

International Journal of Sport Studies for Health

Journal Homepage



Outdoor Activity-Based Physical Education and Wearable Technology for Student Fitness and Well-Being Support

Andry Akhiruyanto^{1*}, Hernawan², Sandey Tantra Paramitha³, Moch. Fahmi Abdulaziz¹, La Ode Adhi Virama⁴, Dewangga Yudhistira⁵

¹Faculty of Sport Sciences, Semarang State University, Semarang, 50229, Central Java, Indonesia

²Faculty of Sport Sciences and Health, State University of Jakarta, Jakarta, 13220, DKI Jakarta, Indonesia

³Faculty of Sports and Health Education, Universitas Pendidikan Indonesia, Bandung, 40154, West Java, Indonesia

⁴Fakultas Tarbiyah Dan Ilmu Keguruan, Institut Agama Islam Negeri Kendari, Kendari, 93116, Southeast Sulawesi, Indonesia

⁵Faculty of Sport Sciences and Health, Surabaya State University, Indonesia

* Corresponding author email address: andryakhiruyanto@mail.unnes.ac.id

Article Info

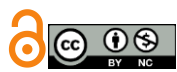
Article type:

Original Research

How to cite this article:

Andry Akhiruyanto, Hernawan, Paramitha, S. T., Fahmi Abdulaziz, M., Virama, L. O. A., & Yudhistira, D. (2026). Outdoor Activity-Based Physical Education and Wearable Technology for Student Fitness and Well-Being Support. *International Journal of Sport Studies for Health*, 9(4), 1-13.

<http://dx.doi.org/10.61838/kman.intjssh.5555>



© 2026 the authors. Published by KMAN Publication Inc. (KMANPUB), Ontario, Canada. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) License.

ABSTRACT

Objective: Physical inactivity among adolescents is a critical global health issue, with over 80% of adolescents failing to meet WHO recommendations for daily physical activity. While conventional physical education (PE) contributes to student health, there remains a need for pedagogical innovation that enhances objective monitoring and deeper student engagement. An outdoor activity-based PE approach integrated with wearable technology offers a promising model within the framework of achieving SDG 3. This study aims to examine the effectiveness of a physical education program based on outdoor activities integrated with wearable technology in improving the physical fitness and psychological well-being of high school students.

Methods and Materials: A pretest–posttest quasi-experimental design with a control group was applied to 30 male students at State Senior High School 12 Semarang, divided equally into an experimental group ($n = 15$) and a control group ($n = 15$) using ordinal pairing based on initial Harvard Fitness Index (HFI) scores. The experimental group participated in a structured outdoor physical education program for eight weeks (3 sessions/week, 50–65 minutes/session) using Polar Watch devices. Psychological well-being was measured using the Indonesian adaptation of Ryff's Psychological Well-Being Scale (RPWB; 6 dimensions), and physical fitness was assessed via the Harvard Step Test (HFI). Data were analyzed using the Wilcoxon Signed-Rank Test and the Mann-Whitney U Test ($\alpha = 0.05$).

Findings: All variables in the experimental group showed statistically significant improvements ($p \leq 0.05$) with moderate to large effect sizes: total well-being score ($W = 0.0$; $Z = -3.41$; $p = 0.001$; $r = 0.604$), all six RPWB dimensions ($r = 0.376$ – 0.548), and HFI ($W = 0.0$; $Z = -3.40$; $p = 0.001$; $r = 0.602$). The proportion of students categorized as Good fitness increased from 0% to 46.7%, and the Low Well-being category disappeared entirely in the post-test. Notably, the control group also showed significant within-group improvements across all variables, confirming that regular physical education also produced meaningful benefits. There were no significant differences in gains between groups ($p > 0.05$) for seven of eight

Article history:

Received 26 May 2026

Revised 23 September 2026

Accepted 30 September 2026

Published online 01 October 2026

outcomes; the only significant between-group difference was in Environmental Mastery, which favored the control group ($p = 0.011$).

Conclusion: An outdoor activity-based physical education program integrated with wearable technology was associated with significant improvements in psychological well-being and physical fitness within the experimental group of male high school students. However, the absence of significant between-group differences indicates that structured physical activity in any format—whether outdoor or conventional—can provide meaningful health benefits for adolescents. Although wearable technology may have supported objective monitoring and self-regulatory awareness during the program, its independent contribution to outcome improvements could not be established in this study.

Keywords: *Outdoor Activity; Physical Education; Wearable Technology; Psychological Well-Being; Physical Fitness; SDG 3*

1. Introduction

Physical Education (PE) plays a fundamental role in fostering active and healthy lifestyles from an early age, aligning with Sustainable Development Goal (SDG) 3: Good Health and Well-being (1, 2). SDG 3 calls for global efforts to ensure healthy lives and promote well-being for people of all ages, with key targets including reducing premature mortality from noncommunicable diseases and promoting mental health and well-being (target 3.4) (3). In the context of education, physical education is viewed as one of the most effective tools for achieving these goals, as it fosters an active lifestyle, builds physical capacity, and promotes students' mental health in a holistic manner (4, 5).

However, the actual situation shows that the physical inactivity crisis among adolescents has reached alarming levels globally. The World Health Organization (WHO) recommends that adolescents aged 5–17 years engage in at least 60 minutes of moderate to vigorous physical activity per day (6). Unfortunately, more than 80% of adolescents worldwide reportedly do not meet these recommendations (7). The global rate of physical inactivity continued to rise by five percentage points between 2010 and 2022, and is projected to reach 35% by 2030 if this trend is not addressed promptly (8). This situation has been further exacerbated by the COVID-19 pandemic, which dramatically shifted adolescents toward sedentary lifestyles, with screen time rising sharply and physical activity declining drastically (9, 10).

A similar situation is unfolding in Indonesia. Data from the Basic Health Research indicate that the proportion of Indonesian adolescents who are insufficiently physically active reaches as much as 85.5%, with even more alarming figures in urban and suburban areas (11). The prevalence of sedentary behavior among Indonesian children and adolescents continues to rise in tandem with increasing reliance on digital devices (12, 13). This situation has serious

long-term consequences, including an increased risk of obesity, cardiovascular disease, type 2 diabetes, and mental health issues among the younger generation (14).

In light of these challenges, physical education in schools should be at the forefront of fostering a culture of active living. In reality, however, physical education in many Indonesian educational institutions is still dominated by conventional indoor activities, with a curriculum that tends to be rigid and teaching methods that are monotonous (15). While conventional PE can produce meaningful improvements in student health outcomes, the assessment system is often product-oriented, focusing on final results rather than on the process of improving effort and active engagement of each individual student (16). Limited physical facilities and a lack of pedagogical innovation are significant barriers that may reduce the potential impact of physical education programs on long-term physical activity participation (17).

In response to these limitations, Outdoor Activity-Based Physical Education offers a promising new paradigm. This approach utilizes the outdoor environment—from open fields and city parks to natural areas surrounding the school—as a dynamic living laboratory where students interact directly with nature through a variety of meaningful physical activities (18, 19). Various empirical studies have demonstrated the potential added benefits of outdoor learning compared to conventional indoor approaches in terms of improving students' physical fitness, cognitive development, and emotional engagement (20, 21). Outdoor activities introduce elements of challenge, adventure, and environmental awareness that cannot be found in a conventional gymnasium, thereby stimulating students' intrinsic motivation to participate actively (22).

More specifically, a number of studies have demonstrated the positive impact of outdoor physical activity on adolescents' mental health and psychological well-being (23, 24). Exposure to the natural environment has been shown to

facilitate recovery from stress, reduce symptoms of anxiety and depression, and boost resilience and self-esteem among adolescents (25, 26). Outdoor Adventure Education (OAE) has been shown to have a significant effect on improving resilience, social connectedness, and reducing anxiety in adolescents compared to no intervention at all (23, 27, 28). School-based research also confirms that nature-based interventions can reduce mental health symptoms, including anxiety and depression, particularly among students who previously experienced more serious issues (29).

Research on outdoor physical education generally continues to focus on physical fitness variables, while in-depth studies exploring psychological well-being in the context of structured outdoor interventions remain very limited (30). The concept of psychological well-being developed by Ryff (1989) covers six key dimensions—self-acceptance, positive relationships with others, autonomy, environmental mastery, purpose in life, and personal growth—which provide a comprehensive theoretical framework for assessing the psychological impact of physical education interventions (31, 32). However, to date, there have been few outdoor physical education intervention studies that use Ryff's Psychological Well-Being Scale (RPWB) as a primary outcome measure, particularly in the context of urban adolescents in Indonesia.

On the other hand, advances in digital technology are opening up emerging opportunities in the field of physical education. Wearable technology—including smartwatches and fitness trackers—now serves as a tool capable of monitoring and recording physical activity objectively and non-invasively in real time (33). These devices can automatically and continuously track key biometric parameters, including step count, heart rate, and calories burned (34). This capability opens up a new paradigm known as Data-Driven Physical Education, in which assessments and feedback based on objective data replace subjective and sporadic evaluations (35).

Several systematic reviews have examined the effectiveness of wearable activity trackers in promoting increased physical activity among children and adolescents in school settings (36, 37). These findings suggest that wearable technology has significant potential as a monitoring and motivational tool, particularly when

integrated into structured intervention programs (38). This technology has also been shown to increase student engagement in physical education through self-monitoring, personal goal-setting, and real-time feedback (39, 40). Scientific validation of modern wearable devices, such as the Polar Watch, has demonstrated adequate accuracy in measuring physiological parameters.

Although both outdoor activities and wearable technology have shown promising evidence of benefits when used separately, their integration into a single, structured physical education intervention design remains a largely unexplored area. There are almost no studies that simultaneously investigate how quantitative data from wearable technology can enrich outdoor learning experiences and provide objective feedback to both teachers and students in a school setting in developing countries. Based on this background, this study aims to: (1) test the effectiveness of an Outdoor Activity-based Physical Education approach integrated with wearable technology in improving students' physical fitness (HFI) and psychological well-being among high school students in Semarang; and (2) examine whether the intervention group achieves significantly greater gains compared to a control group receiving regular physical education.

2. Methods and Materials

2.1 Research Design

This study employs a quantitative approach using a quasi-experimental pretest–posttest design with a control group (41). This design was chosen because it allows researchers to implement structured interventions in a real-world school setting without altering the existing classroom structure, while systematically comparing results between experimental and control groups (42). A quasi-experimental approach is appropriate and ethical for school-based research because full randomization is not feasible given the class assignments already determined by the institution (43). The experimental group participated in an eight-week physical education program based on outdoor activities integrated with wearable technology, while the control group followed the school's regular physical education curriculum.

Table 1. Pretest–Posttest Quasi-Experimental Design with a Control Group

Group	Pre-Test	Treatment (8 Weeks)	Post-Test
Experimental (n = 15)	O ₁	X (Outdoor + Wearable)	O ₂
Control (n = 15)	O ₃	– (Regular PE)	O ₄

Note: O₁ & O₃ = Initial measurements (pre-test); O₂ & O₄ = Final measurements (post-test); X = Outdoor-based physical education intervention using wearable technology; – = Regular (conventional) physical education curriculum, representing an active control condition (not a no-treatment condition).

2.2 Research Location and Time

The study was conducted at State Senior High School 12 Semarang, which was selected based on the availability of adequate outdoor activity facilities, including a sports field, school garden, and access to open areas in the surrounding environment. The study lasted approximately five months (March–July 2025), comprising four main phases: preparation (Month 1), implementation and data collection (Months 2–4), data analysis (Month 4–5), and manuscript preparation (Month 5).

2.3 Population and Sample

The target population consisted of male high school students aged 15–18 years at State Senior High School 12 Semarang. A total of 30 male students from Grade 11 were recruited using purposive sampling, taking into account the following inclusion criteria: (1) actively enrolled at the research partner school; (2) aged 15–18 years; (3) having no medical conditions that prevent participation in moderate-to-vigorous physical activity; and (4) willing to provide informed consent. Exclusion criteria included students with

active musculoskeletal injuries, cardiovascular conditions that contraindicate exercise, or absences accounting for more than 20% of the total intervention sessions.

The final sample of 30 students was divided into an experimental group (n = 15) and a control group (n = 15) using an ordinal pairing technique based on initial HFI scores to ensure equivalent baseline fitness characteristics between the two groups. This sample size, while modest, is consistent with preliminary intervention studies in school-based physical education settings.

2.4 Intervention Procedures

The intervention program is a structured outdoor sports program developed by the research team and validated by experts in Physical Education and Sports Science. The program ran for eight weeks, with three sessions per week lasting 50–65 minutes each, in accordance with WHO physical activity recommendations for adolescents (6). All sessions were led by certified coaches and supervised by physical education instructors to ensure safety and appropriate exercise intensity (44). The intervention was divided into four progressive phases, as shown in Table 2.

Table 2. Wearable Technology-Based Outdoor Activity Intervention Program (8 Weeks)

Week	Phase	Main Activities	Freq.	Duration
1–2	Orientation & Introduction	Wearable (Polar Watch) familiarization, basic orienteering, GPS mapping introduction, outdoor breathing exercises	3×/wk	50 min
3–4	Intensity Building	Light hiking, team games in open areas (capture the flag, relay race), real-time heart rate monitoring	3×/wk	55 min
5–6	Peak Activity	Outdoor circuits (sprint, jumping, climbing), step count & calorie tracking, daily reflection via wearable dashboard	3×/wk	60 min
7–8	Consolidation & Evaluation	Complex activity combinations, group challenges based on wearable data, personal growth & well-being review	3×/wk	65 min

Each intervention session followed a standard structure: (1) a 10-minute warm-up consisting of dynamic stretching and light cardiovascular activation; (2) a 35–45-minute core outdoor activity session comprising a combination of aerobic activities, team games, and functional exercises; and (3) a 10-minute cool-down consisting of group reflection on wearable data and static stretching (18). The control group

followed the school's regular indoor physical education curriculum, with content and duration determined by the school's physical education teacher without any intervention from the research team.

2.5 Implementation of Wearable Technology

All participants in the experimental group were equipped with Polar Watch devices, which they used throughout the intervention program to monitor their daily physical activity. These devices automatically recorded three key parameters: (1) daily step count; (2) real-time heart rate; and (3) estimated calories burned (45). Data from the wearable devices were synchronized and reviewed by researchers during and between intervention sessions to track participants' progress.

The use of wearable technology also served as a motivational tool and feedback mechanism that encouraged self-monitoring among students. Maximum heart rate (HRmax) for each participant was estimated using the standard formula $HR_{max} = 220 - \text{age (years)}$, consistent with widely used protocols in adolescent exercise research. The target heart rate zone for moderate-to-vigorous physical activity was set at 60–80% of individual HRmax. Research assistants monitored Polar Watch readings during each

session to verify that participants maintained appropriate intensity, and verbal feedback was provided when heart rate fell outside the target zone. At the end of each intervention session, aggregated real-time data from the Polar Watch were displayed and discussed during a brief group reflection session, allowing students to understand the relationship between physical activity intensity and the physiological responses detected (39). This procedure aligns with the concept of data-driven physical education, which aims to shift the assessment paradigm from a subjective approach to one based on objective and continuous data (35).

2.6 Measurement and Data Collection Instruments

Measurements were taken twice: before the intervention (pre-test, Week 0) and after the intervention was completed (post-test, Week 9). All measurements were conducted over a two-day period to minimize variations in participants' conditions. Table 3 summarizes the instruments, parameters, and validation references used in this study.

Table 3. Research Instruments and Measurement Parameters

Variable	Instrument	Parameters	Measurement Time
Daily Physical Activity	Polar Watch (wearable)	Step count, heart rate, calories burned (24-hr)	Automatic cloud sync
Physical Fitness	Harvard Step Test	Harvard Fitness Index (HFI)	Pre-test & Post-test
Psychological Well-Being	Ryff's PWB Scale – Indonesian Adaptation (42 items)	Six dimensions: self-acceptance, positive relations, autonomy, environmental mastery, purpose in life, personal growth	Pre-test & Post-test

Physical fitness was assessed using the Harvard Step Test, which measures recovery heart rate following a standardized stepping protocol to estimate cardiorespiratory fitness and compute the Harvard Fitness Index (HFI). This test is widely used in adolescent populations and is well-suited for school-based settings due to its simplicity of administration and minimal equipment requirements (46). The HFI formula used was: $HFI = (\text{Duration of exercise in seconds} \times 100) / (2 \times \text{sum of pulse counts in recovery})$, with a higher HFI indicating better cardiorespiratory fitness. Fitness categories were classified based on the standard Harvard Step Test classification system (46): Poor (< 55), Fair (55–64), and Good (≥ 65). These categories are commonly applied in adolescent populations and were used without modification in the current study, as no Indonesian-specific normative classification was available for this age group and sex.

Psychological well-being was measured using the Indonesian-language adaptation of Ryff's Psychological

Well-Being Scale (RPWB), developed by Rachmayani and Ramdhani (2014) (31), consisting of 42 items covering six dimensions: (1) self-acceptance; (2) positive relationships with others; (3) autonomy; (4) environmental mastery; (5) purpose in life; and (6) personal growth. Psychometric validation of this scale in the Indonesian context has reported an adequate Cronbach's alpha reliability coefficient (47). Items were rated on a 6-point Likert scale (1 = strongly disagree to 6 = strongly agree). Each dimension was scored as the mean of its 7 constituent items, yielding a possible range of 1.00 to 6.00 per dimension. The total well-being score reported in this study represents the sum of the six dimension mean scores, with a possible range of 6 to 36. Well-being categories were defined as: Low Well-Being (total score < 18), Moderate Well-Being (18–27), and High Well-Being (> 27), based on equal-interval division of the scoring range. These cut-off points are consistent with the scoring framework recommended in the original Ryff (1989) scale adapted for the Indonesian context.

2.7 Data Analysis

All quantitative data were analyzed using IBM SPSS Statistics version 26, with a significance level set at $\alpha = 0.05$ (45). Prior to inferential testing, a normality test using the Shapiro-Wilk test was conducted for each variable within each group ($n = 15$). Results indicated that several variables violated the normality assumption ($p < 0.05$), including

Autonomy in the experimental group ($W = 0.844$, $p = 0.014$), Environmental Mastery in the control group ($W = 0.862$, $p = 0.026$), and HFI gain scores in both groups. Given the small group size ($n = 15$ per group) and the presence of non-normal distributions in key variables, non-parametric tests were selected for all inferential analyses to ensure analytical robustness and consistency across variables. Statistical analyses were conducted in two stages, as shown in Table 4.

Table 4. Statistical Analysis Procedures for the Study

Type of Analysis	Statistical Technique	Description
Normality Test	Shapiro-Wilk Test	Assessed normality of distribution for each variable within each group ($n = 15$ per group). Non-normal distributions warranted use of non-parametric tests.
Within-Group Pre-Post Comparison	Wilcoxon Signed-Rank Test	Compared pre-test and post-test scores separately within the experimental and control groups.
Between-Group Gain Comparison	Mann-Whitney U Test	Examined whether gain scores (post – pre) differed significantly between the experimental and control groups.
Effect Size	$r = Z / \sqrt{N}$	Determined the practical significance of within-group changes: small ($r = 0.10-0.29$), medium ($r = 0.30-0.41$), large ($r \geq 0.50$).
Descriptive Analysis	Mean $\pm$ SD, Min, Max	Presented data characteristics and a comprehensive description of pre-post changes for all variables.

The Wilcoxon Signed-Rank Test was used to compare pre-test and post-test scores within each group, examining the significance of change for each variable separately (48). The Mann-Whitney U Test was then applied to the gain scores (post-test minus pre-test) to compare whether the magnitude of improvement differed significantly between the experimental and control groups (49). Effect sizes for within-group comparisons were calculated using the formula $r = Z / \sqrt{N}$, where Z is the standardized test statistic derived from the Wilcoxon Signed-Rank Test output, and N refers to the total number of observations (i.e., the number of participants per group, $n = 15$) (50). The Wilcoxon W statistic (sum of positive ranks) is reported alongside the Z statistic and r value. Where $W = 0.0$, this reflects instances in which all observed changes were in the same direction (exclusively positive), resulting in no negative ranks or ties, which is a valid and interpretable outcome in small-sample within-group comparisons. All findings are reported following APA 7th edition standards, including test statistics, p -values, Z values, and effect size estimates.

3. Results

3.1 Sample Characteristics and Descriptive Statistics

This study involved 30 male students in Grade 11 at State Senior High School 12 Semarang, divided equally into an

experimental group ($n = 15$) and a control group ($n = 15$) using an ordinal pairing technique based on initial Harvard Fitness Index (HFI) scores. In the pre-test, the mean total well-being score for the experimental group was 17.80 ± 3.90 and for the control group 16.07 ± 4.15 , while the mean HFI for the experimental group was 64.81 ± 3.78 and for the control group 64.02 ± 3.09 . These equivalent baseline conditions confirm the success of the ordinal pairing technique in balancing the two groups prior to the intervention. Full descriptive statistics for all variables are presented in Table 5. Wearable technology monitoring data from the experimental group indicated that participants spent an average of 78.4% of each session within the target moderate-to-vigorous intensity zone (60–80% HRmax), with a mean session heart rate of 142.6 ± 9.8 bpm. Mean daily step count during intervention weeks averaged $9,847 \pm 1,243$ steps, and estimated mean caloric expenditure per session was 312 ± 48 kcal. Device adherence (proportion of sessions with complete wearable data) was 96.3% across all participants and sessions, confirming high compliance with the monitoring protocol.

Table 5. Descriptive Statistics for Pre-Test, Post-Test, and Gain Scores of All Variables

Variable	Pre Exp	Post Exp	Gain Exp	Pre Con	Post Con	Gain Con
WB Total	17.80±3.90	22.87±2.06	+5.07±2.64	16.07±4.15	22.13±1.54	+6.07±3.09
A – Self-Acceptance	3.27±1.39	3.93±1.12	+0.67±1.01	2.87±1.20	3.67±0.87	+0.80±0.83
B – Positive Relations	2.67±0.87	3.33±0.87	+0.67±0.94	2.47±0.62	3.33±0.60	+0.87±0.81
C – Autonomy	2.93±0.68	4.00±0.82	+1.07±1.00	2.53±1.02	3.60±0.71	+1.07±1.06
D – Env. Mastery	3.27±1.00	3.67±0.87	+0.40±0.61	2.33±1.07	3.47±0.81	+1.13±0.81
E – Purpose in Life	2.93±1.06	4.07±0.44	+1.13±1.09	2.67±1.30	4.00±0.73	+1.33±1.35
F – Personal Growth	2.73±1.12	3.87±0.88	+1.13±0.88	3.20±1.05	4.07±0.68	+0.87±0.96
HFI	64.81±3.78	72.97±8.23	+8.16±5.86	64.02±3.09	71.91±8.05	+7.89±5.59

3.2 Changes in Well-Being and Physical Fitness Category Distribution

Table 6 shows the changes in the frequency distribution of well-being and HFI categories from pre-test to post-test in both groups. The most notable finding is the complete disappearance of the Low Well-being category in the post-test for both groups (experimental: from 4 students [26.7%] to 0; control: from 6 students [40.0%] to 0). In the experimental group, the proportion of students in the High

Well-being category increased nearly 3.5-fold, from 2 students (13.3%) to 7 students (46.7%), while in the control group it increased from 2 (13.3%) to 4 students (26.7%).

For the physical fitness variable (HFI), in the pre-test, all students in both groups were in the Poor and Fair categories, with none reaching the Good category. After the eight-week intervention, the Good category appeared in 7 students in the experimental group (46.7%) and 6 students in the control group (40.0%), while the proportion in the Poor category dropped drastically from above 53% to just 6.7% in both groups.

Table 6. Distribution of Well-Being and HFI Categories in Pre-Test and Post-Test

Category	Pre-Exp	Post-Exp	Pre-Con	Post-Con
Low Well-Being	4 (26.7%)	0 (0.0%)	6 (40.0%)	0 (0.0%)
Moderate Well-Being	9 (60.0%)	8 (53.3%)	7 (46.7%)	11 (73.3%)
High Well-Being	2 (13.3%)	7 (46.7%)	2 (13.3%)	4 (26.7%)
HFI – Poor	8 (53.3%)	1 (6.7%)	9 (60.0%)	1 (6.7%)
HFI – Fair	7 (46.7%)	7 (46.7%)	6 (40.0%)	8 (53.3%)
HFI – Good	0 (0.0%)	7 (46.7%)	0 (0.0%)	6 (40.0%)

3.3 Within-Group Effectiveness (Wilcoxon Signed-Rank Test)

The first hypothesis states that a physical education program based on outdoor activities integrated with wearable technology significantly improves the well-being and physical fitness of students in the experimental group. The results of the Wilcoxon Signed-Rank Test are presented in Table 7.

All variables in the experimental group exhibited statistically significant improvements ($p < 0.05$): total well-being score ($W = 0.0$; $Z = -3.41$; $p = 0.001$; $r = 0.604$), and all six dimensions—Self-Acceptance ($W = 16.0$; $Z = -2.12$; $p = 0.039$; $r = 0.376$), Positive Relations ($W = 10.0$; $Z = -2.30$; $p = 0.026$; $r = 0.408$), Autonomy ($W = 5.0$; $Z = -2.80$; $p = 0.007$; $r = 0.497$), Environmental Mastery ($W = 15.0$; Z

$= -2.18$; $p = 0.034$; $r = 0.387$), Purpose in Life ($W = 5.5$; $Z = -2.77$; $p = 0.007$; $r = 0.493$), and Personal Growth ($W = 3.0$; $Z = -3.09$; $p = 0.003$; $r = 0.548$)—as well as HFI ($W = 0.0$; $Z = -3.40$; $p = 0.001$; $r = 0.602$). The $W = 0.0$ values for Total Well-Being and HFI indicate that all 15 participants improved (no negative ranks or ties). Effect sizes ranged from moderate to large ($r = 0.376$ to $r = 0.604$), indicating that the intervention effects were both statistically and practically significant. Accordingly, the first hypothesis is accepted.

The control group similarly showed significant within-group improvements across all variables ($p < 0.05$). This finding is noteworthy and is discussed further in the Discussion section, as it demonstrates that structured physical activity in any format can meaningfully improve both physical fitness and psychological well-being in adolescents.

Table 7. Results of the Wilcoxon Signed-Rank Test: Pre–Post Changes by Group

Variable	W (Exp)	p (Exp)	r (Exp)	W (Con)	p (Con)	r (Con)
WB Total	0.0	0.001	0.604	0.0	0.001	0.623
A - Self-Accept.	0.0	0.039	0.376	0.0	0.010	0.472
B - Pos. Relations	0.0	0.026	0.408	0.0	0.006	0.500
C - Autonomy	0.0	0.007	0.497	0.0	0.007	0.493
D - Env. Mastery	0.0	0.034	0.387	0.0	0.002	0.578
E - Purpose	0.0	0.007	0.493	0.0	0.007	0.491
F - Pers. Growth	0.0	0.003	0.548	4.5	0.008	0.483
HFI	0.0	0.001	0.602	0.0	0.001	0.602

3.4 Between-Group Gain Score Comparison (Mann-Whitney U Test)

The second hypothesis tests whether the gain scores of the experimental group are significantly greater than those of the control group. The results of the Mann-Whitney U Test on gain scores are presented in Table 8.

Overall, there were no significant differences between the two groups in total well-being gain score ($U = 93.0$; $p =$

0.428) or HFI gain ($U = 120.5$; $p = 0.756$), nor in any of the five remaining well-being dimensions (all $p > 0.05$). An exception was found in the Environmental Mastery dimension, where the control group showed a significantly greater gain ($M = 1.13$) compared to the experimental group ($M = 0.40$) with $U = 55.5$ and $p = 0.011$. Accordingly, the second hypothesis is rejected: the outdoor activity and wearable technology program did not produce statistically superior gains compared to regular physical education for the majority of outcome variables.

Table 8. Mann-Whitney U Test: Comparison of Gain Scores Between Groups

Variable	Experimental group (n = 15)		Control group (n = 15)		U	p
	M	SD	M	SD		
WB total	5.07	2.64	6.07	3.09	93.0	0.428
A – Self-acceptance	0.67	1.01	0.80	0.83	98.0	0.517
B – Positive relations	0.67	0.94	0.87	0.81	93.5	0.405
C – Autonomy	1.07	1.00	1.07	1.06	113.5	0.983
D – Environmental mastery $p < 0.05^*$	0.40	0.61	1.13	0.81	55.5	0.011
E – Purpose in life	1.13	1.09	1.33	1.35	105.5	0.778
F – Personal growth	1.13	0.88	0.87	0.96	129.5	0.469
HFI	8.16	5.86	7.89	5.59	120.5	0.756

* $p < 0.05$; significant difference favoring the control group. M = mean gain score (post-test minus pre-test); SD = standard deviation; U = Mann-Whitney U statistic; p = two-tailed asymptotic significance

In summary, the main findings of this study are: (1) the Outdoor Activity-based Physical Education program integrated with Wearable Technology significantly improved all aspects of psychological well-being and physical fitness in the experimental group ($p < 0.05$), with moderate to large effect sizes ($r = 0.376$ – 0.604); (2) the control group, which underwent regular physical education, also experienced significant improvements in all variables—a finding that confirms regular PE can produce meaningful health benefits and that should be acknowledged as an equally important result; (3) there were no significant differences in gains between the two groups ($p > 0.05$) for seven of the eight outcome variables, indicating no

measurable superiority of the experimental program; and (4) the only significant between-group difference favored the control group in the Environmental Mastery dimension ($p = 0.011$), an unexpected result discussed further below.

4. Discussion

The most fundamental finding of this study is that the intervention group showed significant within-group improvements of an outdoor activity-based physical education program integrated with wearable technology in significantly improving all dimensions of students' psychological well-being and physical fitness within the

experimental group. All eight variables tested total Well-being, the six dimensions of Ryff's RPWB, and the Harvard Fitness Index showed statistically significant improvements ($p < 0.05$) with effect sizes ranging from moderate to large ($r = 0.376$ – 0.604). These findings confirm the first hypothesis and are consistent with the growing body of literature supporting the effectiveness of structured outdoor interventions for adolescent health (19, 51, 52).

The success of this intervention is consistent with a number of previous studies. A comprehensive meta-analysis encompassing 30 studies found that physical activity interventions significantly improved adolescents' mental health (SMD = 0.37; 95% CI: 0.20–0.50), with the strongest effects observed in stress reduction and improved social competence (53). Specifically in the context of outdoor education, a systematic review by Down et al. (2024) of adolescents aged 10–18 found that Outdoor Adventure Education (OAE) produces moderate to large effects on well-being and social-emotional learning (24). The intervention program in this study—which included orienteering, light hiking, outdoor team games, and an outdoor circuit over eight weeks with three sessions per week—provided sufficient physical and psychological stimulation to produce meaningful adaptations in both domains.

The average HFI score for the experimental group increased from 64.81 to 72.97 (a gain of 8.16 points; $p = 0.001$; $r = 0.602$), accompanied by a dramatic shift in category distribution: the proportion of students in the Good category rose from 0% to 46.7%, while the Poor category dropped from 53.3% to just 6.7%. These findings are consistent with the literature showing that an eight-week structured exercise program of moderate to high intensity consistently produces measurable cardiorespiratory adaptations in adolescent populations (54). The PEER-HEART study (55), which involved 307 high school students, demonstrated that an eight-week school-based intervention with a progressive design significantly improved cardiorespiratory fitness (55). The outdoor activity program in this study was designed on a similar principle of progressive overload, beginning with orientation and familiarization (Weeks 1–2), gradual intensity increases (Weeks 3–4), a peak activity phase (Weeks 5–6), and consolidation (Weeks 7–8).

The role of wearable technology (Polar Watch) in this context was primarily as a monitoring and feedback mechanism during the intervention. Real-time heart rate data allowed students and supervisors to track whether exercises

were performed within the target intensity zone (moderate-to-vigorous, 60–80% of HRmax), facilitating a more consistent cardiovascular stimulus throughout the program. Monitoring data confirmed that participants maintained appropriate intensity during the majority of sessions (mean 78.4% of time in target zone). However, because the study design did not include a separate outdoor-only group without wearables, it is not possible to isolate the specific contribution of the technology from that of the outdoor environment or the structured program itself.

All six dimensions of Ryff's Psychological Well-Being Scale showed significant improvements in the experimental group. These findings indicate that an outdoor activity-based PE program can holistically enhance psychological well-being within the framework of Ryff's eudaimonic model (32), though the specific contribution of wearable technology cannot be disaggregated from the outdoor activity component in this design. The consistent improvements across all dimensions are consistent with a meta-analysis by van Dierendonck and Lam (2023), which found that comprehensive intervention programs combining various active components yield the most comprehensive improvements in Ryff's PWB (56).

The dimensions of Autonomy ($r = 0.497$) and Personal Growth ($r = 0.548$) showed the highest effect sizes among the six dimensions in the experimental group. This can be explained by the inherent characteristics of outdoor education: the unstructured outdoor environment provides students with space to make their own decisions, face varied challenges, and experience authentic learning through direct experience (57). The challenge-by-choice concept in OAE, in which students determine the level of challenge they face, directly fosters the Autonomy dimension within the Ryff framework (58). Meanwhile, the increase in personal growth reflects experiences of pushing beyond perceived limits—a hallmark of exposure to new and challenging outdoor environments (59).

The integration of the Polar Watch into the intervention program provided a monitoring and feedback mechanism that may have supported student self-regulation during the outdoor sessions. The self-monitoring mechanism—where students could view their step count, heart rate, and calories burned in real-time—may have contributed to greater self-regulatory awareness, particularly given the relatively higher effect sizes observed for Autonomy ($r = 0.497$) and Personal Growth ($r = 0.548$). However, because the current design did not isolate the wearable component from the outdoor activity component, it is not possible to attribute these improvements

specifically to wearable technology use. Wearable activity trackers have been shown to increase daily step counts in adolescent populations in other studies (38), and evidence suggests they can serve as motivational tools when integrated into structured programs (37); yet the extent to which these effects were realized in the present study remains an open empirical question.

The fact that the control group, which participated only in regular physical education classes, also showed significant improvements across all variables, warrants careful interpretive analysis. The improvements observed in this control group likely reflect two mechanisms. First, the universal benefits of structured physical activity: any physical activity program conducted routinely over eight weeks has been shown to improve adolescents' physical and mental health (60). Second, the Hawthorne effect—the tendency of research subjects to improve their performance simply because they are aware that they are being observed and are part of a study (61). A systematic review by McCambridge et al. (2014) confirmed that the impact of research participation on the behavior under study exists in most quasi-experimental contexts (61).

It is important to emphasize that the equivalence of gains between the two groups ($p > 0.05$ for the majority of variables) does not imply that the outdoor program with wearables is ineffective. On the contrary, these results indicate that both approaches are equally capable of improving well-being and fitness within their respective groups; however, the data do not support the claim that the outdoor and wearable technology approach is superior to regular physical education at this sample size and duration. To verify a more definitive comparative advantage, a research design with a larger sample, longer duration, and a more tightly controlled active control group is required (62).

The only significant between-group difference was in the Environmental Mastery dimension, where the control group's gain ($M = +1.13$) was significantly greater than that of the experimental group ($M = +0.40$), with $U = 55.5$ and $p = 0.011$. This is an unexpected finding that must be interpreted with considerable caution, particularly because it runs counter to the theoretical expectation that outdoor settings would enhance this dimension. One speculative post-hoc explanation is that students in the control group, participating in PE in a familiar indoor school environment, may have experienced greater perceived mastery by leveraging existing environmental familiarity. In contrast, students in the experimental group, exposed to varied and novel outdoor settings, may have undergone an adaptation

period that temporarily attenuated their sense of environmental control (63). However, this explanation was not pre-specified as a hypothesis and should not be treated as an established finding. This result is best regarded as an anomalous outcome that constitutes a genuine limitation of the study and requires replication and further investigation in future research. Future studies should include longer intervention periods and pre-specified measures of environmental familiarity to systematically examine this dimension in outdoor PE contexts.

The findings of this study have direct implications for efforts to achieve SDG 3 (Good Health and Well-Being) at the school institutional level. The shift in HFI categories from a predominance of Poor in the pre-test to the emergence of the Good category in the post-test (0%–46.7% in the experimental group) provides preliminary evidence supporting the program's potential contribution to SDG target 3.4, namely reducing the burden of noncommunicable diseases through increased regular physical activity. Similarly, the disappearance of the Low Well-being category in the post-test for both groups is consistent with the mental health and well-being objectives embedded within SDG target 3.4, which calls for the promotion of mental health and well-being across populations.

This study has several limitations that must be acknowledged. First, the small sample size ($n = 30$) and the homogeneity of the sample (only male Grade 11 students from a single senior high school in Semarang) substantially limit the generalizability of the findings. Results should not be generalized to female students, students at other grade levels, or students from different socioeconomic or geographic contexts. Second, the quasi-experimental design without full randomization leaves room for selection bias, although this was minimized through ordinal pairing. Third, the absence of an outdoor-only control condition (i.e., without wearable technology) means that the independent contribution of wearable technology cannot be isolated from the effect of the outdoor environment or structured activity. Fourth, the lack of post-intervention follow-up measurements limits the ability to assess whether the observed improvements are sustained over time. Fifth, the unexpected Environmental Mastery finding represents an anomalous outcome that warrants further investigation. Sixth, no wearable-derived data were pre-specified as primary outcomes, which limits conclusions about the role of real-time feedback in the improvement process. Future research should: (1) expand the sample to include multiple schools, cities, and female students; (2) extend the

intervention to 12–16 weeks with at least one follow-up measurement; (3) add an outdoor-only arm to isolate the wearable technology effect; (4) pre-register wearable data as primary outcomes; and (5) explore mediation mechanisms between outdoor setting, wearable use, and health outcomes through longitudinal and multivariate designs.

5. Conclusions

An outdoor activity-based physical education program integrated with wearable technology was associated with significant short-term improvements in the psychological well-being and physical fitness scores of male high school students within the experimental group. All variables in the experimental group showed statistically significant improvements after eight weeks of intervention, including total well-being scores ($p = 0.001$; $r = 0.604$), all six dimensions of Ryff's RPWB ($p = 0.003$ – 0.039 ; $r = 0.376$ – 0.548), and the Harvard Fitness Index ($p = 0.001$; $r = 0.602$), with moderate to large effect sizes. Practically, the Low Well-being category disappeared entirely in the post-test, and the proportion of students in the Good Fitness category increased from 0% to 46.7%.

However, the absence of significant between-group differences ($p > 0.05$) for seven of the eight outcome variables indicates that the outdoor and wearable technology program did not produce measurably superior gains compared to regular physical education at the current sample size and study duration. The one exception, Environmental Mastery favored the control group, suggesting that a longer exposure period may be needed for outdoor environments to fully foster this dimension of psychological well-being. These findings reinforce the conclusion that structured physical activity in any format—whether outdoor or conventional—can provide meaningful health benefits for adolescents, consistent with SDG target 3.4 and its emphasis on promoting mental health and reducing noncommunicable disease burden. Although wearable technology may have supported objective monitoring and participant self-awareness during the program, its independent contribution to the observed improvements could not be established in this study; this should be a focus of future research with more rigorous comparative designs. Future studies with larger, more diverse samples, longer intervention durations, and active control groups are needed to more definitively establish the comparative advantage of this innovative model.

Authors' Contributions

AAR: Conceptualization, research design, coordination, data analysis, primary drafting, final revisions. HNW: Intervention design, field supervision, contributions to the methodology section. STP: Statistical analysis, revisions and enrichment of the discussion. All authors have read and approved the final version of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

The researchers would like to thank the Institute for Research and Community Service (LPPM) at Universitas Negeri Semarang for its administrative support and facilitation of the 2025 Indonesian Collaborative Research Scheme A. Our deepest appreciation goes to the Principal, Physical Education teachers, and all students of State High School 12 Semarang who participated with full commitment throughout the eight-week intervention. We also thank the team of research assistants from Universitas Negeri Jakarta and Universitas Pendidikan Indonesia for their contributions in data collection and verification.

Declaration of Interest

The authors report no conflict of interest.

Funding

This study was financially supported by an international collaboration research project funded by the Indonesian Endowment Fund for Education (LPDP) on behalf of the Indonesian Ministry of Higher Education, Science, and Technology, and managed under the EQUITY Program (Contract No. 4311/B3/DT.03.08/2025) and grant number 35.11.11/UN37/PPK.R01/2025.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

1. Baena-Morales S, González-Víllora S. Physical Education For Sustainable Development Goals: Reflections And Comments For Contribution In The Educational Framework. *Sport, Education and Society*. 2023;28(6):697-713. [DOI]
2. Fröberg A, Lundvall S. The Distinct Role Of Physical Education In The Context Of Agenda 2030 And Sustainable Development Goals: An Explorative Review And Suggestions For Future Work. *Sustainability*. 2021;13(21). [DOI]
3. Baena-Morales S, Ferriz-Valero A. What About Physical Education And Sustainable Development Goals? A Scoping Review. *Physical Education and Sport Pedagogy*. 2025;30(2):200-17. [DOI]
4. Ahmed MD, Al Salim ZA. Provision Of Quality Physical Education To Enhance The Motive Of Physical Activity And Its Underlying Behavior Among University Students. *Heliyon*. 2024;10(3):e25152. [PMID: 38327484] [PMCID: PMC10847599] [DOI]
5. Sun H, Du CR, Wei ZF. Physical Education And Student Well-Being: Promoting Health And Fitness In Schools. *PLoS One*. 2024;19(1):e0296817. [PMID: 38271399] [PMCID: PMC10810495] [DOI]
6. World Health O. WHO Guidelines on Physical Activity and Sedentary Behaviour. World Health Organization; 2020.
7. Guthold R, Stevens GA, Riley LM, Bull FC. Global Trends In Insufficient Physical Activity Among Adolescents: A Pooled Analysis Of 298 Population-Based Surveys With 1.6 Million Participants. *The Lancet Child & Adolescent Health*. 2020;4(1):23-35. [PMID: 31761562] [DOI]
8. World Health O. Global status report on physical activity 2022: country profiles. World Health Organization; 2022.
9. Andriyani FD, Biddle SJH, Arovah NI, De Cocker K. Physical Activity And Sedentary Behavior Research In Indonesian Youth: A Scoping Review. *International Journal of Environmental Research and Public Health*. 2020;17(20):7665. [PMID: 33096653] [PMCID: PMC7593924] [DOI]
10. Lopez-Fernandez J, Serrano C, Hernandez-Martin A, Martin-Sanchez ML. Physical Inactivity Behaviour Of European Adolescents Between 2013 And 2022. *BMC Public Health*. 2025;25(1). [PMID: 41204150] [PMCID: PMC12595841] [DOI]
11. Hanifah L, Nasrulloh N, Sufyan DL. Sedentary Behavior And Lack Of Physical Activity Among Children In Indonesia. *Children*. 2023;10(8). [PMID: 37628282] [PMCID: PMC10453900] [DOI]
12. Andriyani FD, Biddle SJH, De Cocker K. Adolescents' Physical Activity And Sedentary Behaviour In Indonesia During The COVID-19 Pandemic: A Qualitative Study Of Mothers' Perspectives. *BMC Public Health*. 2021;21(1):1-14. [PMID: 34654384] [PMCID: PMC8519321] [DOI]
13. Raehang, Virama LOA, Yudhistira D. Identifying Challenges And Opportunities In The Implementation Of Mobile Learning In Physical Education: A Literature Review. *Physical Education Theory and Methodology*. 2025;25(3):719-24. [DOI]
14. Rizka M, Ambardini RL, Virama LOA, Yudhistira D. The Effect Of Walking Exercise On Blood Pressure And Blood Glucose In The Elderly. *International Journal of Kinesiology and Sports Science*. 2022;10(1):30-5. [DOI]
15. Pasek M, Szark-Eckardt M, Wilk B. Physical Fitness As Part Of The Health And Well-Being Of Students Participating In Physical Education Lessons Indoors And Outdoors. *International Journal of Environmental Research and Public Health*. 2020;17(1):1-14. [PMID: 31906407] [PMCID: PMC6981643] [DOI]
16. Rocliffe P, Adamakis M, O'Keeffe BT. The Impact Of Typical School Provision Of Physical Education, Physical Activity And Sports On Adolescent Mental Health And Wellbeing: A Systematic Literature Review. *Adolescent Research Review*. 2024;9(2):339-64. [DOI]
17. Simonsen N, Wackström N, Ray J. Lär miljö (Learning Environment) - Study Protocol: Movement, Outdoor Learning And Well-Being In School. *European Journal of Public Health*. 2022;32(Suppl_3):ckac131.337. [PMCID: PMC9594400] [DOI]
18. Biernat E, Piątkowska M. Outdoor Physical Activity In The Service Of Sustainable Development And One Health: The Role Of Physical Activity In Shaping Pro-Social And Pro-Environmental Attitudes. *Sustainability*. 2025;17(15). [DOI]
19. O'Carroll C, Scanlon D. An Outdoor Educator'S Self-Study Of Enacting A Pedagogical Model For Outdoor Adventure Education To Facilitate Affective Learning Experiences. *Physical Education and Sport Pedagogy*. 2026;31(1):81-96. [DOI]
20. Martínez-Mirambell C, Boned-Gómez S, Urrea-Solano M, Baena-Morales S. Step By Step Towards A Greener Future: The Role Of Plogging In Educating Tomorrow'S Citizens. *Sustainability*. 2023;15(18):1-15. [DOI]
21. Molyneux TM, Zeni M, Oberle E. Choose Your Own Adventure: Promoting Social And Emotional Development Through Outdoor Learning. *Early Childhood Education Journal*. 2023;51(8):1525-39. [PMID: 36277325] [PMCID: PMC9579527] [DOI]
22. Nugraha H, Ali M, Rahmat A, Septianto I, Suryadi D. Actividades Al Aire Libre Y Entornos Al Aire Libre Para La Forma Física Y La Salud Mental: Una Revisión Sistemática. *Retos*. 2024;2041:642-8. [DOI]
23. Davidson C, Ewert A. Exploring Mental Health Outcome Variables In Outdoor Adventure And Experiential Education. *Journal of Experiential Education*. 2024;47(2):185-90. [DOI]
24. Down M, Picknoll D, Hoyne G. 'When The Real Stuff Happens': A Qualitative Descriptive Study Of The Psychosocial Outcomes Of Outdoor Adventure Education For Adolescents. *Journal of Outdoor and Environmental Education*. 2025;28(1):43-63. [DOI]
25. Drapeau C, Lenze L, Montiel C. Association Between Outdoor Physical Activity And Positive Mental Health In Adolescence: Estimating The Mediation Effect Of Autonomy, Competence And Relatedness. *International Journal of Behavioral Nutrition and Physical Activity*. 2025;22(1):1-12. [PMID: 41286859] [PMCID: PMC12642063] [DOI]
26. Loose T, Fuoco J, Malboeuf-Hurtubise C. A Nature-Based Intervention And Mental Health Of Schoolchildren: A Cluster Randomized Clinical Trial. *JAMA Network Open*. 2024;7(11):e2444824. [PMID: 39546315] [PMCID: PMC11568460] [DOI]
27. Davidson C, Ewert A. College Student Commitment And Outdoor Orientation Programming. *Journal of Experiential Education*. 2020;43(3):299-316. [DOI]
28. Pearson R, Owen M, Inman J, Relph N. 'I Climbed A Mountain! I Can Do It!' Outdoor Adventure For Female Youth Resilience. *International Journal of Adolescence and Youth*. 2026;31(1):2606688. [DOI]
29. Loose T, Côté S, Malboeuf-Hurtubise C. Protocol For The Open Sky School: A Two-Arm Clustered Randomized Controlled Trial. *BMC Public Health*. 2023;23(1):1-9. [PMID: 36737725] [PMCID: PMC9896439] [DOI]

30. Ridho AMY, Siregar NM. Outdoor Education Model Based On Experiential Learning In Character Education For Junior High School Students. *Gladi Jurnal Ilmu Keolahragaan*. 2023;14(01):1-17.
31. Rachmayani D, Ramdhani N, editors. *Adaptasi Bahasa Dan Budaya Skala Psychological Well-Being* 2014.
32. Ryff CD. Happiness Is Everything, OR Is It? Explorations On The Meaning Of Psychological Well-Being. *Journal of Personality and Social Psychology*. 1989;57(6):1069. [DOI]
33. Huhn S, Axt M, Gunga HC. The Impact Of Wearable Technologies In Health Research: Scoping Review. *JMIR mHealth and uHealth*. 2022;10(1):e34384. [PMID: 35076409] [PMCID: PMC8826148] [DOI]
34. Creaser AV, Frazer MT, Costa S. The Use Of Wearable Activity Trackers In Schools To Promote Child And Adolescent Physical Activity. *International Journal of Environmental Research and Public Health*. 2022;19(21). [PMID: 36360944] [DOI]
35. Zhong Q, Jiang J, Bai W. Application Of Digital-Intelligent Technologies In Physical Education: A Systematic Review. *Frontiers in Public Health*. 2025;13. [PMID: 40777650] [PMCID: PMC12328460] [DOI]
36. Chen X, Wang F, Zhang H. Effectiveness Of Wearable Activity Trackers On Physical Activity Among Adolescents In School-Based Settings: A Systematic Review And Meta-Analysis. *BMC Public Health*. 2025;25(1). [PMID: 40102761] [PMCID: PMC11921619] [DOI]
37. Sousa AC, Ferrinho SN, Travassos B. The Use Of Wearable Technologies In The Assessment Of Physical Activity In Preschool- And School-Age Youth: Systematic Review. *International Journal of Environmental Research and Public Health*. 2023;20(4). [PMID: 36834100] [PMCID: PMC9966103] [DOI]
38. AU WW, Recchia F, Fong DY. Effect Of Wearable Activity Trackers On Physical Activity In Children And Adolescents: A Systematic Review And Meta-Analysis. *The Lancet Digital Health*. 2024;6(9):e625-39. [PMID: 39112110] [DOI]
39. Cui Z, Song Y, Du X. Multilevel Modeling Of Technology Use, Student Engagement, And Fitness Outcomes In Physical Education Classes. *Frontiers in Psychology*. 2024;15. [PMID: 39512567] [PMCID: PMC11540672] [DOI]
40. Martín-Rodríguez A, Madrigal-Cerezo R. Technology-Enhanced Pedagogy In Physical Education: Bridging Engagement, Learning, And Lifelong Activity. *Education Sciences*. 2025;15(4):1-31. [DOI]
41. Grove SK, Burns N, Gray J. *The Practice Of Nursing Research: Appraisal, Synthesis, And Generation Of Evidence*: Elsevier Health Sciences; 2012.
42. Maciejewski ML. Quasi-Experimental Design. *Biostatistics & Epidemiology*. 2020;4(1):38-47. [PMCID: PMC11527330] [DOI]
43. Cook TD. *Quasi-Experimentation: Design And Analysis Issues For Field Settings*: Rand McNally College Publishing; 1979.
44. Gasser M, Nadenbousch AM, Egger F. Increasing Adolescents' Physical Activity Levels Through A Comprehensive School-Based Physical Activity Program: Study Protocol Of Active School. *BMC Pediatrics*. 2024;24(1). [PMID: 39232723] [PMCID: PMC11373237] [DOI]
45. Gasser M, Nadenbousch AM, Egger F, Kamer M, Valkanover S, Schmidt M. Increasing Adolescents' Physical Activity Levels Through A Comprehensive School-Based Physical Activity Program: Study Protocol Of The Cluster Randomized Controlled Trial Active School. *BMC Pediatrics*. 2024;24(1). [PMID: 39232723] [PMCID: PMC11373237] [DOI]
46. Mackenzie B. 101 Performance Evaluation Tests 2008.
47. Fadhil A. Evaluasi Properti Psikometris Skala Psychological Well-Being (Pwb) Versi Indonesia. *Jurnal Pendidikan Tambusai*. 2021;5(2):4666-74.
48. Portney LG. *Foundations Of Clinical Research: Applications To Evidence-Based Practice*: FA Davis; 2020.
49. Field A. *Discovering Statistics Using Ibm SPSS Statistics*: Sage Publications Limited; 2024.
50. Barton B, Peat J. *Medical Statistics: A Guide To SPSS, Data Analysis And Critical Appraisal*: John Wiley & Sons; 2014.
51. Biernat E, Piątkowska M. Outdoor Physical Activity In The Service Of Sustainable Development And One Health. *Sustainability*. 2025;17(15):6926. [DOI]
52. Fang BB, Lu FJH, Gill DL, Liu SH, Chyi T, Chen B. A Systematic Review And Meta-Analysis Of The Effects Of Outdoor Education Programs On Adolescents' Self-Efficacy, Perceptual and Motor Skills. 2021;128(5):1932-58. [PMID: 34107802] [DOI]
53. Fu Q, Li L, Li Q, Wang J. The Effects Of Physical Activity On The Mental Health Of Typically Developing Children And Adolescents: A Systematic Review And Meta-Analysis. *BMC Public Health*. 2025;25(1). [PMID: 40269876] [PMCID: PMC12016293] [DOI]
54. Jovanović R, Živković M, Stanković M. Effects Of School-Based High-Intensity Interval Training On Health-Related Fitness In Adolescents. *Frontiers in Physiology*. 2024;15. [PMID: 39619092] [PMCID: PMC11604620] [DOI]
55. Domaradzki J, Popowczak M, Kochan-Jacheć K. Effects Of Two Forms Of School-Based High-Intensity Interval Training On Body Fat, Blood Pressure, And Cardiorespiratory Fitness In Adolescents: The Peer-Heart Study. *Frontiers in Physiology*. 2025;16. [PMID: 40265155] [PMCID: PMC12011756] [DOI]
56. Van Dierendonck D, Lam H. Interventions To Enhance Eudaemonic Psychological Well-Being: A Meta-Analytic Review With Ryff'S Scales Of Psychological Well-Being. *Applied Psychology: Health and Well-Being*. 2023;15(2):594-610. [PMID: 36073601] [DOI]
57. Fang WT, Hassan A, Lepage BA. *The Living Environmental Education* 2023. 1-264 p. [DOI]
58. Down MJA, Picknoll D, Edwards T. Outdoor Adventure Education For Adolescent Social And Emotional Wellbeing: A Systematic Review And Meta-Analysis. *Journal of Adventure Education and Outdoor Learning*. 2025;25(4):869-98. [DOI]
59. Gray T, Down MJA, Mann J. Risky Outdoor Play And Adventure Education In Nature For Child And Adolescent Wellbeing: A Scoping Review. *Behavioral Sciences*. 2025;16(1). [PMID: 41594946] [PMCID: PMC12837311] [DOI]
60. Li Z, Li J, Kong J. Adolescent Mental Health Interventions: A Narrative Review Of The Positive Effects Of Physical Activity And Implementation Strategies. *Frontiers in Psychology*. 2024;15. [PMID: 38993342] [PMCID: PMC11236730] [DOI]
61. Mccambridge J, Witton J, Elbourne DR. Systematic Review Of The Hawthorne Effect: New Concepts Are Needed To Study Research Participation Effects. *Journal of Clinical Epidemiology*. 2014;67(3):267-77. [PMID: 24275499] [PMCID: PMC3969247] [DOI]
62. Thomas JR, Nelson JK. *Research Methods In Physical Activity: Human Kinetics Publishers*; 1990.
63. Ryff CD, Keyes CLM. The Structure Of Psychological Well-Being Revisited. *Journal of Personality and Social Psychology*. 1995;69(4):719. [PMID: 7473027] [DOI]