations between sedentary behaviors and metabolic syndrome in women, possibly due to differences in body composition, hormonal milieu, or the type of screen activities pursued (Lavie et al., 2023). Larger studies are needed to explore these sex-specific nuances. No differences were observed by degree program, indicating that the problem is pervasive across MBBS, BDS, and nursing disciplines.

Our study has several strengths. We employed stratified random sampling to ensure representation across degree programs and study years. A comprehensive panel of metabolic biomarkers was analyzed with rigorous quality control, and anthropometric measurements were taken by a single observer. The availability of data on dietary habits, sleep duration, and MVPA allowed for robust control of confounding. Moreover, we focused on a population South Asian medical students that is underrepresented in the global screen-time literature.

Several limitations must be acknowledged. The cross-sectional design precludes causal inference; it remains possible that students with poorer metabolic health are more likely to engage in screen-based activities, although the reverse is biologically more plausible. Screen time and physical activity were self-reported, which introduces recall and social desirability biases. However, the instruments have acceptable validity in similar populations, and non-differential misclassification would bias results toward the null, making our estimates conservative. The sample was drawn from a single public-sector university, limiting generalizability to private medical colleges or other regions. Finally, we did not measure body composition or dietary intake through gold-standard methods, and residual confounding by unmeasured factors (e.g., stress, genetic susceptibility) cannot be excluded.

Conclusion

In a well-characterized sample of young medical, dental, and nursing students, screen time emerged as an independent and dose-dependent correlate of adverse metabolic

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biomarkers, including elevated BMI, lower HDL-C, higher triglycerides, greater insulin resistance, and increased systemic inflammation. These associations persisted after accounting for total sedentary time, physical activity, dietary quality, and sleep, and they were most pronounced among students who combined high screen time with low physical activity. Medical universities in Pakistan and similar settings have a unique opportunity to embed screen-time reduction and active-living initiatives into their curricula. Prospective intervention studies are urgently needed to determine whether structured reductions in screen time can translate into measurable improvements in the metabolic health of future healthcare professionals, who will themselves be frontline actors in the nation's response to non-communicable diseases.

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