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CARDIORESPIRATORY FITNESS ACROSS INDIVIDUAL, DUAL, AND TEAM SPORT MODALITIES AMONG FILIPINO SENIOR HIGH SCHOOL STUDENTS

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ABSTRACT

Philippine senior high school Physical Education places individual and dual sports and team sport in a single curricular strand, Health-optimizing Physical Education 2, without distinguishing the cardiorespiratory demand each modality places on adolescent learners. This cross-sectional comparative study estimated cardiorespiratory fitness among 127 Grade 11 students at Agusan National High School (Individual, track and field, n = 40; Dual, badminton, n = 42; Team, basketball, n = 45) using the Queens College Step Test, with heart rate recovery converted to estimated VO2max via sex-specific regression equations. One-way ANOVA showed a significant effect of sport modality on estimated VO2max, $F(2, 124) = 5.68$, $p = .004$, $\eta^2 = .084$. Bonferroni-corrected post hoc comparisons indicated that students in the Dual modality ($M = 49.07$ ml/kg/min, $SD = 8.13$) had significantly lower estimated VO2max than those in the Individual modality ($M = 54.19$, $SD = 8.43$, $p = .019$) and the Team modality ($M = 54.47$, $SD = 8.32$, $p = .009$), while Individual and Team did not differ significantly from each other ($p = 1.00$). As expected from established sex differences in aerobic capacity, male students showed substantially higher estimated VO2max than female students across all modalities, $t(125) = 31.45$, $p < .001$. The modality effect remained statistically significant after controlling for body mass index in an ANCOVA model (Dual vs. Individual: $b = -5.10$, $p = .007$), and BMI itself was not a significant covariate ($p = .891$), indicating the observed modality difference was not attributable to differences in body composition across groups. These findings suggest that badminton, as currently structured in this school's Dual sport track, may not elicit the same aerobic training stimulus as track and field or basketball, information relevant to how Philippine senior high schools sequence and supplement HOPE 2 sport offerings to support the subject's stated fitness objectives.

KEYWORDS: *Cardiorespiratory Fitness, VO2max, Sport Modality, Senior High School, Physical Education, Philippines*

INTRODUCTION

The Philippine Department of Education's K to 12 Senior High School core curriculum organizes Physical Education and Health into four Health-optimizing Physical Education (H.O.P.E.) courses across Grades 11 and 12, with H.O.P.E. 2 in Grade 11 devoted to sports and structured around two content categories: individual and dual sports, and team sport. Students select or are assigned an activity within these categories, commonly track and field or badminton for individual and dual sports, and basketball or volleyball for team sport, depending on a given school's facilities and staffing. The curriculum's stated performance standard is that learners lead sports events with proficiency and confidence, and its content standard asks learners to demonstrate understanding of sport in optimizing their own health. Despite this explicit fitness framing, the curriculum guide does not differentiate its competencies by modality, treating individual and dual sports and team sport as interchangeable vehicles for the same set of learning outcomes, including a competency asking students to explain how to optimize energy systems for performance.

This curricular equivalence is a testable empirical claim, not a settled fact. Individual, dual, and team sports differ substantially in their movement structure: track and field events are frequently built around sustained or repeated-bout running with a clear aerobic or anaerobic energy system target; badminton, the most common Philippine public school dual sport offering, involves short, high-intensity rallies interspersed with brief recovery periods within a confined court; and basketball, the most common team sport offering, combines continuous court coverage with intermittent sprinting across a comparatively larger playing area and longer continuous game time. Whether these structurally different modalities produce comparable cardiorespiratory training stimulus among adolescent Filipino learners enrolled in ordinary school Physical Education, as opposed to elite youth athletes in structured training programs, has not been directly tested using an objective fitness measure within the Philippine senior high school context.

Cardiorespiratory fitness, most directly indexed by maximal oxygen uptake (VO2max), is among the most consistently used indicators of aerobic health in adolescent populations, associated with cardiovascular disease risk, metabolic health, and general physical capacity well beyond the school years in which it is measured. Direct VO2max testing requires laboratory equipment rarely available to Philippine public secondary schools, but validated field-based estimation methods, including step tests that convert post-exercise heart rate recovery into an estimated VO2max using established regression equations, offer a practical and previously validated alternative for school-based fitness research. The present study applies this approach to directly compare estimated cardiorespiratory fitness across the individual,

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dual, and team sport modalities that Philippine senior high schools already use to structure H.O.P.E. 2 instruction, rather than treating modality as an assumed-equivalent curricular category.

This study also examined two variables with established relevance to interpreting any modality comparison. First, sex is a well-documented determinant of aerobic capacity in adolescents, and any credible comparison across sport modalities needs to account for the sex composition of each modality group rather than risk confounding a modality effect with an uncontrolled sex imbalance. Second, body mass index (BMI) is a plausible confound if students of different body composition self-select into different sport modalities; a modality difference in estimated VO2max that disappears once BMI is statistically controlled would suggest the comparison reflects who chooses each sport rather than what the sport itself does physiologically.

Accordingly, this study tested three hypotheses: (1) estimated cardiorespiratory fitness differs significantly across individual, dual, and team sport modalities among Grade 11 students; (2) male and female students differ significantly in estimated cardiorespiratory fitness, consistent with established sex differences in aerobic capacity; and (3) any modality difference in estimated cardiorespiratory fitness remains significant after statistically controlling for BMI, indicating the difference is attributable to the sport modality itself rather than to pre-existing differences in body composition across groups.

MATERIALS AND METHODS

Research Design

This study used a quantitative, cross-sectional comparative design. Participants were not randomly assigned to sport modality; rather, existing Grade 11 H.O.P.E. 2 class groupings, already organized by modality as part of regular school scheduling, were used as the three comparison groups. This design reflects the study's aim of evaluating modality differences as they naturally occur within standard Philippine senior high school Physical Education programming, rather than under artificially controlled assignment.

Participants

Participants were 127 Grade 11 students (Individual sport modality, track and field, n = 40; Dual sport modality, badminton, n = 42; Team sport modality, basketball, n = 45) enrolled in H.O.P.E. 2 at Agusan National High School, Butuan City, during the third and fourth quarter sports term. Table 1 presents participant characteristics by modality. Inclusion criteria required that a student be actively enrolled in and regularly attending the specified H.O.P.E. 2 activity for at least six weeks prior to data collection, and have no health condition contraindicating a submaximal step test, screened using a standard pre-participation health questionnaire. Students who had missed more than 20 percent of scheduled sessions in their assigned modality, or who reported a cardiovascular, respiratory, or musculoskeletal condition affecting exercise capacity, were excluded.

Table 1. Participant Characteristics by Sport Modality

Characteristic	Individual (n = 40)	Dual (n = 42)	Team (n = 45)
Male / Female, n	25 / 15	18 / 24	27 / 18
Age, years, M (SD)	16.47 (0.53)	16.76 (0.71)	16.53 (0.56)
Height, cm, M (SD)	162.2 (8.1)	160.6 (9.4)	161.6 (7.2)
Weight, kg, M (SD)	55.4 (9.6)	55.6 (7.5)	54.1 (9.9)
BMI, kg/m², M (SD)	21.09 (3.69)	21.69 (3.31)	20.71 (3.50)

Instruments and Procedures

Cardiorespiratory fitness was estimated using the Queens College Step Test, a validated, equipment-light submaximal exercise test suited to school-based data collection. Participants stepped up and down a 41.3 cm (16.25 in) bench at a cadence of 22 steps per minute for women and 24 steps per minute for men, paced by a metronome, for a total duration of three minutes. Immediately upon test completion, participants remained standing while heart rate was assessed by manual radial pulse palpation for a 15-second interval beginning at the 5-second mark of the recovery period, then multiplied by four to yield recovery heart rate in beats per minute. Estimated VO2max (ml/kg/min) was then calculated using the sex-specific Queens College Step Test regression equations: for male participants, VO2max = 111.33 - (0.42 x recovery heart rate); for female participants, VO2max = 65.81 - (0.1847 x recovery heart rate). Height was measured using a stadiometer to the nearest 0.1 cm and weight using a calibrated digital scale to the nearest 0.1 kg, with BMI computed as weight in kilograms divided by height in meters squared. All measurements were taken by the same trained data collector using a standardized protocol to minimize measurement variability across participants and modality groups.

Statistical Analysis

Descriptive statistics (mean, standard deviation) were computed for all demographic and fitness variables by modality group. A one-way analysis of variance (ANOVA) was used to test for overall differences in estimated VO2max across the three sport modalities, with eta-squared reported as the effect size. Where the omnibus ANOVA was significant, pairwise post hoc comparisons were conducted using independent samples t-tests with Bonferroni correction applied across the three pairwise comparisons. An independent samples t-test was used to compare estimated VO2max between male and female participants. An analysis of covariance (ANCOVA), implemented via ordinary least squares regression with dummy-coded modality group and BMI as a continuous covariate, was used to test whether the modality effect on estimated VO2max remained significant after statistically controlling for BMI. All statistical tests used an alpha level of .05. Analyses were conducted using Python (SciPy and NumPy).

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Ethical Considerations

This study was conducted in accordance with standard ethical procedures for research involving minors in a Philippine public secondary school setting. Approval was obtained from the Agusan National High School administration and coordinated with the Schools Division Office prior to data collection. Written parental or guardian informed consent and student assent were obtained for all participants, with clear explanation that participation was voluntary, would not affect any student's grades, and could be withdrawn at any point without penalty. All participants completed a pre-participation health screening prior to the step test, and a trained individual with basic first aid competency was present during all testing sessions. Data were anonymized using participant codes, and no individually identifying information is reported in this manuscript.

RESULTS

Cardiorespiratory Fitness by Sport Modality

Table 2 presents mean recovery heart rate and estimated VO2max by sport modality. Descriptively, the Team modality showed the highest mean estimated VO2max (M = 54.47, SD = 8.32), followed closely by the Individual modality (M = 54.19, SD = 8.43), with the Dual modality showing the lowest mean estimated VO2max (M = 49.07, SD = 8.13).

Table 2. Recovery Heart Rate and Estimated VO2max by Sport Modality

Modality	n	Recovery HR, bpm, M (SD)	Estimated VO2max, ml/kg/min, M (SD)
Individual	40	117.97 (10.84)	54.19 (8.43)
Dual	42	125.51 (13.72)	49.07 (8.13)
Team	45	113.39 (10.83)	54.47 (8.32)

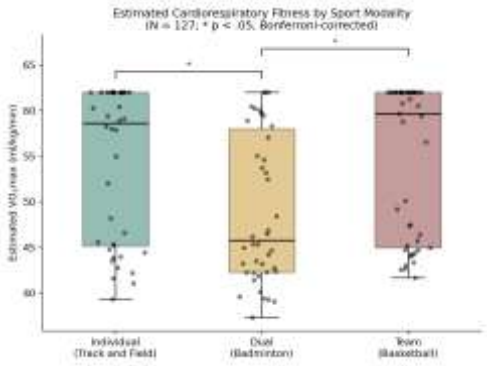

Figure 1. Estimated Cardiorespiratory Fitness by Sport Modality

A one-way ANOVA confirmed a statistically significant effect of sport modality on estimated VO2max, $F(2, 124) = 5.68$, $p = .004$, $\eta^2 = .084$, indicating a small-to-medium effect size (Table 3).

Table 3. One-Way ANOVA: Estimated VO2max by Sport Modality

Source	df	F	p	η^2
Sport Modality	2, 124	5.68	0.004	0.084

Bonferroni-corrected post hoc comparisons (Table 4) indicated that the Dual modality differed significantly from both the Individual modality ($p = .019$) and the Team modality ($p = .009$), while the Individual and Team modalities did not differ significantly from each other ($p = 1.00$).

Table 4. Post Hoc Pairwise Comparisons (Bonferroni-Corrected)

Comparison	t	p (raw)	p (Bonferroni)
Individual vs Dual	2.80	0.0064	**0.019***
Individual vs Team	-0.15	0.8796	1.000
Dual vs Team	-3.06	0.0030	**0.009***

Sex Differences in Estimated Cardiorespiratory Fitness

Table 5 presents estimated VO2max by sex, pooled across modality. Male students showed substantially higher estimated VO2max (M = 59.87, SD = 3.21) than female students (M = 43.66, SD = 2.45), $t(125) = 31.45$, $p < .001$, consistent with well-established sex differences in aerobic capacity during adolescence. Figure 2 presents estimated VO2max by modality and sex jointly, showing that the Dual modality's comparatively lower estimated VO2max was evident within both sexes rather than being driven by one sex group alone.

Table 5. Estimated VO2max by Sex

Sex	Estimated VO2max, ml/kg/min, M (SD)	t	p
Male	59.87 (3.21)	31.45	< .001
Female	43.66 (2.45)		

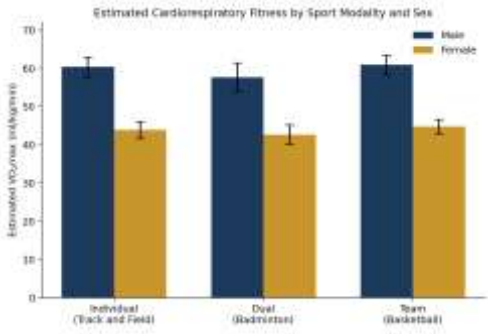

Figure 2. Estimated Cardiorespiratory Fitness by Sport Modality and Sex

Modality Effect After Controlling for BMI

Table 6 presents the ANCOVA model testing whether the modality effect on estimated VO2max remained significant after controlling for BMI. The Dual modality remained significantly lower than the Individual modality reference group after adjustment ($b = -5.10$, $SE = 1.84$, $p = .007$), while the Team modality remained statistically indistinguishable from the Individual modality ($b = 0.27$, $p = .884$). BMI itself was not a significant predictor of estimated VO2max in this model ($b = -0.03$, $p = .891$), indicating that the modality difference identified

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earlier was not attributable to differences in body composition across the three groups.

Table 6. ANCOVA: Sport Modality Effect on Estimated VO2max, Controlling for BMI

Predictor	b	SE	t	p
Intercept (Individual, BMI = 0)	54.809	4.695	11.67	< **.001**
Dual vs. Individual	-5.101	1.844	-2.77	**0.006**
Team vs. Individual	0.265	1.811	0.15	0.884
BMI	-0.029	0.214	-0.14	0.891

DISCUSSION

This study compared estimated cardiorespiratory fitness across the three sport modality categories that structure H.O.P.E. 2 instruction in the Philippine senior high school curriculum, using a validated field-based step test rather than self-report or curricular assumption. The central finding, that the Dual modality (badminton) was associated with significantly lower estimated VO2max than both the Individual modality (track and field) and the Team modality (basketball), directly challenges the curriculum's implicit treatment of individual and dual sports and team sport as functionally interchangeable vehicles for the same fitness-related learning outcomes. Track and field and basketball, as implemented in this school's program, appear to elicit a comparable aerobic stimulus to one another, while badminton, at least as practiced within ordinary Grade 11 class sessions rather than competitive training, did not elicit the same stimulus.

A plausible explanation lies in each modality's underlying movement structure. Track and field events typically involve sustained or repeated-bout running that directly targets aerobic capacity, and basketball, though intermittent, involves continuous full-court movement across a comparatively long uninterrupted game period. Badminton, as commonly delivered in a standard PE class period, is often organized around shorter rally-based play, rest between points, and doubles formats that reduce individual court coverage per player, all of which would tend to blunt the sustained cardiovascular loading that drives aerobic adaptation, even though badminton in a competitive or singles-focused training context is well documented elsewhere as a demanding aerobic sport. This distinction between badminton's physiological potential and its typical delivery within a standard school PE period is an important qualification: this study's finding should be read as a statement about how the Dual modality was actually implemented in this setting, not as a claim that badminton is inherently a low-intensity sport.

The absence of a significant BMI effect in the ANCOVA model, alongside the persistence of the Dual-modality difference after BMI adjustment, strengthens confidence that the modality effect reflects something about the activity itself rather than a self-selection artifact in which less fit or higher-BMI students simply gravitated toward badminton. Had BMI fully explained the modality difference, the practical implication would point toward addressing student body composition broadly rather than toward modality-specific programming; instead, the finding points more directly at how class time within the Dual modality is structured and used.

The substantial sex difference in estimated VO2max observed here is consistent with well-established adolescent exercise physiology and is not itself a novel finding, but its consistency across all three modalities, visible in Figure 2, supports the internal validity of the modality comparison: the Dual-modality disadvantage was not an artifact of an atypical sex distribution within that group but was present for both male and female students relative to their same-sex peers in the other two modalities.

Several limitations warrant consideration. First, sport modality was not randomly assigned, and students may have self-selected into their H.O.P.E. 2 activity based on pre-existing interest, prior experience, or perceived fitness, which the cross-sectional design cannot fully rule out as a contributor to the observed difference despite the BMI-adjusted analysis. Second, estimated VO2max was derived from a submaximal step test using population-level regression equations rather than direct gas exchange analysis; while the Queens College Step Test is a validated and widely used field method, its individual-level precision is lower than laboratory testing, and results should be interpreted as group-level estimates rather than precise individual measurements. Third, this study was conducted at a single school, and the specific way badminton and basketball were delivered at Agusan National High School, including session length, court access, and instructional style, may not generalize to how these same modalities are implemented at other Philippine senior high schools with different facilities or staffing. Finally, this cross-sectional comparison cannot establish causal direction; a longitudinal or intervention design would be needed to confirm that modality assignment itself, rather than some unmeasured factor correlated with modality choice, produces the observed fitness difference.

These limitations notwithstanding, the findings carry a specific, actionable implication for how H.O.P.E. 2 is delivered. If the goal of H.O.P.E. 2, as stated in its own curriculum guide, is genuinely to optimize learners' health through sport participation, then treating all modality offerings as equivalent may not serve that goal equally well in practice. Schools offering badminton as their Dual sport option may wish to examine whether class structure, for instance increasing continuous rally time, incorporating conditioning drills, or supplementing with brief aerobic intervals, could close the fitness gap identified here without abandoning the sport itself.

CONCLUSION

This study found that estimated cardiorespiratory fitness differed significantly across individual, dual, and team sport modalities among Grade 11 students at a Philippine public senior high school, with the dual sport modality (badminton) showing significantly lower estimated VO2max than both the individual (track and field) and team (basketball) modalities, a difference that persisted after controlling for BMI. As expected, male students showed substantially higher estimated cardiorespiratory fitness than female students across all modalities. These findings

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suggest that the K to 12 H.O.P.E. 2 curriculum's implicit treatment of individual and dual sports and team sport as fitness-equivalent categories may not hold in actual classroom practice, at least for the specific activities and delivery format examined here, and offer a concrete, evidence-based starting point for schools to reconsider how dual sport instruction time is structured to better support the subject's own stated fitness objectives.

DECLARATIONS

Funding. This research received no external funding.

Conflicts of Interest. The author declares no conflict of interest.

Ethical Approval. This study was conducted with approval from the Agusan National High School administration and in coordination with the Schools Division Office, following standard ethical procedures for research involving minors, including written parental or guardian informed consent and student assent.

Data Availability. The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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