



Research article

Association of sports participation and sedentary behavior with fiber intake in college students

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Abstract: *Background:* The health benefits of regular physical activity and a balanced diet have been well documented. Even though dietary fiber has been shown to be a critical contributor to health, research remains limited on the association of fiber intake with lifestyle choices. *Purpose:* This study aimed to analyze the associations of dietary fiber intake with sports participation and screen time among Austrian college students. *Methods:* A total of 802 students (88.2% female; mean age 22.2 ± 2.2 years) completed an online questionnaire that included the 18-item FiberScreen, alongside questions on club sports participation, recreational sports, and screen time (smartphone, computer, TV). *Results:* Fiber intake was generally low (15.8 ± 5.8 g/day), with only 7.0% of participants meeting the recommended 25–30 g/day. After adjusting for sex, age, BMI, and breakfast habits, no interaction effects of sports participation and screen time with fiber intake were observed. Participation in both recreational and club sports, however, was significantly associated with higher total fiber intake ($p < 0.01$) due to a higher intake from fruits and vegetables. Associations between total fiber intake or specific foods and screen time were limited. *Conclusion:* Even though sports participation is cross-sectionally associated with fiber consumption, comprehensive approaches promoting active lifestyles and dietary quality are essential to address the generally low fiber intake in college students and to ensure future public health.

Keywords: physical activity; recreational sports; club sports; screen time; smartphone use; computer use; TV time; diet

1. Introduction

The importance of regular physical activity and a balanced diet for health and overall well-being has been well documented [1,2]. However, technological developments and societal changes over recent decades have substantially influenced the physical activity and dietary behaviors of many individuals. In particular, the increasing availability of digital media has led to a rise in sedentary behaviors, which are frequently associated with prolonged screen time [3,4]. At the same time, epidemiological studies indicate that dietary habits and physical activity behaviors are closely interrelated and jointly exert a considerable influence on metabolic and cardiovascular health [5,6]. Accordingly, the investigation of potential associations between a fiber-rich diet, physical activity, and sedentary behaviors (e.g., smartphone use, computer gaming, television time) is gaining increased scientific relevance.

A diet rich in dietary fiber represents an essential component of health-promoting nutritional patterns [7]. Dietary fiber consists largely of indigestible components of plant-based foods that fulfill various physiological functions within the human digestive system [8]. Primary sources of dietary fiber are whole-grain products, fruits, vegetables, legumes, and nuts; the consumption of these foods is often considered when evaluating the overall quality of a diet [9]. Various scientific studies have shown that a higher intake of dietary fiber is associated with lower concentrations of low-density lipoprotein (LDL) cholesterol and improved metabolic parameters as well as a reduced risk for several chronic diseases, including type 2 diabetes, colorectal cancer, and obesity [10–12]. Despite these well-established health benefits, the average daily dietary fiber intake in many industrialized countries remains below the recommended levels of 25–30 g [13–15], which is partly due to the increasing consumption of highly processed foods.

In addition to diet, physical activity plays a crucial role in maintaining health. Similar to diet, regular physical activity has beneficial effects on the cardiovascular system, energy balance, and metabolism, and contributes to the prevention of numerous chronic diseases [16]. International recommendations, therefore, emphasize the promotion of regular physical activity for public health [17]. Furthermore, studies suggest that physically active individuals tend to make more health-conscious lifestyle choices in general [18]. These include, among others, a higher intake of fruits, vegetables, and whole grains as well as a lower consumption of energy-dense and highly processed foods, which suggests that dietary and physical activity behaviors often occur as part of a broader pattern of health-related behaviors [18–20]. In contrast, high levels of electronic media use or screen time are frequently associated with increased sedentary behavior and less favorable health indicators. Accordingly, numerous studies indicate that increased screen time is associated with a higher risk of overweight/obesity, reduced physical fitness, metabolic disturbances, and unfavorable dietary habits [21,22].

At this time, however, limited information remains on the interaction between physical activity and screen time with dietary choices and, particularly, fiber intake. Therefore, the aim of the present study was to analyze potential associations of total fiber intake as well as the consumption of fiber-rich foods with participation in sports and daily screen time among male and female college students. A better understanding of these relationships may provide important insights for preventive strategies, health promotion, and the development of targeted interventions.

2. Materials and methods

2.1. Participants

Six higher education institutions from various regions in Austria were contacted. Data were collected between May 5, 2025, and June 8, 2025, via an online questionnaire that was created with Microsoft Forms and distributed via e-mail and QR code. To enhance the response rate, all participating institutions received a reminder e-mail at the end of the third week of data collection. Students at the respective institutions between 18 and 30 years of age were eligible for participation. Participants were informed about the purpose and procedures of the study, which was approved by the Ethics Committee for Scientific Research of the University of Innsbruck (*Certificate of Good Standing, 18/2025*). Participation was voluntary and anonymous, and completing the questionnaire implied consent. Incomplete questionnaires (e.g., missing or incomplete dietary information) were excluded from the data analysis.

2.2. Dietary fiber intake

Dietary fiber intake was assessed via the 18-item FiberScreen questionnaire, which covers a broad range of fiber-rich food categories, including whole-grain products, fruits, vegetables, legumes, nuts, and seeds [23]. The questionnaire was originally developed and validated in the Netherlands and demonstrates high test-retest reliability (Intraclass Correlation Coefficient, ICC = 0.89). Sensitivity and specificity for identifying individuals with low versus adequate dietary fiber intake were 79% and 75%, respectively [23]. While the original FiberScreen questionnaire is in English, the present study used a validated German version that has been implemented in a recent study among Austrian students [24]. Participants were asked to report the frequency and portion size of various foods for the week preceding the completion of the questionnaire, with visual aids for the estimation of portion size. Dietary fiber intake was subsequently calculated as described by Rijnaarts et al. using frequency, quantity, and fiber content of the respective foods [23]:

$$\text{Daily dietary fiber intake (g)} = \Sigma (\text{frequency} \times \text{portion size} \times \text{fiber content})$$

Total daily fiber intake was subsequently calculated as the sum of food-based fiber intake, which has shown a strong correlation with dietary fiber intake in grams ($r = 0.76$) and can, therefore, be used as a reliable screening indicator [23]. Additionally, a principal component analysis (PCA) that included all foods that were used to determine total fiber intake, using Varimax rotation, revealed four factors with an Eigenvalue > 1 (retention criterion), which explained 62.3% of the total variance of fiber intake. Sampling adequacy was confirmed by a Kaiser–Meyer–Olkin (KMO) value of 0.76 ($p < 0.01$), and data suitability for factorization was confirmed by a significant result for Bartlett’s test of sphericity ($p < 0.01$). Specifically, factor 1 was characterized by high positive loadings (values above 0.40) of fruits, vegetables, legumes, and nuts as well as a high negative loading of white bread (Fruit and Veggie); factor 2 was characterized by high loadings of cereal and granola bars (Cereal); factor 3 was characterized by high loadings of brown bread, pasta, and potatoes (Carbs); and factor 4 was characterized by a high loading of crackers (Crackers). Table 1 shows the complete factor loading matrix along with the explained variability of the individual factors.

Table 1. Factor loading matrix and explained variability of dietary factors.

	Fruit and Veggie	Cereal	Carbs	Crackers
Variability explained (%)	25.973	15.198	10.772	10.357
Fruits	0.700	0.077	0.079	−0.114
Dried fruits	0.485	0.137	−0.168	−0.282
Vegetables	0.593	−0.158	0.350	−0.085
Legumes	0.630	0.284	0.216	0.034
Nuts	0.592	−0.012	−0.018	0.160
Cereal	0.379	0.589	−0.240	−0.245
Granola bars	−0.106	0.612	−0.136	−0.276
Brown bread	0.013	−0.103	0.761	−0.108
White bread	−0.668	0.287	0.236	0.143
Wholegrain bread	0.233	0.282	0.003	0.058
White pasta	−0.335	0.125	0.548	0.029
Wholegrain pasta	−0.004	0.095	0.653	0.199
Potatoes	−0.295	0.358	0.409	0.102
Crackers	0.058	0.326	−0.113	0.813

2.3. Anthropometry, sports participation, and screen time

In addition to the FiberScreen questionnaire, anthropometric and demographic data such as body height, body weight, age, and sex were collected. Body Mass Index (BMI) was calculated (kg/m^2), and participants with a BMI above 25 were categorized as overweight/obese. Furthermore, information on sports club membership, recreational sports participation, and screen use was obtained. Specifically, participants were asked whether they were active members in a sports club and to report their weekly engagement in recreational sports (in a club and/or outside a club) using a six-point Likert scale (1... no regular sports activity; 6... >3 h of sports per week). Recreational sports participation was subsequently categorized into three groups (no regular sports; less than 2 h/week; more than 2 h/week). For screen use, participants reported their average daily usage time of television (TV), smartphone, and computer/tablet using a five-point Likert scale (1... <30 min; 5... >3 h). Smartphone and computer time was subsequently categorized into less than 2 h/day, 2–3 h/day, and more than 3 h/day, while TV time was categorized into less than 30 min/day, 30–60 min/day, and more than 60 min/day. Even though this approach differentiates general tiers of physical activity and screen time involvement, it is not based on clinical absolute metabolic thresholds.

2.4. Statistical analysis

Normal distribution of continuous data was checked using absolute values of ± 2 for skewness and ± 4 for kurtosis [25]. Differences by weight category and sex were examined via independent samples t-tests and chi-square tests for continuous and categorical variables, respectively. Cohen's d and Cramer's V were used to determine effect size. Cohen's d values of 0.2, 0.5, and 0.8 were considered as small, moderate, and large effects; for Cramer's V, reference values were 0.1, 0.2, and 0.3, respectively [26]. Associations of fiber intake with sports participation and screen time were initially analyzed via 2-way multivariate analyses of variance (MANOVA). To control for potential

confounding based on prior evidence linking demographic and lifestyle factors to dietary quality, two-way multivariate analyses of covariance (MANCOVA) were conducted. Specifically, sex, age, BMI, and breakfast frequency were included as covariates, as these variables are established determinants of energy needs, food choices, and overall dietary quality in young adults [27,28]. Partial eta squared (η_p^2) was used as an indicator for effect size, using standard benchmarks of 0.01 (small), 0.06 (moderate), and 0.14 (large) [26]. Even though primary inferences were drawn based on sex-adjusted total sample models, exploratory sex-stratified analyses were conducted due to descriptive differences in food choices between male and female participants. To balance the risk of Type I error inflation resulting from multiple comparisons against the risk of Type II error in an exploratory observational setting, a conservative significance threshold of $p < 0.01$ was adopted rather than the standard $p < 0.05$. Furthermore, effect size metrics and 95% confidence intervals are reported throughout the results to mitigate reliance on p-value thresholds and provide a robust evaluation of observed patterns. This is particularly important for the sex-specific analyses due to an imbalance in sample size (708 female vs. 94 male participants). All statistical analyses were conducted using SPSS 29.0.

3. Results

A total of 802 participants (88.2% female) were included in this study. The average age was 22.2 ± 2.2 years, with the majority (86.9%) being younger than 25 years (Table 2). There was no significant age difference between male and female participants. Mean BMI fell within the healthy range, but 12.5% of the participants were considered to be overweight/obese. BMI was significantly higher in male participants, which was also reflected by a higher prevalence of overweight/obesity (20.2% vs. 11.4%).

Across the entire sample, 18.1% reported no regular sports participation, while 32.4% participated in club sports. There was no significant difference in recreational sports participation, but male participants were more commonly members in club sports ($p < 0.01$), even though the effect size was small. No significant sex differences were observed for engagement with various screen-based activities between male and female participants (Table 2). Bread (wholegrain, brown, and white), fruits (including dried fruits), vegetables, and legumes were the major sources of fiber across the total sample. A mean daily fiber intake of 15.8 ± 5.8 g, however, indicated generally low fiber intake, with only 7.0% reporting a recommended fiber consumption of at least 25 g/day [13]. Participants with overweight/obesity reported a significantly lower total daily fiber intake compared to their peers (13.2 ± 4.4 g vs. 16.1 ± 5.9 g; $p < 0.01$; Cohen's $d = 0.51$). Age and sex, on the other hand, were not significantly associated with total fiber intake.

Table 2. Descriptive characteristics for the total sample and separately for female and male participants. Values are means with SD or prevalence (%).

	Total sample (N = 802)	Female (N = 708)	Male (N = 94)	Effect size Cohen's d
Age (years)	22.2 ± 2.2	22.1 ± 2.2	22.6 ± 2.2	0.177
Height (cm)*	170.2 ± 6.4	168.7 ± 4.9	181.8 ± 3.8	2.749
Weight (kg)*	64.2 ± 7.9	62.4 ± 6.1	77.7 ± 6.5	2.456
BMI (kg/m ²)*	22.1 ± 2.2	22.0 ± 2.2	23.5 ± 1.6	0.714
Sports participation				Cramer's V 0.084
Not regularly	18.1	19.1	10.6	
<2 h/week	39.4	39.7	37.2	
>2 h/week	42.5	41.2	52.1	
Club sports participation (%)*				0.095
Yes	32.4	30.8	44.7	
No	67.6	69.2	55.3	
Smartphone time (%)				0.047
<2 h/day	37.5	37.9	35.1	
2–3 h/day	34.2	34.6	30.9	
>3 h/day	28.3	27.5	34.0	
Computer/tablet time (%)				0.024
<2 h/day	37.4	37.0	40.4	
2–3 h/day	28.1	28.1	27.7	
>3 h/day	34.5	34.9	31.9	
TV time (%)				0.077
<30 min/day	36.3	35.7	40.4	
30–60 min/day	32.2	33.5	22.3	
>60 min/day	31.5	30.8	37.2	

Note: *significant sex difference at $p < 0.01$.

Considering specific foods, overweight/obesity was associated with a lower Fruit and Veggie but higher Carbs factor score ($p < 0.01$; Cohen's $d > 0.95$). There were also significant sex differences in fiber intake from various foods (Table 3). Specifically, female participants reported a higher fiber intake from fruits, vegetables, legumes, nuts, and crackers, while male participants reported a higher fiber intake from white bread and white pasta, potatoes, and granola bars ($p < 0.01$). Effect sizes, however, were generally small except for fiber intake from vegetables (moderate effect) and granola bars (large effect). Accordingly, there were significant sex differences in factor scores ($p < 0.01$), but effect sizes were also small except for Cereal (large effect) (Table 3).

There were no significant recreational sport or club sport by screen time interaction effects for total fiber intake. Significant main effects were observed for recreational and club sports ($p < 0.01$), with a higher fiber intake among club sports participants ($\eta_p^2 = 0.035$) and those spending more time with recreational sports ($\eta_p^2 = 0.080$). No significant main effects for total fiber intake

were observed for smartphone and computer utilization as well as TV time (Figure 1). These results remained essentially unchanged after including sex, age, BMI, and breakfast frequency as covariates.

Table 3. Fiber intake for the total sample and separately for female and male participants. Values are means with SD.

Fiber intake from	Total sample (N = 802)	Female (N = 708)	Male (N = 94)	Effect size Cohen's d
Fruits (g/day)*	1.93 ± 1.26	1.97 ± 1.26	1.61 ± 1.24	0.285
Dried fruits (g/day)	0.45 ± 0.34	0.46 ± 0.35	0.37 ± 0.25	0.264
Brown bread (g/day)	1.30 ± 1.42	1.29 ± 1.42	1.42 ± 1.41	-0.092
Wholegrain bread (g/day)	1.11 ± 1.29	1.11 ± 1.29	1.11 ± 1.32	0.001
White bread (g/day)*	0.70 ± 0.88	0.66 ± 0.86	1.03 ± 0.95	-0.431
Vegetables (g/day)*	2.15 ± 1.13	2.22 ± 1.14	1.60 ± 0.94	0.551
Legumes (g/day)*	2.00 ± 2.06	2.07 ± 2.14	1.48 ± 1.20	0.286
Wholegrain pasta (g/day)	0.95 ± 1.05	0.96 ± 1.05	0.80 ± 0.98	0.154
White pasta (g/day)*	0.81 ± 0.41	0.79 ± 0.40	0.97 ± 0.45	-0.442
Potatoes (g/day)*	1.57 ± 0.97	1.53 ± 0.98	1.84 ± 0.86	-0.323
Cereal (g/day)	1.38 ± 1.59	1.31 ± 1.46	1.95 ± 2.30	-0.407
Nuts (g/day)*	0.89 ± 0.66	0.92 ± 0.67	0.65 ± 0.51	0.421
Crackers (g/day)*	0.30 ± 0.81	0.33 ± 0.86	0.07 ± 0.26	0.319
Granola bars (g/day)*	0.23 ± 0.42	0.19 ± 0.34	0.57 ± 0.74	-0.930
Total Fiber (g/day)	15.76 ± 5.80	15.80 ± 5.88	15.47 ± 5.19	0.057
Fruit and Veggie (z score)*	0.0 ± 1.0	0.05 ± 1.01	-0.41 ± 0.81	0.472
Cereal (z score)*	0.0 ± 1.0	-0.11 ± 0.78	0.81 ± 1.81	-0.963
Carbs (z score)*	0.0 ± 1.0	-0.04 ± 0.99	0.31 ± 1.03	-0.357
Crackers (z score)*	0.0 ± 1.0	0.03 ± 1.05	-0.25 ± 0.43	0.290

Note: *significant sex difference at $p < 0.01$.

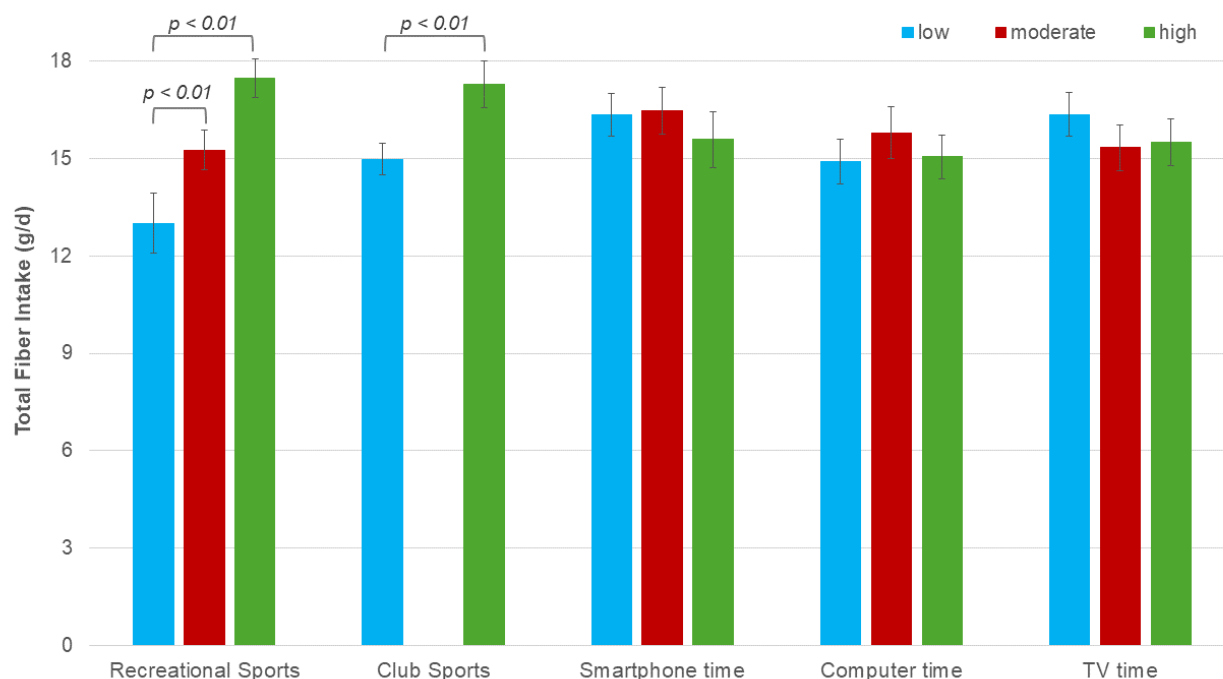


Figure 1. Total fiber intake (g/day) by sports participation and screen time. Values are means with 95% CI. Low: no recreational or club sports; <2 h/day smartphone or computer time; <30 min/day TV time. Moderate: <2 h/week recreational sports; 2–3 h/day smartphone or computer time; 30–60 min/day TV time. High: >2 h/week recreational sports; >3 h/day smartphone or computer time; >60 min/day TV time.

Unadjusted results were similar in the sex specific analyses, with no significant sport by screen time interaction effects on total dietary fiber intake. Main effects for recreational and club sports were significant for male and female participants ($p < 0.01$; recreational sports: $\eta_p^2_{\text{female}} = 0.083$, $\eta_p^2_{\text{male}} = 0.131$; club sports: $\eta_p^2_{\text{female}} = 0.030$, $\eta_p^2_{\text{male}} = 0.088$), while neither sex displayed significant associations between screen time and total fiber intake (Table 4). After including age, BMI, and breakfast frequency as covariates, results remained essentially unchanged among female participants, even though effect sizes were small. Among male participants, associations between club or recreational sports participation and total fiber intake did not reach statistical significance after adjusting for covariates. However, the observed effect sizes in men ($\eta_p^2 = 0.062$ for recreational sports and $\eta_p^2 = 0.041$ for club sports) were comparable to or larger than those in women ($\eta_p^2 = 0.036$ and $\eta_p^2 = 0.019$, respectively; Table 4), indicating that the lack of statistical significance in the male subgroup was driven by limited statistical power rather than an absence of effect.

Table 4. Total fiber intake (g/day) by sports participation and screen time, separately for men and women. Values are means adjusted for age, BMI, and breakfast frequency with SD.

	Female			Effect (η_p^2)	Male			Effect (η_p^2)
	Low	Moderate	High		Low	Moderate	High	
Recreational sports ¹	13.9 ± 5.8	15.4 ± 5.5	17.0 ± 5.7	0.036	12.2 ± 4.8	15.0 ± 5.1	16.3 ± 5.1	0.062
Club sports ¹	15.2 ± 5.5		16.9 ± 5.6	0.019	14.5 ± 4.8		16.5 ± 4.9	0.041
Smartphone time	15.9 ± 5.6	16.0 ± 5.6	15.2 ± 5.6	0.004	16.3 ± 4.8	13.8 ± 4.7	15.9 ± 4.8	0.051
Computer time	15.6 ± 5.6	16.4 ± 5.6	15.5 ± 5.6	0.005	15.8 ± 5.0	14.7 ± 4.9	15.5 ± 4.9	0.009
TV time	16.0 ± 5.6	15.4 ± 5.6	15.8 ± 5.6	0.002	16.3 ± 4.8	14.9 ± 4.8	14.7 ± 4.8	0.022

Note: ¹significant difference across categories among female participants, $p < 0.01$. Low: no recreational or club sports; <2 h/day smartphone or computer time; <30 min/day TV time. Moderate: <2 h/week recreational sports; 2–3 h/day smartphone or computer time; 30–60 min/day TV time. High: >2 h/week recreational sports; >3 h/day smartphone or computer time; >60 min/day TV time.

Considering factor scores for dietary intake, no significant recreational or club sport by screen time interaction effects were observed. There were, however, significant main effects for recreational sports participation for the factor scores Fruit and Veggie ($p < 0.01$; $\eta_p^2 = 0.130$), Cereal ($p < 0.01$; $\eta_p^2 = 0.028$), and Carbs ($p < 0.01$; $\eta_p^2 = 0.019$), but not for Cracker. Specifically, higher recreational sports participation was associated with a higher factor score for Fruit and Veggie as well as Cereal, while scores for carbs were lower. Club sports participation showed small positive associations with the Fruit and Veggie ($p < 0.01$; $\eta_p^2 = 0.046$) and Cereal ($p < 0.01$; $\eta_p^2 = 0.029$) factor scores, while Cracker scores were lower compared to non-club sports participants ($p < 0.01$; $\eta_p^2 = 0.016$). Low smartphone and TV time were only associated with higher Fruit and Veggie factor scores, but effect sizes were trivial ($p < 0.01$; $\eta_p^2_{\text{Phone}} = 0.012$; $\eta_p^2_{\text{TV}} = 0.013$). No main effects for fiber intake scores were observed for computer time.

Table 5. Factor scores for fiber intake by sports participation and sedentary behavior. Values are means adjusted for sex, age, BMI, and breakfast frequency, 95% CI.

		Fruit and Veggie	Cereal	Carbs	Cracker
Sports participation ¹	Not regularly	−0.47 [−0.63; −0.32]	−0.19 [−0.35; −0.03]	0.13 [−0.04; 0.30]	0.12 [−0.05; 0.29]
	<2 h/week	−0.07 [−0.16; 0.03]	−0.03 [−0.13; 0.07]	0.04 [−0.07; 0.15]	0.03 [−0.08; 0.14]
	>2 h/week	0.26 [0.16; 0.36]	0.11 [0.00; 0.21]	−0.09 [−0.20; 0.02]	−0.08 [−0.19; 0.03]
Club sports ^{1,2,3}	Yes	0.27 [0.15; 0.38]	0.17 [0.06; 0.29]	−0.02 [−0.14; 0.11]	−0.19 [−0.31; −0.07]
	No	−0.13 [−0.20; −0.05]	−0.08 [−0.16; −0.01]	0.01 [−0.08; 0.09]	0.09 [0.01; 0.17]
Smartphone time	<2 h/day	0.04 [−0.07; 0.14]	−0.01 [−0.11; 0.10]	0.00 [−0.11; 0.11]	0.01 [−0.11; 0.12]
	2–3 h/day	0.05 [−0.06; 0.16]	−0.05 [−0.16; 0.07]	0.03 [−0.09; 0.14]	−0.03 [−0.15; 0.09]
	>3 h/day	−0.11 [−0.23; 0.14]	0.07 [−0.06; 0.19]	−0.03 [−0.16; 0.10]	0.02 [−0.11; 0.15]
Computer time	<2 h/day	−0.02 [−0.12; 0.09]	0.01 [−0.10; 0.12]	0.01 [−0.10; 0.12]	0.00 [−0.11; 0.11]
	2–3 h/day	0.05 [−0.07; 0.17]	−0.03 [−0.16; 0.09]	0.06 [−0.07; 0.19]	−0.02 [−0.15; 0.11]
	>3 h/day	−0.02 [−0.13; 0.09]	0.02 [−0.09; 0.13]	−0.06 [−0.18; 0.05]	0.01 [−0.10; 0.13]
TV time	<30 min/day	0.10 [−0.01; 0.20]	−0.07 [−0.17; 0.04]	0.04 [−0.07; 0.16]	−0.10 [−0.22; 0.01]
	30–60 min/day	−0.04 [−0.15; 0.07]	−0.02 [−0.13; 0.10]	−0.07 [−0.19; 0.05]	0.02 [−0.10; 0.14]
	>60 min/day	−0.07 [−0.18; 0.04]	0.09 [−0.03; 0.21]	0.03 [−0.09; 0.15]	0.10 [−0.03; 0.22]

Note: Significant difference ($p < 0.01$) for fiber scores ¹Fruit and Veggie, ²Cereal, and ³Cracker.

As observed in the unadjusted model, no significant interaction effects were observed after including sex, age, BMI, and breakfast frequency in the analysis. Results for club sports remained similar to those in the unadjusted model, while for recreational sports participation, significant differences ($p < 0.01$) remained only for the factor score Fruit and Veggie ($\eta_p^2 = 0.070$); the association with the factors Cereal and Carbs was no longer significant (Table 5). Differences in factor scores across any screen time variable were no longer significant after adjusting for sex, age, BMI, and breakfast frequency.

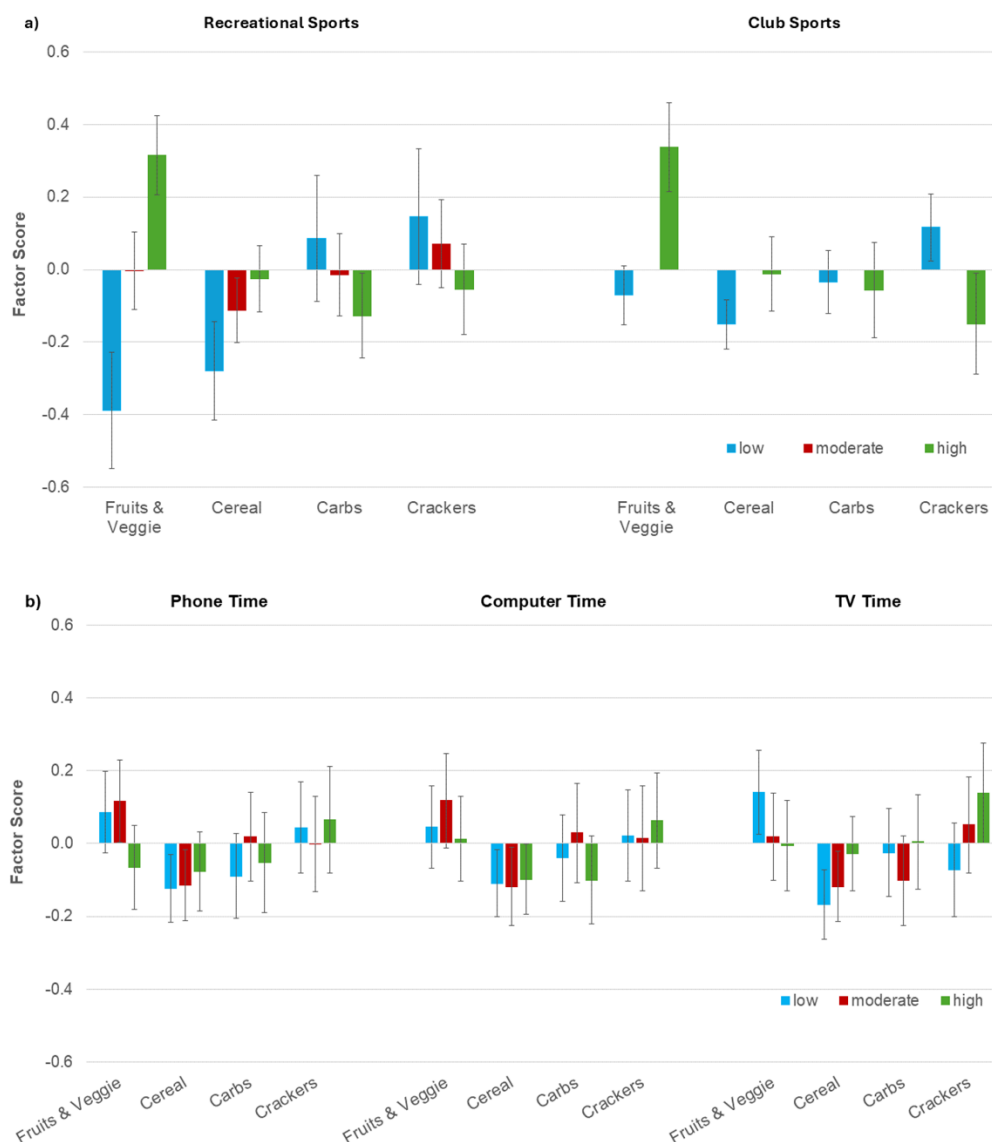


Figure 2. Fiber scores by (a) sports participation and (b) screen time among female participants. Values are means with 95% CI. Low: no recreational or club sports; <2 h/day smartphone or computer time; <30 min/day TV time. Moderate: <2 h/week recreational sports; 2–3 h/day smartphone or computer time; 30–60 min/day TV time. High: >2 h/week recreational sports; >3 h/day smartphone or computer time; >60 min/day TV time.

Sex-specific analyses did not show any significant interaction effects for recreational or club sports with various forms of screen time on fiber scores. Main effects of recreational and club sports participation, as well as screen time, on fiber scores among females were similar to those observed in the total sample. After adjusting for age, BMI, and breakfast frequency, club sports participation was associated with a higher factor score for Fruit and Veggie ($p < 0.01$; $\eta_p^2 = 0.040$), as well as a lower factor score for Crackers ($p < 0.01$; $\eta_p^2 = 0.014$). Further, recreational sports participation was associated with a higher factor score for Fruit and Veggie ($p < 0.01$; $\eta_p^2 = 0.064$), while significant associations between screen time and dietary factor scores were no longer significant (Figure 2).

Among males, results of the unadjusted model were similar for club sports, while recreational sports participation was only significantly associated with the Fruit and Veggie score ($p < 0.01$; $\eta_p^2 = 0.199$). Neither form of screen time was associated with fiber factor scores among male participants. After adjusting for age, BMI, and breakfast frequency, the association between recreational sports and the Fruit and Veggie score remained significant ($p < 0.01$; $\eta_p^2 = 0.124$), while club sports participation was significantly associated with a lower factor score for Crackers ($p < 0.01$; $\eta_p^2 = 0.087$) (Figure 3).



Figure 3. Fiber scores by (a) sports participation and (b) screen time among male participants. Values are means with 95% CI. Low: no recreational or club sports; <2 h/day smartphone or computer time; <30 min/day TV time. Moderate: <2 h/week recreational sports; $2\text{--}3$ h/day smartphone or computer time; $30\text{--}60$ min/day TV time. High: >2 h/week recreational sports; >3 h/day smartphone or computer time; >60 min/day TV time.

4. Discussion

This cross-sectional study aimed to determine the daily fiber intake of Austrian college students and to investigate its association with sports participation and screen time. The results suggest that total daily fiber intake is generally low, with 93% of participants reporting an intake below the current recommendation of 25–30 g/day [13]. Bread, fruits, vegetables, and legumes were reported as the main sources of fiber. Excess body weight was associated with a lower total fiber intake, due to a lower intake from fruits and vegetables, while fiber intake from carbs was higher among participants with overweight/obesity. Although female participants reported a higher fiber intake from fruits, vegetables, legumes, nuts, and crackers, there was no sex difference in total fiber intake, as male participants reported a higher fiber intake from white bread, white pasta, potatoes, and granola bars. Participation in recreational sports showed a moderately strong association with total fiber intake independent of sex, age, BMI, and breakfast frequency. Club sports participation was also significantly associated with total fiber intake, even though the effect size was small.

No significant association, on the other hand, was observed between total fiber intake and any type of screen time when accounting for sex, age, BMI, and breakfast frequency. In terms of specific sources of fiber, sports participation was associated with a higher fiber intake from fruits and vegetables; the effect size was moderate for recreational sports participation and small for club sports. Club sports participation was also associated with a lower fiber intake from crackers. Associations between screen time and fiber intake were limited and not significant after adjusting for sex, age, BMI, and breakfast frequency. Although sex-stratified analyses revealed differences in statistical significance across subgroups, the effect sizes for the association between sports participation and fiber intake were consistent across both men and women. The loss of statistical significance in the adjusted models among men, therefore, reflects the smaller subgroup sample size ($n = 94$) and associated reduced statistical power rather than true sex-specific differences. Consequently, overall conclusions should be drawn from the pooled, sex-adjusted models.

The inverse association between body weight and fiber intake has been well documented [29] and has been discussed in more detail in a previous study [24]. The present study, however, further highlights a concerning trend in dietary habits among young adults, with a low fiber intake independent of weight status, which has been attributed to a high consumption of ultra-processed foods and refined carbohydrates in general [8,15,30,31]. Accordingly, Torres et al. [32] showed a high sodium and fat intake, particularly of saturated fat, along with a low fiber consumption among university students. This has been attributed to limited healthy options in cafeterias, along with low prices and the convenience of junk foods [33]. Main sources of fiber were similar to those reported in previous studies, particularly with regard to fruits, vegetables, and legumes [8,30,34], despite a low fruit and vegetable consumption among university students [32]. Similarly, the observed sex differences in fiber intake from specific foods were consistent with previous research [35,36]. Such sex differences, however, have been predominantly attributed to food preferences and eating styles, rather than dietary needs [37]. Nevertheless, a previous study showed that health benefits attributed to specific fiber food sources were only significant in men, even though women displayed a higher consumption of potentially healthier fiber-rich foods [37]. Total fiber intake, however, was associated with a reduced chronic disease risk in both men and women [37], which emphasizes the need to promote adequate fiber intake in young adults.

The results of the present study further indicate a beneficial association between recreational sports participation and total fiber intake, while associations with screen time were limited. The higher fiber consumption among more active young adults may be attributed to generally healthier dietary choices among sports participants, which are often associated with higher intrinsic motivation [38]. Although physiological and biological mechanisms were not directly evaluated in the present study, literature-based theories offer several possible explanations for a higher fiber intake among more active individuals. For instance, previous studies have proposed potential roles of dietary fiber in exercise recovery and overall performance via influences on glycemic regulation, metabolic health, oxidative stress, systemic inflammation, and immune function [39,40]. Additionally, prior research suggests that fiber intake may modulate gut microbiota composition and reduce gastrointestinal discomfort, which is a common issue among active populations [41]. A higher fiber intake has been further associated with a more gradual release of glucose into the bloodstream as a result of slower gastric emptying, which improves energy stability during engagement in exercise [42]. Particularly, the consumption of soluble fiber (e.g., fruits, vegetables, legumes) has been associated with more stable blood glucose profiles that benefit endurance performance [43]. These physiological pathways, however, must be viewed as speculative possibilities derived from prior literature rather than mechanisms demonstrated by the present data. Nevertheless, such concepts provide a plausible context for the observed higher intake of fruits and vegetables among physically active participants compared to their less active peers.

Associations between fiber intake and screen time, on the other hand, were limited in the present study. Even though excess screen time has been associated with poorer dietary choices among adolescents and adults [44–46], there remains limited research on the association with fiber intake. Vizcaino et al. [46], however, showed that particularly high TV and smartphone time was associated with less healthy dietary patterns but not necessarily fiber intake. Nevertheless, it should be considered that screen time and physical activity or sports participation are associated with leisure time choices [47,48]. The present study, however, did not differentiate between screen-based activities for recreational, academic, or occupational use. The small to moderate effect sizes also emphasize that even though an active lifestyle trends alongside healthy choices, recreational sports participation is only a partial contributor to dietary variations, and particularly when examining recreational choices, individual health behaviors should not be considered in isolation. The importance of considering diet and physical activity in combination for general health is also reflected by the fact that current dietary guidelines include recommendations for physical activity [49]. Additional research, however, is needed to enhance the understanding of potential combined associations of recreational sports and screen time with dietary fiber intake and health-related outcomes.

5. Conclusions

Taken together, the results of this study suggest an association between sports participation and elevated fiber metrics, while associations with screen-based behaviors are limited. The generally low fiber intake further emphasizes the need to promote an adequate fiber intake in college students, independent of their recreational behavioral choices. Late adolescence and early adulthood may be a particularly important time period, as many start to live independently and make their own lifestyle choices at this age. Therefore, public health frameworks should concurrently promote active routines alongside healthy dietary choices to shift young adult behaviors effectively.

The limitations of this study

In addition to the lack of information on specifics of screen time (e.g., reason for usage, time of day), other limitations of the present study must be considered. Information on diet, anthropometry, frequency of physical activity, and screen time was collected via questionnaires. Questionnaires, however, are susceptible to response bias due to social desirability as well as recall errors, which can lead to misclassification. Nevertheless, they are frequently used in large samples [50], and the dilution or compression of the used categories may actually result in conservative estimates of the observed association between sports participation and fiber intake. It should also be considered that the 18-item FiberScreen questionnaire does not provide a comprehensive assessment of an individual's overall diet. Accordingly, it does not determine total nutrient or energy intake, and there was no information on dietary habits beyond information on breakfast frequency. Furthermore, no information was available regarding smoking status, alcohol consumption, nutritional knowledge/literacy, and academic discipline, as well as the participants' socioeconomic background or living conditions. These variables, therefore, could not be considered in the statistical analyses. The cross-sectional nature of the study also does not allow for establishing causality, and the unequal gender distribution within the sample (88% female) may limit the generalizability of findings. Specifically, results for the male subsample should be interpreted with caution as they lack the statistical power of the total sample. This imbalance of male and female participants, however, largely reflects the sex distribution among primary school education majors. The large number of statistical models evaluated across various behavioral variables, dietary factors, and subgroup analyses also holds the risk for Type I error inflation despite setting a conservative significance threshold of $p < 0.01$. Formal step-down corrections (e.g., Holm–Bonferroni), however, were omitted to prevent excessive Type II errors given the correlated nature of dietary variables. Findings, therefore, should be interpreted with a focus on effect sizes and need to be verified in future pre-registered confirmatory studies. The large sample size, with more than 800 participants from six universities, on the other hand, should be considered a strength of the study, along with the use of a validated questionnaire to determine fiber intake, which adds credibility to the study, despite the previously mentioned limitations.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Authors' contributions

Conceptualization, K.G. and MC.G.; methodology, K.G. and Cl.D.; formal analysis Cl.D.; writing - original draft preparation, Cl.D.; writing - review and editing, MC.G., M.B., G.R., Co.D.; project administration, K.G., G.R. Co.D. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

Clemens Drenowatz and Martin Burtcher are editorial board members for AIMS Public Health. They were not involved in the editorial review or the decision to publish this article. All authors declare that there are no competing interests.

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