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ORIGINAL RESEARCH ARTICLE | SIMULATION-BASED STUDY

Physical Activity Patterns and Health-Related Fitness Among University Students

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Abstract

Background: Physical activity varies substantially during university education, yet total movement and structured exercise may show different associations with fitness. Objective: To characterize activity profiles and estimate associations with health-related fitness in a synthetic university cohort. Methods: A cross-sectional dataset of 240 simulated students aged 18–25 years was constructed with correlated activity, sedentary time, cardiorespiratory fitness, muscular endurance, and anthropometric measures. Activity groups were defined using simulated moderate-to-vigorous physical activity (MVPA): low (<150), moderate (150–299), and high (≥300 min/week). Results: The low, moderate, and high groups comprised 78, 98, and 64 observations. Mean estimated VO_2max was 35.2, 39.1, and 43.0 $mL \cdot kg^{-1} \cdot min^{-1}$, respectively. Adjusted differences versus the low group were 3.4 (95% CI 2.0–4.8) and 6.8 (5.1–8.5) $mL \cdot kg^{-1} \cdot min^{-1}$. Sedentary time was inversely associated with estimated VO_2max after adjustment (-0.42 $mL \cdot kg^{-1} \cdot min^{-1}$ per additional daily hour). Conclusion: Under the specified simulation assumptions, greater weekly activity co-occurred with higher fitness, whereas sedentary exposure contributed an independent negative association. Findings describe synthetic observations, not recruited participants.

Keywords: physical activity; university students; cardiorespiratory fitness; sedentary time; muscular endurance; simulation

How to Cite This Article

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Research integrity statement: No students were recruited or tested. All observations, effect estimates, and statistical summaries are simulated.

1. Introduction

University years coincide with changes in transportation, academic workload, living arrangements, and discretionary time. These transitions can modify the balance between organized exercise, incidental movement, and sedentary behavior. Describing these behaviors as a single activity score conceals differences in their physiological relevance.

Health-related fitness encompasses cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition. The dimensions are related, but each reflects distinct functional capacities. Weekly activity volume is expected to align most consistently with aerobic fitness when the accumulated movement is sufficiently intense and sustained.

Student populations provide a useful setting for examining heterogeneous movement patterns. Some students achieve high volumes of walking while reporting little structured exercise; others perform vigorous training yet remain sedentary throughout most of the academic day. These combinations challenge simple active-versus-inactive classifications.

This study uses a transparent synthetic cross-sectional cohort to demonstrate how activity exposure, sedentary time, and fitness outcomes can be examined jointly. Numerical relationships are specified for methodological illustration and do not represent estimates from a real university population.

2. Conceptual Framework

The analytical framework distinguishes three domains: accumulated moderate-to-vigorous physical activity (MVPA), structured exercise participation, and sedentary exposure. MVPA captures the weekly dose of movement; structured exercise describes planned sessions; sedentary exposure reflects time spent in seated or reclining activities while awake.

Cardiorespiratory fitness is represented by estimated maximal oxygen uptake (VO_2max). Muscular endurance is represented by a standardized push-up count. Body mass index is included as a descriptive anthropometric indicator rather than a direct measure of body composition.

The central expectation is a positive activity–fitness gradient, with higher weekly MVPA corresponding to higher VO_2max and muscular endurance. A secondary expectation is that sedentary exposure retains a negative association with aerobic fitness after accounting for MVPA and covariates.

Because the design is cross-sectional, the relationships are associations rather than causal intervention effects. The simulation permits assessment of regression behavior, category contrasts, and sensitivity to plausible measurement error.

3. Research Questions and Hypotheses

Three research questions organize the analysis. First, how do estimated aerobic and muscular fitness outcomes vary across low, moderate, and high weekly MVPA groups? Second, does daily sedentary time show an association with fitness independent of reported activity? Third, how do alternative activity thresholds and reporting error influence the estimated associations?

H1 specifies a monotonic positive gradient in estimated VO_2max across activity groups. H2 specifies a positive association between MVPA and muscular endurance. H3 specifies a negative adjusted association between sedentary time and VO_2max.

Each hypothesis is evaluated within a synthetic dataset with pre-specified dependencies. Statistical uncertainty describes variability generated by the simulation model; it must not be interpreted as sampling uncertainty from a real population.

4. Materials and Methods

A cross-sectional cohort of 240 synthetic student records was generated to resemble a mixed undergraduate population aged 18–25 years. The sample size was selected to permit three activity strata and multivariable analyses with several covariates. No institutional recruitment, consent procedure, or physical testing occurred.

Each record contains age, sex category, weekly MVPA, daily sedentary hours, planned exercise sessions, estimated VO_2max, push-up count, and body mass index. Continuous variables were generated from bounded distributions with prespecified correlations, and group assignments were determined from MVPA thresholds.

The data-generating mechanism assigned positive coefficients to MVPA and planned exercise and a negative coefficient to sedentary hours for aerobic fitness. Independent residual terms were introduced to avoid deterministic outcomes. A separate equation generated muscular endurance with a stronger structured-exercise component.

All analysis conventions were established before descriptive tables were assembled. The purpose is to illustrate reporting of a complete observational research workflow using openly identified synthetic outcomes.

Variable	Operational definition	Unit
MVPA	Moderate-to-vigorous physical activity	min/week
Sedentary time	Average waking sitting time	h/day
VO_2max	Estimated aerobic capacity	$mL \cdot kg^{-1} \cdot min^{-1}$
Push-ups	Modeled muscular endurance	repetitions

5. Measures and Operational Definitions

MVPA was expressed as total minutes per week and divided into three categories: low (<150 min/week), moderate (150–299 min/week), and high (≥300 min/week). The thresholds were chosen for clear group comparison and do not constitute a clinical classification of individual students.

Sedentary exposure was expressed as average hours per day. Structured exercise frequency was recorded as sessions per week. Estimated VO_2max was expressed in $mL \cdot kg^{-1} \cdot min^{-1}$; push-up performance was recorded as repetitions completed in a standardized hypothetical assessment.

Age and body mass index were included as continuous covariates. Sex category was included for stratified description and adjusted models. In real research, these measures would require documented instruments, administration protocols, and measurement reliability; here they are generated variables.

Outcome distributions were restricted to plausible adult ranges to prevent impossible values. These bounds improve internal coherence but do not establish empirical validity.

6. Statistical Analysis

Descriptive statistics summarize group sizes, means, and standard deviations. Group differences are presented using a simulated one-way analysis of variance and pairwise contrasts. Linear regression models estimate adjusted associations with estimated VO_2max and push-up performance.

The aerobic fitness model includes MVPA category, sedentary hours, age, sex category, and body mass index. A secondary model uses weekly MVPA as a continuous predictor per additional 60 minutes. The muscular endurance model additionally includes planned exercise sessions.

Confidence intervals and p values are reported as outputs of the synthetic analysis. They quantify uncertainty under the assumed data-generating process, not the precision of any claim about university students outside the simulated cohort.

Collinearity was assessed conceptually by limiting overlap among activity predictors; model diagnostics focused on residual patterns and the stability of coefficients under alternative category definitions.

7. Sample Characteristics

The cohort comprised 240 synthetic observations with a mean age of 21.1 years. Activity strata contained 78 low-activity, 98 moderate-activity, and 64 high-activity records. The modeled cohort contained a balanced distribution of sex categories.

The high-activity group accumulated more planned exercise sessions and less sedentary time on average. Differences in body mass index were modest across activity categories, consistent with the decision not to encode body size as a dominant determinant of activity status.

Between-group differences in exposure were substantial by construction, while within-group dispersion was retained to reflect heterogeneous individual patterns. The descriptive results are presented as an internally consistent example of a university fitness dataset.

Characteristic	Low (n=78)	Moderate (n=98)	High (n=64)
Age, years	21.0	21.2	21.1
MVPA, min/week	93	218	372
Sedentary, h/day	8.7	7.6	6.6
Exercise, sessions/week	1.1	2.5	4.1

8. Activity Patterns and Fitness Outcomes

Estimated VO_2max increased across the three activity groups. Mean values were 35.2, 39.1, and 43.0 $mL \cdot kg^{-1} \cdot min^{-1}$ in the low, moderate, and high groups, respectively. The high–low contrast was 7.8 $mL \cdot kg^{-1} \cdot min^{-1}$ before adjustment.

Muscular endurance followed a similar gradient. The simulated push-up means were 18.4, 23.7, and 29.1 repetitions. Greater exercise frequency contributed additional between-person variability beyond total MVPA minutes.

These patterns are consistent with the imposed positive exposure–outcome associations. They illustrate how categorical analyses can communicate dose gradients while masking substantial overlap among individual observations.

Fitness outcome	Low	Moderate	High
VO_2max, $mL \cdot kg^{-1} \cdot min^{-1}$	35.2 ± 5.2	39.1 ± 5.0	43.0 ± 5.4
Push-ups, repetitions	18.4 ± 7.1	23.7 ± 7.5	29.1 ± 8.0

9. Multivariable Results

After adjustment for sedentary time, age, sex category, and body mass index, the moderate group showed an estimated VO_2max difference of 3.4 mL·kg^{-1}·min^{-1} (95% CI 2.0–4.8) relative to the low group. The corresponding high-group difference was 6.8 (5.1–8.5).

Each additional hour of daily sedentary time was associated with a modeled −0.42 mL·kg^{-1}·min^{-1} difference in estimated VO_2max (95% CI −0.65 to −0.19). The direction remained negative in the continuous-MVPA specification.

The adjusted muscular endurance model showed higher repetition counts in more active groups, although effect sizes were attenuated after structured exercise frequency was included. This attenuation reflects the overlapping contributions of general activity and targeted muscular training.

Coefficients are conditional on the chosen simulation model and should not be used as population benchmarks.

Predictor	Adjusted difference	95% CI
Moderate vs low MVPA	+3.4	2.0 to 4.8
High vs low MVPA	+6.8	5.1 to 8.5
Sedentary time, per hour	−0.42	−0.65 to −0.19

10. Sensitivity Analyses

Sensitivity analyses evaluated whether the positive activity–fitness gradient depended on a single classification scheme. Alternative group thresholds changed group sizes but preserved the ordering of mean estimated VO_2max across categories.

When random reporting error was added to weekly MVPA, estimated associations weakened. This behavior illustrates attenuation arising from imprecise activity measurement and highlights the importance of distinguishing questionnaire-derived exposure from device-measured movement.

Excluding the highest simulated activity values reduced the magnitude of the high-group contrast but did not reverse its direction. Adding structured exercise frequency to the aerobic model also attenuated the MVPA coefficient, consistent with shared explanatory information.

These analyses are internal stress tests of the data-generating assumptions rather than external replication.

11. Discussion

The principal modeled finding is a graded association between weekly activity and estimated cardiorespiratory fitness. The contrast between low and high activity categories is large enough to be visible in descriptive statistics and remains present after adjustment for selected covariates.

The second finding is that sedentary exposure contributes a distinct negative coefficient in the aerobic fitness model. This distinction matters because a student may complete exercise sessions yet spend much of the remaining day sitting. Separate measures allow these patterns to be analyzed without treating them as exact opposites.

Muscular endurance displayed a positive relationship with overall activity, but structured exercise frequency accounted for part of that association. The result reflects the specificity principle: targeted muscular work can be more directly related to a repetition-based test than aggregate weekly movement alone.

No causal inference follows from the simulated cross-sectional comparisons. The model shows how assumptions translate into observable results and how careful reporting prevents descriptive associations from being overstated.

12. Practical Interpretation

For university-based research, the framework supports simultaneous assessment of movement volume, structured exercise, and sitting time. A single weekly activity total may be insufficient to characterize the combination of exposures most relevant to fitness outcomes.

An applied campus assessment could combine validated activity questionnaires or accelerometry with standardized field fitness tests. Protocols would need consistent timing, participant instructions, instrument calibration, and prespecified analysis decisions.

The modeled group contrasts illustrate the value of reporting absolute differences with confidence intervals rather than relying exclusively on significance tests. Fitness outcomes should be presented with units, group distributions, and the extent of overlap across activity levels.

The analysis also highlights that activity patterns are shaped by course schedules, commuting options, recreation facilities, and social circumstances. These contextual factors deserve explicit measurement in observational research.

13. Limitations and Conclusion

The primary limitation is that the dataset is entirely synthetic. Neither the exposure distributions nor the estimated regression coefficients were observed in students. Consequently, the reported associations have illustrative rather than evidentiary value.

The use of cross-sectional observations prevents estimation of change over time. Self-report measurement error is represented only through sensitivity assumptions. The simplified covariate structure excludes diet, sleep, disability, socioeconomic position, prior sport experience, and institutional environment.

Within these boundaries, the model demonstrates a coherent positive activity–fitness gradient and a negative adjusted association between sedentary time and aerobic fitness. The results provide a structured example of reporting an observational exercise-science analysis.

The broader methodological conclusion is that activity exposure, sedentary behavior, and fitness outcomes benefit from separate operational definitions and transparent multivariable reporting.

Declarations

Ethics approval and consent: Not applicable; no human participants were enrolled. Funding: None. Conflicts of interest: None declared. Data availability: Synthetic dataset and numerical summaries are illustrative. DOI: Not assigned.

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