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# Impact of CrossFit intervention on mental health and well-being among first-year law students

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This study investigates the impact of a four-week CrossFit intervention on the physical and mental well-being of 75 first-year law students, divided equally into three groups: outdoor CrossFit ($n = 25$), indoor CrossFit ($n = 25$), and a control group ($n = 25$). A linear mixed effects model (LMM) was employed to assess the intervention's effects while accounting for intraindividual variability and repeated measures. Participants in both active groups demonstrated statistically significant improvements in physical health ($p < 0.001$, Cohen's $d > 1.20$), as measured by the WHOQOL-BREF Physical Health domain. Psychological well-being (WHOQOL-BREF Domain 2) also improved significantly in both groups ($p < 0.001$), while the control group showed no such gains. Mental health indicators—including depression, anxiety, and stress—measured by the DASS-21, decreased significantly in both intervention groups ($p < 0.001$), with large to very large effect sizes (Cohen's d ranging from 0.87 to 1.69). The control group exhibited no significant improvements. Although no significant differences were found between the indoor and outdoor groups in most domains, outdoor training showed a significantly greater effect on environmental health (WHOQOL-BREF Domain 4, $p < 0.01$, Cohen's $d = 1.39$), underscoring the added benefit of exercising in natural settings. Social relationships (Domain 3) remained unaffected across all groups. These findings highlight CrossFit's efficacy as a structured intervention for enhancing physical and psychological well-being in high-stress academic environments. Moreover, training outdoors appears to offer additional environmental benefits that may further enhance students' perceived quality of life.

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## Introduction

The concept of well-being has garnered considerable attention in the fields of psychology and public health, being defined as a state in which individuals experience positive emotions, a sense of purpose, and life satisfaction. According to Diener (1984), subjective well-being refers to an individual's overall assessment of their life satisfaction and balance between positive and negative emotions. Keyes (2007) further distinguishes between emotional, psychological, and social well-being, suggesting that flourishing individuals not only feel good but also function well in their social and personal lives. Emotional well-being, now recognized as a multi-dimensional concept, involves both the experiential quality of everyday emotional experiences and reflective judgments about life satisfaction and purpose (Bagozzi 2020). This builds upon earlier definitions by integrating elements such as cultural context and individual life circumstances, demonstrating how well-being evolves across different stages of life. Furthermore, research highlights the growing importance of purpose in well-being. A sense of meaning and the ability to pursue personally significant goals are critical to overall emotional well-being, not only in general populations but also among specific groups like students (Park et al. 2023). These findings align with earlier definitions by Diener but place greater emphasis on individual purpose and long-term fulfillment as essential components of well-being.

Psychological disturbances such as depression, anxiety, and stress play a significant role in negatively affecting well-being. Depression is typically characterized by a persistent state of sadness or a marked loss of interest in activities that were once enjoyed, leading to impairments in daily functioning and social interaction (American Psychiatric Association 2013). This condition often disrupts emotional balance and reduces life satisfaction by fostering feelings of hopelessness, fatigue, and an inability to experience pleasure.

Anxiety, conversely, is marked by excessive and often irrational worry or fear that can manifest in a range of emotional and physiological symptoms (Ayres et al. 2017). This heightened state of alertness or unease is typically disproportionate to the actual stressor or situation at hand (Barlow 2002). Prolonged anxiety can lead to chronic stress responses, which further deteriorate mental health and well-being.

Stress, as initially defined by Selye (1976), is the body's non-specific response to demands, which can trigger both psychological and physiological changes. This response, while adaptive in short-term situations, becomes detrimental when prolonged, as it disrupts both physical health and emotional functioning (Bergin and Pakenham 2015).

Recent studies have further elaborated on the intricate relationship between these psychological disturbances and well-being. Research confirms that depression, anxiety, and stress significantly lower life satisfaction and contribute to emotional dysregulation (Park et al. 2023; Chafouleas et al. 2023). These disturbances create a vicious cycle where reduced well-being exacerbates symptoms of mental health disorders, which in turn further impairs emotional health.

In response to these challenges, interventions such as mindfulness-based stress reduction (MBSR) and resilience training are being increasingly explored. These interventions have shown promise in managing psychological stressors, particularly in high-stress environments like legal education, where students often experience heightened levels of these psychological disturbances (Chafouleas et al. 2024). By promoting emotional regulation and mental resilience, these interventions aim to restore balance and improve overall well-being in individuals facing significant mental health challenges.

The World Health Organization (WHO) developed the WHOQOL-BREF, a widely used instrument to assess quality of life across four key domains: physical health, psychological health, social relationships, and environmental health. Physical health refers to the individual's capacity to perform daily activities and the presence or absence of pain and discomfort (World Health Organization 1996). Psychological health encompasses emotional well-being, self-esteem, and mental disorders, including anxiety and depression (Skevington et al. 2004). Social relationships pertain to the quality of personal relationships, social support, and sexual activity (O'Connell et al. 2000). Finally, environmental health relates to factors such as financial resources, safety, and access to healthcare services and information (Harper and Power 1998).

Law students have been identified as a group particularly vulnerable to mental health issues, with research showing higher rates of stress, anxiety, and depression compared to other student populations (Wilczek-Rużyczka 2024). In a recent study, Duncan et al. (2020) found that law students often experience a significant decline in well-being during their studies, driven by intense academic pressures, competitive environments, and a lack of work-life balance. Moreover, the rigid culture of legal education, which prioritizes cognitive over emotional development, has been shown to exacerbate feelings of alienation and mental health struggles (Strevens and Field 2019; Jaffe et al. 2021; Organ et al. 2016).

Additionally, the COVID-19 pandemic has worsened these mental health challenges. The abrupt shift to remote learning, coupled with concerns over future employment, has led to heightened stress levels among law students (Collier 2020; Rosu et al. 2024). According to research by Voltmer et al. (2021), the mental health of law students during the pandemic deteriorated at a faster rate compared to other disciplines, emphasizing the need for targeted mental health support.

In light of these findings, there is a growing emphasis on the development of interventions aimed at fostering resilience and well-being in law students. For instance, mindfulness-based stress reduction (MBSR) programs have shown promise in alleviating stress and promoting emotional well-being among this population (Rosky et al. 2022). Such interventions align with the broader goal of enhancing quality of life and mental health, as measured by instruments like the WHOQOL-BREF.

CrossFit is known for its intense, varied workouts that enhance overall fitness, combining elements of weightlifting, gymnastics, and cardiovascular activities. It helps improve strength, endurance, and flexibility while also fostering mental resilience (Meier et al. 2023). A characteristic aspect of CrossFit training is the use of specific equipment, such as dumbbells, kettlebells, jump ropes, tractor tires, and various fitness apparatus. Bodyweight exercises, such as push-ups, pull-ups, and gymnastics movements, are also commonly incorporated (Curtin 2021). Studies have shown that regular CrossFit participation can lead to significant improvements in cardiovascular and muscular endurance, alongside benefits to mental health, such as reduced stress and anxiety (Meier et al. 2023).

Yale Law School has integrated CrossFit into its curriculum as part of fostering a healthy work-life balance for students. Professor Ian Ayres, Deputy Dean of Yale Law, has successfully introduced CrossFit classes for students to help them manage stress, improve physical fitness, and build a sense of community (Yinger 2020). This approach highlights how CrossFit can be used to support both physical and mental well-being in academic settings.

The primary aim of this research is to assess the impact of CrossFit intervention on the mental health and well-being of first-

year law students. The study seeks to determine whether structured physical activity can significantly reduce levels of depression, anxiety, and stress, and enhance overall quality of life in a population known for high mental health risks.

Research objectives:

1. To evaluate the effect of a CrossFit training program on depression, anxiety, and stress levels in law students using the DASS-21 scale.
2. To assess the impact of the CrossFit intervention on various domains of quality of life (physical health, psychological health, social relationships, and environmental health) using the WHOQOL-BREF.
3. To compare the outcomes of outdoor and indoor CrossFit training to identify any differences in effectiveness.
4. To explore the feasibility of integrating CrossFit into regular student wellness programs to improve mental health outcomes.

## Materials and methods

**Study design**. The research employed an observational, descriptive, experimental, and cross-sectional design, carried out from April 17 to June 2, 2023, with a focus on quantitative data collection (Fleetwood 2023).

The process is a structured and well-organized research design, with clear stages of data collection, intervention, and analysis (Fig. 1):

1. Participant invitation (April 17, 2023)—the first step in the research process involved sending out invitations to potential participants, explaining the study's purpose, and encouraging them to take part.
2. Consent agreement (April 24, 2023)—after the invitations, participants were required to sign consent forms to formally agree to participate in the study.
3. Initial evaluation (April 25-29, 2023)—the study began with an initial assessment of the participants, collecting baseline data necessary for the research.
4. Data centralization for initial evaluation (April 28-29, 2023)—following the initial evaluation, the data were compiled and organized for analysis.
5. Subject grouping (April 30, 2023)—based on the initial evaluation, the participants were divided into groups to ensure balanced and controlled experimental conditions.
6. Training program (May 1-27, 2023)—the main intervention phase, during which participants followed a specific training regimen designed for the study.
7. Final evaluation (May 29-31, 2023)—after completing the training program, a final evaluation was conducted to assess any changes in the participants' performance or condition.
8. Data centralization for final evaluation (June 1-2, 2023)—similar to the initial evaluation, the final data were collected and organized.
9. Data analysis (June 3-30, 2023)—the last stage involved analyzing the gathered data to draw conclusions and assess the outcomes of the intervention program.

**Participant selection, grouping, and socio-demographic characteristics in a CrossFit training study**. The research involved 75 students (46 females and 29 males) from the 1 Decembrie 1918 University of Alba Iulia, Faculty of Law and Social Sciences, specializing in Law, first-year, Romania. The students were randomly and voluntarily divided into three research groups:

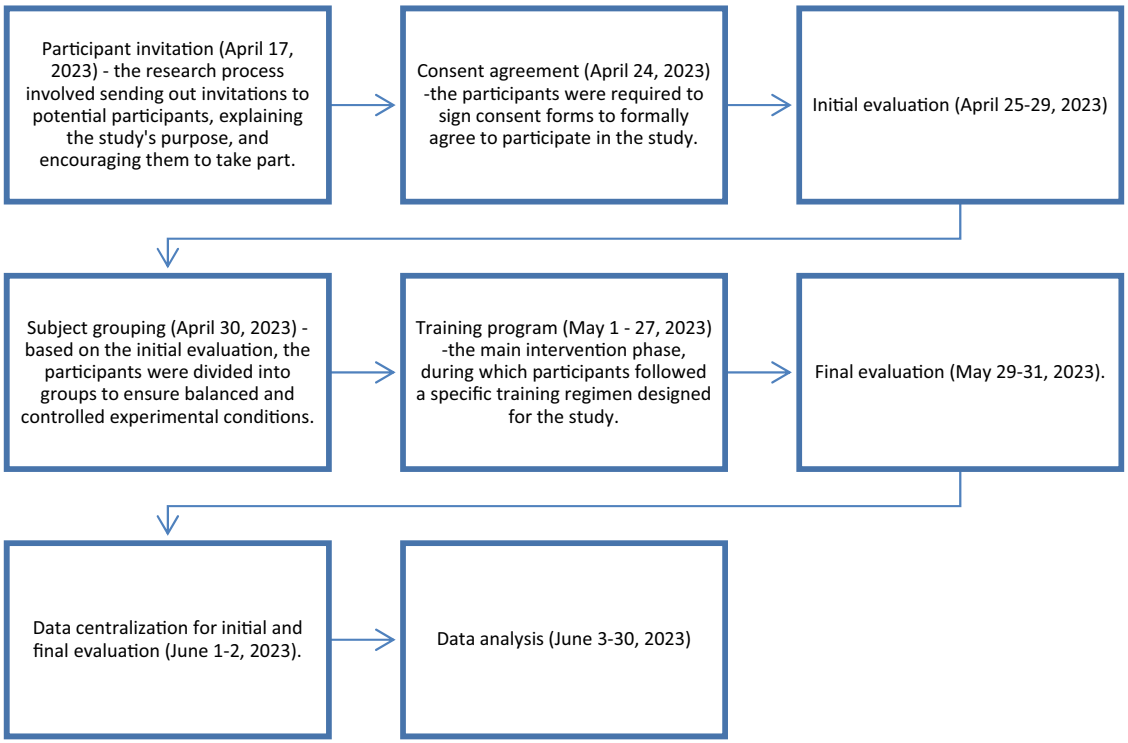


**Fig. 1 Study design.** The figure outlines the sequential phases of the research process, starting with participant invitation and consent (April 17–24, 2023), followed by the initial evaluation phase (April 25–29, 2023). Participants were then grouped (April 30, 2023) into balanced experimental conditions based on initial assessments. The intervention period took place from May 1 to May 27, 2023, during which participants engaged in a structured training program. A final evaluation was conducted between May 29–31, 2023. Data centralization for both initial and final assessments occurred on June 1–2, 2023, followed by comprehensive statistical analysis from June 3 to June 30, 2023. The figure visually represents each stage of the study in chronological order with directional flow arrows.

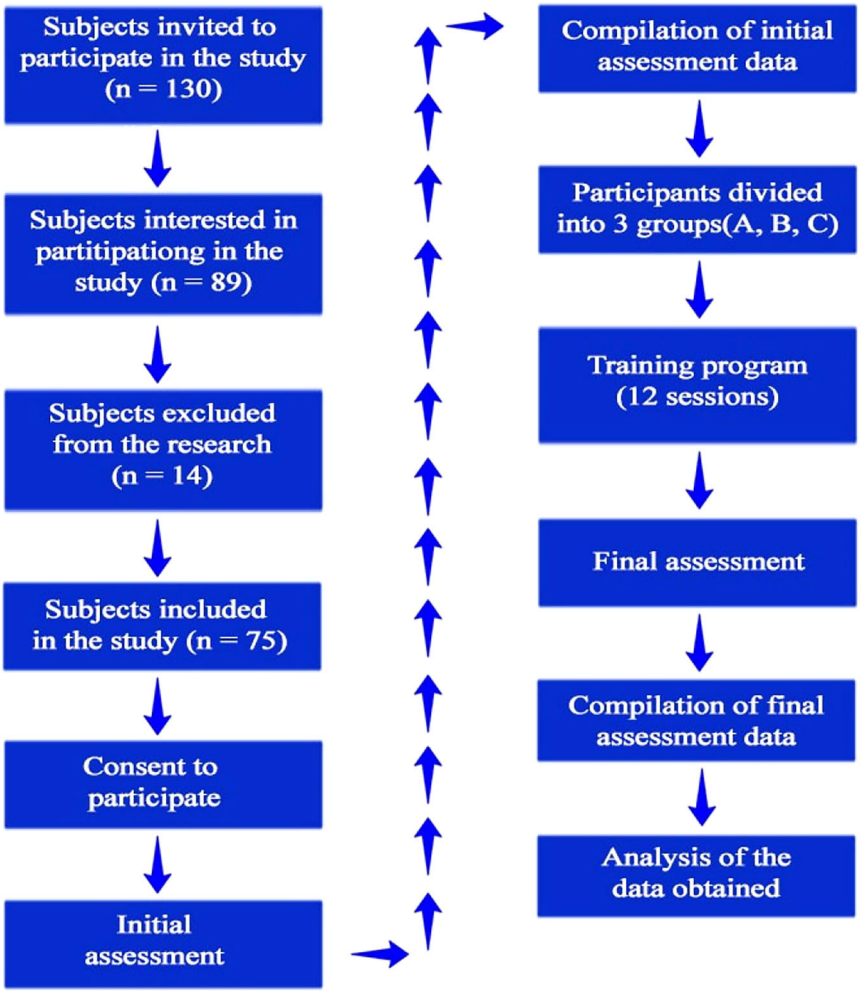


**Fig. 2 Flowchart of participant selection and data collection process in a CrossFit training study.** This flowchart illustrates the selection process and data collection timeline for participants in the intervention study. Out of 130 individuals invited, 89 expressed interest, with 14 subsequently excluded based on eligibility criteria. A total of 75 participants consented and were included in the study. Following initial assessment and data compilation, participants were divided into three experimental groups (A, B, and C) and engaged in a 12-session CrossFit-based training program. Post-intervention, participants underwent a final assessment, followed by data compilation and statistical analysis.

-Group A (1): This group followed a CrossFit intervention program conducted outdoors, in open air. The mean age for Group A was 21.72 years, with a standard deviation of 3.273.

-Group B (2): This group followed the same CrossFit intervention program as Group A, but the exercises were performed indoors, in a gym without specialized fitness equipment. The mean age for Group B was 20.52 years, with a standard deviation of 2.023.

-Group C (3): This control group continued with their usual daily activities and regular university sports curricula. The mean age for Group C was 20.84 years, with a standard deviation of 2.968.

We used a convenience sampling method, considering that university students tend to have more available free time (Simkus 2022).

Initially, 120 students were invited, and 85 showed interest in participating. The recruitment process occurred through mandatory Physical Education and Sports classes, without any incentives provided. After screening, 10 students were excluded: 5 for exceeding the age limit, 2 with a history of cardiac surgery, 2 with asthma, and 1 due to locomotor impairments. Ultimately, the sample size was finalized at 75 participants (Fig. 2).

Participants were chosen according to defined inclusion and exclusion criteria to ensure the accuracy and relevance of the study's findings.

Inclusion Criteria:

-Age- students aged between 19 and 30 years.

-Student Status -all participants were required to be current students.

-Mental Health Diagnosis- students exhibiting symptoms of depression, anxiety, and/or stress, identified through a semi-structured interview, were included based on the severity of their symptoms.

-Physical Activity Level -using a semi-structured interview, students were categorized into „active" (engaging in at least 150 minutes of physical activity per week over at least three days, with each session lasting a minimum of 30 minutes) and „inactive" groups. This segmentation allowed for a comprehensive analysis of how different levels of physical activity related to mental health.

Exclusion Criteria:

-Severe Medical or Psychological Conditions -students with serious medical or psychological issues that could affect their participation or influence their mental health symptoms were excluded.

**Table 1 Socio-demographic characteristics of study participants.**

| Variable | Result *n* (%) |
|---|---|
| Age (years) | Mean (SD): 21.03 (2.91) |
| Sex | F: 46 (61.33%); M: 29 (38.67%) |
| Educational background | High School Education: 75 (100.00%) |
| Socioeconomic status | Employed at Minimum Wage: 41 (54.67%); No Income: 34 (45.33%) |
| Living situation | Living with Parents: 32 (42.67%); Living in Student Dormitory: 26 (34.67%); Renting: 17 (22.67%) |
| Physical activity history | Slightly Above Average Physical Activity: 34 (45.33%); Low Physical Activity: 41 (54.67%) |
| Demographic location | Urban: 48 (64.00%); Rural: 27 (36.00%) |

-Use of Psychoactive Medication -participants using psychoactive drugs that could impact their symptoms or responses to physical activity were excluded.

-Previous Participation in Exercise Programs or Therapy- those who had previously taken part in similar exercise programs or therapies were excluded to avoid prior influences on the study's outcomes.

-Medical Contraindications for Exercise -students with severe cardiovascular or chronic illnesses that posed risks during exercise were excluded.

-Missed Sessions- participants who missed more than two CrossFit sessions were excluded.

-Lack of Written Consent- students who did not provide written consent to participate were also excluded.

The group had an average age of 21.03 years, with minimal variation, and was predominantly female (61.33%). All participants shared a common educational background, having completed high school. Socioeconomically, 54.67% were employed with minimum wage jobs, while the remaining 45.33% had no income, placing most of the participants in lower-income categories. Regarding living conditions, 42.67% lived with their parents, 34.67% in student dormitories, and 22.67% rented their own places (Table 1).

In terms of physical activity, 54.67% reported low activity levels, while 45.33% engaged in slightly above-average physical activity. Most participants (64%) came from urban areas, with 36% from rural regions. This group comprised primarily young adult females from urban environments, with limited financial resources and generally low levels of physical activity (Table 1) (Muntean et al. 2024).

Before joining the study, each participant provided written consent in compliance with the Declaration of Helsinki, ensuring adherence to ethical standards. Students were thoroughly informed about the objectives, methods, and any potential risks or benefits associated with the study. Consent was collected before the research began, confirming their voluntary participation. The study received ethical clearance from the Ethics Committee of the Doctoral School of Physical Education and Sport Science at the West University of Timișoara (Approval ID: 08/21.03.2023). Although the study was overseen by the West University of Timișoara, the participants were first-year law students from 1 Decembrie 1918 University of Alba Iulia, Faculty of Law and Social Sciences. All procedures followed both institutional and international ethical research guidelines, ensuring the study's integrity and the protection of participants' rights.

**Research tools**. Two standardized psychological instruments were employed both pre- and post-intervention to evaluate the mental health and quality of life of participants: the WHOQOL-BREF and the DASS-21.

WHOQOL-BREF

The World Health Organization Quality of Life-BREF (WHOQOL-BREF) is a 26-item instrument designed to assess individuals' perceived quality of life across four major domains:

1. Physical Health (7 items) – mobility, pain, sleep, fatigue, etc.
2. Psychological Health (6 items) – body image, emotional states, self-esteem, cognition.
3. Social Relationships (3 items) – personal relationships, social support, sexual life.
4. Environment (8 items) – safety, home, financial resources, access to information and care.

Each item is rated using a 5-point Likert scale, ranging from 1 (very dissatisfied / not at all) to 5 (very satisfied / completely), which enables a quantitative representation of subjective perceptions. Two general items assess overall quality of life and general health.

This instrument has been extensively validated in diverse populations and cultural contexts, offering a reliable and efficient multidimensional evaluation of well-being (Gholami et al. 2013; Harper and Power 1998). In the present study, reliability was confirmed by Cronbach's Alpha values exceeding 0.80 across all domains in both pre- and post-intervention assessments, and construct validity was supported through Kaiser-Meyer-Olkin (KMO) values above 0.85 and statistically significant Bartlett's Tests of Sphericity ($p < 0.001$). The WHOQOL-BREF questionnaire, a widely recognized instrument for assessing quality of life, has undergone rigorous validation in a series of studies conducted across diverse population categories, including patients with chronic illnesses, elderly individuals, and various demographic cohorts (Ramji et al. 2023; Almarabheh et al. 2023; Kalfoss et al. 2021). These studies have demonstrated the reliability and construct validity of the instrument, confirming its ability to effectively measure quality of life across different cultural contexts and health conditions.

The Depression, Anxiety and Stress Scales-21 (DASS-21) is a set of three 7-item subscales designed to measure emotional states experienced during the past week:

- Depression – low positive affect, hopelessness, anhedonia.
- Anxiety – autonomic arousal, situational anxiety, tension.
- Stress – irritability, impatience, difficulty relaxing.

Items are rated on a 4-point scale from 0 (Did not apply to me at all) to 3 (Applied to me very much or most of the time). The total scores for each subscale are doubled to match the original DASS-42 scale for interpretive purposes.

Originally developed by Lovibond and Lovibond (1995), DASS-21 has shown excellent psychometric properties. In the current study, the instrument demonstrated high internal consistency, with Cronbach's alpha values ranging from 0.869 to 0.930, confirming its reliability. KMO values exceeded 0.85, and Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), confirming the data's suitability for factor analysis and supporting the instrument's four structural validity. The DASS 21 questionnaire, designed to assess levels of depression, anxiety, and stress, was validated in a non-clinical population through studies conducted by Kyriazis et al. (2018) and Pezirkianidis et al. (2018). These validations are significant as they establish the instrument's reliability and effectiveness for use outside clinical settings, ensuring that it can be a valuable tool for researchers and practitioners alike. Both studies contributed to a growing body of evidence supporting the applicability of the

**Table 2 Intervention program for Group A (outdoor) and Group B (indoor).**

| Week | Monday (Group A/B) | Wednesday (Group A/B) | Friday (Group A/B) |
|---|---|---|---|
| 1 | Jump from prone to standing (10»1) Push-ups (10»1) Squats (10»1) | 100 Push-ups 100 Sit-ups 100 Squats | 20 Squats X 5 20 Alternating Lunges X 5 20 Jumping Jacks X 5 10 Jump Squats X 5 |
| 2 | 5 Handstand Push-ups X n 10 One-legged Squats X n | 20 Push-ups X 5 20 Squats X 5 20 Jump from prone to standing X 5 20 One-legged Squats X 5 | Jump from prone to standing 74 / 44 / 11 Push-ups 74 / 44 / 11 Sit-ups 74 / 44 / 11 Squats 74 / 44 / 11 |
| 3 | 10 Jump from prone to standing X 4 100 Meter Run X 4 10 Squats X 4 10 Sit-ups X 4 | 11 Push-ups with hand release X 8 30 Walking Lunges X 8 19 Sit-ups X 8 | 15 Squats X 5 15 Jump from prone to standing X 5 15 Push-ups with hand release X 5 |
| 4 | 10 Push-ups X 5 15 Sit-ups X 5 20 Squats X 5 | 15 Reverse Lunges X 6 15 Jackknife Sit-ups X 6 15 Push-ups X 6 | 10 Stationary Climbing X n 10 Push-ups X n 10 Jackknife Sit-ups X n 10 Sit-ups X n |

DASS-21 in diverse populations, thereby enhancing our understanding of mental health in everyday contexts.

Both tools have been successfully applied in previous studies on student populations. They are suitable for evaluating changes in subjective mental health and quality of life within the context of exercise-based interventions.

**Experimental intervention program**. The experimental intervention was conducted through a customized CrossFit program, applied to Group A, which performed the program outdoors, and Group B, which followed the same program indoors. Group C, the control group, did not follow a systematic physical activity program, only engaging in occasional and routine sports activities as part of their university curriculum. The training sessions took place three times a week, each lasting 30-45 minutes. The content of the workouts is detailed in Table 2.

This program, designed to enhance physical conditioning through varied exercises, was tailored for both indoor and outdoor environments, ensuring a comprehensive workout for both experimental groups.

**Data analysis**. The data analysis for this study employed both descriptive and inferential statistical methods to evaluate the impact of the CrossFit intervention on the mental health and well-being of first-year law students. Descriptive statistics, including means and standard deviations (SD), were used to summarize participant characteristics and outcome measures. The internal consistency of the measurement instruments (DASS-21 and WHOQOL-BREF) was assessed using Cronbach's alpha, while the adequacy of the sample for factor analysis was verified through the Kaiser-Meyer-Olkin (KMO) index and Bartlett's test of Sphericity. To analyze changes over time within each group, paired t-tests were initially conducted. Cohen's d was calculated to determine the effect sizes, with benchmarks set at $d < 0.3$ (small), $d < 0.5$ (medium), $d < 0.8$ (large), and $d > 0.8$ (very large). One-Way ANOVA with Tukey's Honestly Significant Difference (HSD) post-hoc tests was applied to compare between-group differences across outcome domains. Recognizing the limitations of these classical approaches in accounting for individual variability and repeated measures structure, a linear mixed effects model (LMM) was employed to provide a more accurate analysis. The LMM incorporated random intercepts for each participant to model intraindividual variability, along with fixed effects for group, time (pre- and post), and their interaction (group × time). This allowed for the evaluation of both between- and within-subject effects. The LMM analysis was conducted using SPSS version 30. Furthermore, given the longitudinal design of the study, measurement invariance over time was evaluated for both the DASS-21 and WHOQOL-BREF instruments. Configural, metric, and scalar invariance were tested to ensure that the constructs measured remained consistent across the two time points. This step was essential for validating the reliability and interpretability of observed changes over time and ensuring that the instruments functioned equivalently in both pre- and post-intervention assessments. A linear regression analysis was conducted to explore the relationship between the indicators of the Depression, Anxiety, and Stress Scale (DASS-21) and the scales of the World Health Organization Quality of Life-BREF (WHOQOL-BREF) across all participant groups. This analysis aimed to identify how the psychological factors measured by the DASS-21 might predict one another, as well as their impact on the quality of life outcomes assessed by the WHOQOL-BREF.

## Results

Figures 3 and 4 present a comparison between the arithmetic means of the initial and final evaluations of the WHOQOL-BREF and DASS-21 tests for the three groups: the outdoor group, the indoor group, and the control group.

Analyzing the results in Table 3, we observe that both questionnaires recorded Cronbach's Alpha values greater than 0.7, indicating a satisfactory level of internal consistency and reliability of the results. Additionally, the Kaiser-Meyer-Olkin (KMO) values for all program types, as well as for the three subscales of the questionnaire, ranged from 0.8152 to 0.939, confirming the adequacy of the sample for factor analysis. Bartlett's test of Sphericity demonstrated that the inter-item correlations within each subscale were sufficient to justify Principal Component Analysis (PCA), yielding statistically significant results at a reference threshold of $p < 0.01$). These findings support the construct validity of the questionnaire and confirm the suitability of the data for dimensionality reduction techniques.

Table 4 presents the main statistical processing results, highlighting that for all DASS-21 subscales, the mean differences between Group A and Group B were statistically significant ($p < 0.001$). In contrast, for Group C, the differences between the initial and final assessments were not statistically significant ($p \geq 0.05$). Analyzing the recorded mean differences, we observe that Group A reported higher values compared to Group B and Group C across all scales. The Cohen's d values for Group A and Group B exceeded 0.80 for all three scales, indicating a very large effect size and demonstrating the effectiveness of the intervention program. In contrast, for Group C, Cohen's d values were below 0.30 for the Depression and Anxiety scales, reflecting a small effect size. For the Stress scale, the effect size was at the lower threshold of a large effect ($d = 0.566$).

In Table 5, an examination of the mean differences reveals that Group A consistently outperformed both Group B and Group C across all domains. The Cohen's d values for Group A and Group B surpassed 0.80 for each of the four domains, indicating a very large effect size and confirming the substantial effectiveness of the intervention program. The Cohen's d values for Group A and Group B exceeded 0.80 for all four subscales, indicating a very

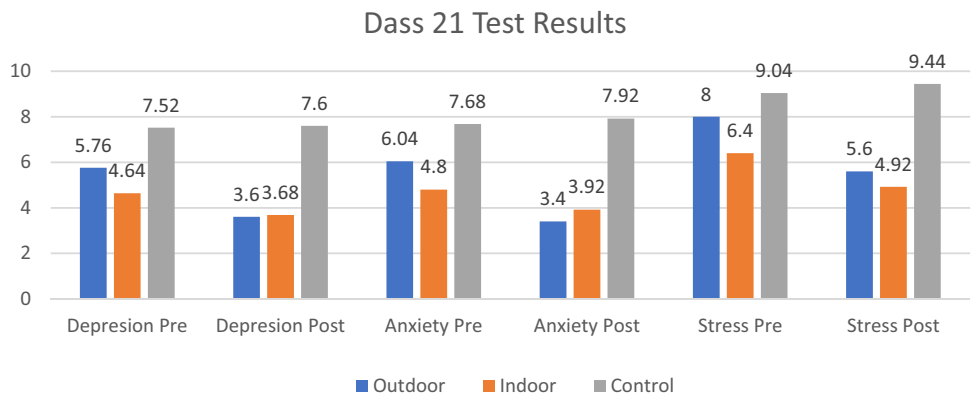


**Fig. 3 Comparison of the arithmetic mean between the initial and final evaluation of the progression of common mental disorders that affect a person's quality of life.** This figure presents the arithmetic mean scores from the DASS-21 test for Depression, Anxiety, and Stress subscales before and after the intervention, across three groups: Outdoor (blue), Indoor (orange), and Control (gray). Notable reductions in mean scores are observed in the Outdoor and Indoor groups post-intervention, particularly for Depression and Anxiety, while the Control group shows either minimal change or slight increases. These results illustrate the differential impact of physical activity environments on common mental health outcomes.

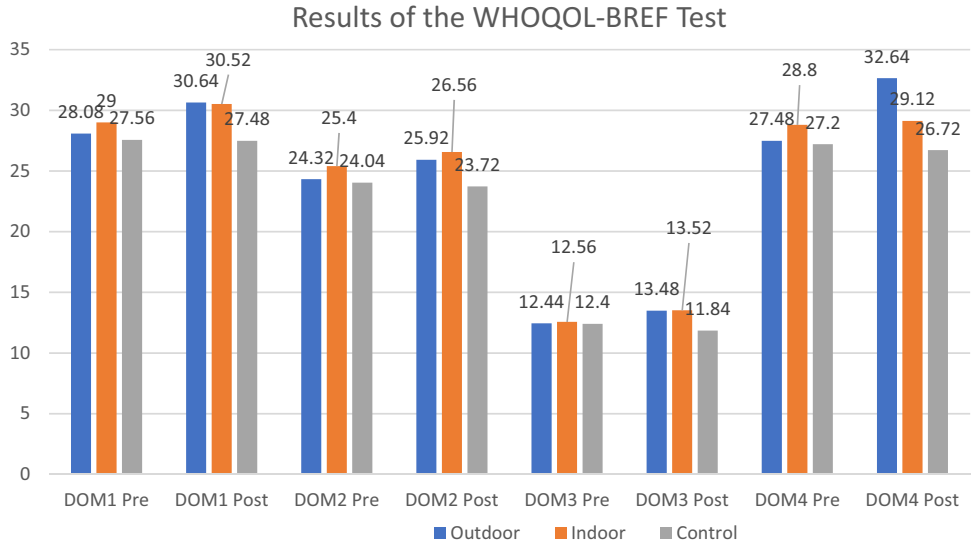


**Fig. 4 Comparison of WHOQOL-BREF test results: pre- and post-intervention scores across outdoor, indoor, and control groups.** The figure displays the mean scores for all four domains (DOM1: Physical Health, DOM2: Psychological Health, DOM3: Social Relationships, DOM4: Environment) of the WHOQOL-BREF test, measured before and after the intervention in three groups: Outdoor (blue), Indoor (orange), and Control (gray). Improvements are observed in both experimental groups across all domains, with the Outdoor group showing the most pronounced increases, particularly in DOM1 (Physical Health) and DOM4 (Environment). The Control group showed minimal or negative changes, indicating limited natural progression without intervention.

large effect size and demonstrating the effectiveness of the CrossFit program. In contrast, for Group C, Cohen's d values were below 0.30 for the Physical Health and Psychological Health domains, reflecting a small effect size. For the Social Relationships and Environment domains, the values of Cohen's d of group C were less than 0.5, which reflects a medium effect size

Table 6 presents the analysis, including ANOVA comparisons for pre- and post-intervention scores on the Depression, Anxiety, and Stress Scales (DASS-21) after a CrossFit intervention program. For each DASS-21 indicator, ANOVA F-values, significance levels, and post-hoc Tukey multiple comparison tests are presented across group pairs (A-B, A-C, and B-C) in Table 6. Post-intervention results for depression showed significant differences [$F(2,72) = 31.071$; $p < 0.01$] between the three groups in post-intervention depression scores. Tukey's post hoc test revealed that both Group A ($m = 3.60$, $s = 3.253$) and Group B ($m = 3.68$, $s = 2.462$) had significantly lower scores than Group C ($m = 7.60$, $s = 3.990$), but no significant differences were found between Groups A and B. This suggests that depression can be significantly alleviated through CrossFit intervention, regardless of whether the activity takes place outdoors or indoors. About Anxiety -there were significant differences [$F(2,72) = 13.432$; $p < 0.01$] between the three groups for post-intervention anxiety. Both Group A ($m = 3.40$, $s = 2.784$) and Group B ($m = 3.92$, $s = 3.027$) showed significantly lower anxiety levels than Group C ($m = 7.92$, $s = 4.153$). Again, no significant differences were found between Groups A and B, indicating that anxiety can also be reduced through CrossFit, irrespective of the environment. Significant stress differences were found [$F(2,72) = 9.122$; $p < 0.01$] among the three groups in post-intervention stress levels. Both Group A ($m = 5.60$, $s = 3.452$) and Group B ($m = 4.92$, $s = 3.696$) showed significantly lower stress than Group C ($m = 9.44$, $s = 4.823$). No significant differences were detected between Groups A and B, implying that stress reduction can be achieved through the CrossFit program, regardless of whether it's conducted outdoors or indoors.

**Table 3 Cronbach's alpha and KMO and Bartlett's test of WHOQOL-BREF and DASS-21.**

| Questionnaire | Group | Test | Cronbach's alpha | KMO and Bartlett's test | | |
|---|---|---|---|---|---|---|
| | | | | KMO | Chi² | p |
| WHOQOL-BREF | Group A (outdoor) | IT | 0.819 | 0.855 | 41,008 | <0.001 |
| | | FT | 0.812 | 0.850 | 24,444 | <0.001 |
| | Group B (indoor) | IT | 0.918 | 0.815 | 74,178 | <0.001 |
| | | FT | 0.763 | 0.911 | 34,558 | <0.001 |
| | Group C (control) | IT | 0.889 | 0.905 | 57,696 | <0.001 |
| | | FT | 0.823 | 0.863 | 32,636 | <0.001 |
| DASS-21 | Group A (outdoor) | IT | 0.923 | 0.854 | 51,100 | <0.001 |
| | | FT | 0.892 | 0.815 | 42,475 | <0.001 |
| | Group B (indoor) | IT | 0.869 | 0.885 | 37,436 | <0.001 |
| | | FT | 0.852 | 0.889 | 33,337 | <0.001 |
| | Group C (control) | IT | 0.930 | 0.934 | 57,367 | <0.001 |
| | | FT | 0.920 | 0.939 | 51,821 | <0.001 |

*KMO* Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's test of sphericity, $Chi^2$ approx. chi-square, *p* level of statistical probability, *IF* initial test, *FT* final test.

**Table 4 Statistical analysis of DASS-21.**

| Group | Scale | Test | Mean | SD | Mean (TF-TI) | 95%CI | | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper | | |
| Group A (outdoor) | Depression | IT | 5760 | 4985 | 2160 | 1363 | 2956 | <0.001 | 1119 |
| | | FT | 3600 | 3253 | | | | | |
| | Anxiety | IT | 6040 | 5111 | 2640 | 1548 | 3731 | <0.001 | 0.999 |
| | | FT | 3400 | 2783 | | | | | |
| | Stress | IT | 8000 | 5212 | 2400 | 1532 | 3267 | <0.001 | 1142 |
| | | FT | 5600 | 3452 | | | | | |
| Group B (indoor) | Depression | IT | 4640 | 2870 | 0.960 | 0.613 | 1307 | <0.001 | 1142 |
| | | FT | 3680 | 2461 | | | | | |
| | Anxiety | IT | 4800 | 3730 | 0.880 | 0.461 | 1298 | <0.001 | 0.868 |
| | | FT | 3920 | 3026 | | | | | |
| | Stress | IT | 6400 | 3937 | 1480 | 1120 | 1839 | <0.001 | 1698 |
| | | FT | 4920 | 3695 | | | | | |
| Group C (control) | Depression | IT | 7520 | 4154 | 0.080 | −0.344 | 0.184 | 0.269 | 0.125 |
| | | FT | 7600 | 3989 | | | | | |
| | Anxiety | IT | 7680 | 4497 | 0.240 | −0.657 | 0.177 | 0.124 | 0.237 |
| | | FT | 7920 | 4152 | | | | | |
| | Stress | IT | 9040 | 4978 | 0.400 | −0.691 | −0.108 | 0.005 | 0.566 |
| | | FT | 9440 | 4822 | | | | | |

*IF* initial test, *FT* final test, *SD* standard deviation, *p* level of statistical probability, *CI* interval of confidence.

In Table 7, the results of the linear regression analysis for DASS-21 highlight several statistically significant predictive relationships between the indicators. For Group A (outdoor), we find that the Depression variable recorded statistically significant relationships with both the Anxiety predictor and the Stress predictor, but only at the initial testing. The most substantial relationships between variables for Group A were found between Depression and the Stress predictor, with $R^2 = 22\%$ ($F = 6.484$, $p < 0.018$). Group B (indoor) showed statistically significant dependency relationships between the Depression variable and the Anxiety predictor at the final testing, as well as with the Stress predictor at the initial testing; additionally, the Anxiety variable was related to the Stress predictor at the final testing, which also yielded the highest results: $R^2 = 28.5\%$ ($F = 0.177$, $p < 0.036$). For Group C (control), statistically significant relationships were observed between the Depression variable and the Stress predictor at both the initial and final tests. No statistically significant predictive relationships were identified between the other characteristics at either the initial or final testing for $p < 0.05$.

Table 8 presents the results of ANOVA comparisons for the WHOQOL-BREF indicators (Quality of Life domains) before and after the CrossFit intervention. The analysis reveals significant differences in the post-intervention phase among the three groups (outdoor, indoor, and control). Each WHOQOL-BREF domain—Domain 1 (Physical Health), Domain 2 (Psychological Health), Domain 3 (Social Relationships), and Domain 4 (Environment) is analyzed using F-values, significance levels, and post-hoc Tukey multiple comparisons across group pairs (A-B, A-C, B-C). The data demonstrates improvements in specific WHOQOL-BREF domains post-intervention, showing significant enhancements in Physical and Environmental health domains. Physical Health (WHOQOL-BREF Domain 1) - Significant differences were observed [$F(2, 72) = 9.122$; $p < 0.01$] post-intervention in physical health between the groups. Group A ($m = 30.64$, $s = 3.277$) and Group B ($m = 30.52$, $s = 3.653$) had significantly higher scores than Group C ($m = 27.48$, $s = 4.665$), with no significant difference between Groups A and B. Psychological Health (WHOQOL-BREF Domain 2) - there were significant differences [$F(2,72) = 9.122$; $p < 0.01$] in psychological health scores post-intervention. Group A ($m = 25.92$, $s = 2.737$) and Group B ($m = 26.56$, $s = 2.083$) showed significantly better scores than Group C ($m = 23.72$, $s = 3.758$), again without significant

**Table 5 Statistical analysis of WHOQOL-BREF.**

| Group | Domain | Test | Mean | SD | Mean (TF-TI) | 95%CI | | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper | | |
| Group A (outdoor) | Physical Health | IT | 28,080 | 3893 | 2560 | 1683 | 3436 | <0.001 | 1206 |
| | | FT | 30,640 | 3277 | | | | | |
| | Psychological Health | IT | 24,320 | 4210 | 1600 | 0.875 | 2324 | <0.001 | 0.911 |
| | | FT | 25,920 | 2737 | | | | | |
| | Social Relationships | IT | 12,440 | 2310 | 1040 | 0.556 | 1523 | <0.001 | 0.887 |
| | | FT | 13,480 | 1326 | | | | | |
| | Environment | IT | 27,480 | 3254 | 5160 | 3621 | 6698 | <0.001 | 1385 |
| | | FT | 32,640 | 2563 | | | | | |
| Group B (indoor) | Physical Health | IT | 29,000 | 4330 | 1520 | 0.834 | 2205 | <0.001 | 1661 |
| | | FT | 30,520 | 3652 | | | | | |
| | Psychological Health | IT | 25,400 | 3304 | 1160 | 0.089 | 2230 | 0.017 | 2592 |
| | | FT | 26,560 | 2083 | | | | | |
| | Social Relationships | IT | 12,560 | 2399 | 0.960 | 0.324 | 1595 | 0.002 | 1540 |
| | | FT | 13,520 | 1661 | | | | | |
| | Environment | IT | 28,800 | 3926 | 0.320 | 0.061 | 0.578 | 0.009 | 0.627 |
| | | FT | 29,120 | 3789 | | | | | |
| Group C (control) | Physical Health | IT | 27,560 | 4519 | 0.080 | −0.348 | 0.508 | 0.703 | 0.077 |
| | | FT | 27,480 | 4664 | | | | | |
| | Psychological Health | IT | 24,040 | 3758 | 0.320 | 0.195 | 0.835 | 0.212 | 0.256 |
| | | FT | 23,720 | 3758 | | | | | |
| | Social Relationships | IT | 12,400 | 2380 | 0.560 | 0.000 | 1119 | 0.050 | 0.413 |
| | | FT | 11,840 | 2640 | | | | | |
| | Environment | IT | 27,200 | 3452 | 0.480 | 0.027 | 0.987 | 0.063 | 0.391 |
| | | FT | 26,720 | 3234 | | | | | |

*IF* initial test, *FT* final test, *SD* standard deviation, *p* level of statistical probability, *CI* interval of confidence.

**Table 6 ANOVA comparisons for pre- and post-CrossFit intervention on DASS-21 indicators.**

| Test | Scale | F | Sig. | p | Multiple comparisons–Tukey | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Pairs of groups | | | |
| IT | Depression | 3.139 | 0.049 | p < 0.05* | Groups | A-B | A-C | B-C |
| | | | | | Sig. | 0.600 | 0.288 | 0.040 |
| | | | | | p | p > 0.05 | p > 0.05 | *p < 0.05* |
| FT | | 12.044 | 0.000 | p < 0.01** | Groups | A-B | A-C | B-C |
| | | | | | Sig. | 0.996 | 0.000 | 0.000 |
| | | | | | p | p > 0.05 | p < 0.01** | p < 0.01** |
| IT | Anxiety | 2.597 | 0.081 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | Sig. | 0.593 | 0.403 | 0.403 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| FT | | 13.432 | 0.000 | p < 0.01** | Groups | A-B | A-C | B-C |
| | | | | | Sig. | 0.849 | 0.000 | 0.000 |
| | | | | | p | p > 0.05 | p < 0.01** | p < 0.01** |
| IT | Stress | 1.966 | 0.147 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | Sig. | 0.461 | 0.719 | 0.127 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| FT | | 9.122 | 0.000 | p < 0.01** | Groups | A-B | A-C | B-C |
| | | | | | Sig. | 0.823 | 0.003 | 0.001 |
| | | | | | p | p > 0.05 | p < 0.05* | p < 0.05* |

*F (one-way ANOVA)* F statistic indicating the variance between groups, *Sig.* p-value indicating the statistical significance of the *F* statistic, *p* the significance level of each group comparison (p < 0.05 or p < 0.01).
*Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed).

differences between Groups A and B. Social Relationships (WHOQOL-BREF Domain 3) - no significant differences [F (2,72) = 2.973; p > 0.05] were observed post-intervention between the groups in terms of social relationships. The mean scores for Group A (m = 13.48, s = 1.327), Group B (m = 13.52, s = 1.661), and Group C (m = 12.40, s = 2.380) did not differ significantly, suggesting that CrossFit intervention did not affect social relationships. Environmental Health (WHOQOL-BREF Domain 4) -significant differences were observed [F (2,72) = 21.182; p < 0.01] in environmental health post-intervention. Group A (m = 32.64, s = 2.564) had significantly higher scores than both Group B (m = 29.12, s = 3.789) and Group C (m = 26.72, s = 3.234). Additionally, significant differences were also found between Group B and Group C, indicating that outdoor training had a superior effect on environmental health compared to both indoor training and the control group.

**Table 7 Linear regression of pre- and post-CrossFit intervention on DASS-21 indicators.**

| Group | Predictor Variable | Statistics | | Anxiety | | Stress | |
|---|---|---|---|---|---|---|---|
| | | | | IT | FT | IT | FT |
| Group A (outdoor) | Depression | Regression | $R^2$ | 0.168 | 0.148 | 0.220 | 0.141 |
| | | ANOVA | F | 4.642 | 4.007 | 6.484 | 3.772 |
| | | | p | 0.042 | 0.057 | 0.018 | 0.064 |
| | Anxiety | Regression | $R^2$ | - | - | 0.023 | 0.114 |
| | | ANOVA | F | - | - | 0.538 | 2.964 |
| | | | p | - | - | 0.470 | 0.099 |
| Group B (indoor) | Depression | Regression | $R^2$ | 0.118 | 0.203 | 0.187 | 0.050 |
| | | ANOVA | F | 3.068 | 5.861 | 5.301 | 1.198 |
| | | | p | 0.093 | 0.024 | 0.031 | 0.285 |
| | Anxiety | Regression | $R^2$ | - | - | 0.005 | 0.177 |
| | | ANOVA | F | - | - | 0.113 | 4.942 |
| | | | p | - | - | 0.740 | 0.036 |
| Group C (control) | Depression | Regression | $R^2$ | 0.135 | 0.109 | 0.172 | 0.267 |
| | | ANOVA | F | 3.602 | 2.805 | 4.772 | 8.377 |
| | | | p | 0.070 | 0.108 | 0.039 | 0.008 |
| | Anxiety | Regression | $R^2$ | - | - | 0.044 | 0.072 |
| | | ANOVA | F | - | - | 1.055 | 1.791 |
| | | | p | - | - | 0.315 | 0.194 |

$R^2$ R Square, *p* level of probability.

**Table 8 ANOVA comparisons of pre- and post-CrossFit intervention scores for WHOQOL-BREF indicators.**

| Test | Indicators | F | Sig. | P | Multiple comparisons-Tukey | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Pairs of groups | | | |
| IT | Physical Health | 0.734 | 0.484 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.726 | 0.902 | 0.459 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| FT | | 31.071 | 0.000 | p < 0.05* | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.994 | 0.015 | 0.020 |
| | | | | | p | p > 0.05 | p < 0.05* | p < 0.05* |
| IT | Psychological Health | 0.904 | 0.409 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.572 | 0.963 | 0.415 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| FT | | 6.411 | 0.003 | p < 0.05* | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.723 | 0.027 | 0.003 |
| | | | | | p | p > 0.05 | p < 0.05* | p < 0.05* |
| IT | Social Relationships | 0.031 | 0.969 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.982 | 0.998 | 0.969 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| FT | | 2.973 | 0.057 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.997 | 0.103 | 0.087 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| IT | Environment | 1.444 | 0.243 | p > 0.05 | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.393 | 0.958 | 0.256 |
| | | | | | p | p > 0.05 | p > 0.05 | p > 0.05 |
| FT | | 21.182 | 0.000 | p < 0.05* | Groups | A-B | A-C | B-C |
| | | | | | F Sig. | 0.001 | 0.000 | 0.028 |
| | | | | | p | p < 0.05* | p < 0.05* | p < 0.05* |

*F (one-way ANOVA)* F statistic indicating the variance between groups, *Sig.* p-value indicating the statistical significance of the F-statistic.
*Correlation is significant at the 0.05 level (two-tailed).

In Table 9, we present the results of the linear regression analysis of the scores from the four indicators of WHOQOL-BREF. Analyzing the results from both tests, in the initial test of Group A (outdoor), we find that the Physical Health variable is significantly influenced by the predictors Psychological Health, Social Relationships, and Environment. For Group A, the strongest influence on the Physical Health variable comes from the final Psychological Health predictor, with $R^2 = 69.4\%$, ($F = 52.108$, $p < 0.001$) at the final test, followed by the Social Relationships predictor, which has $R^2 = 75.4\%$, ($F = 74.621$, $p < 0.001$). The results for the Psychological Health and Social Relationships variables regarding the Environment predictor were not statistically significant. For Group B (Indoor), we observe statistically significant predictive relationships between the Physical Health variable and the Social Relationships predictor, evident only at the final test, along with the Environment predictor.

**Table 9 Linear regression of pre- and post-CrossFit intervention scores for WHOQOL-BREF indicators.**

| Group | Predictor | Statistics | | Psychological health | | Social relationships | | Environment | |
|---|---|---|---|---|---|---|---|---|---|
| | Variable | | | IT | FT | IT | FT | IT | FT |
| Group A (outdoor) | Physical Health | Regression | $R^2$ | 0.425 | 0.694 | 0.246 | 0.754 | 0.334 | 0.454 |
| | | ANOVA | F | 16,970 | 52,108 | 7507 | 74,621 | 13,061 | 19,140 |
| | | | p | <0.001 | <0.001 | 0.012 | <0.001 | 0.001 | <0.001 |
| | Psychological Health | Regression | $R^2$ | - | - | 0.578 | 0.573 | 0.125 | 0.017 |
| | | ANOVA | F | - | - | 31,465 | 30,830 | 3278 | 0.410 |
| | | | p | - | - | <0.001 | <0.001 | 0.083 | 0.529 |
| | Social Relationships | Regression | $R^2$ | - | - | - | - | 0.102 | 0.003 |
| | | ANOVA | F | - | - | - | - | 2620 | 0.076 |
| | | | p | - | - | - | - | 0.119 | 0.785 |
| Group B (indoor) | Physical Health | Regression | $R^2$ | 0.081 | 0.047 | 0.164 | 0.253 | 0.006 | 0.260 |
| | | ANOVA | F | 3107 | 1142 | 4528 | 7785 | 0.150 | 8087 |
| | | | p | 0.091 | 0.296 | 0.044 | 0.010 | 0.702 | 0.009 |
| | Psychological Health | Regression | $R^2$ | - | - | 0.554 | 0.277 | 0.017 | 0.403 |
| | | ANOVA | F | - | - | 30,830 | 8814 | 0.410 | 15,544 |
| | | | p | - | - | <0.001 | 0.007 | 0.529 | <0.001 |
| | Social Relationships | Regression | $R^2$ | - | - | - | - | 0.003 | 0.083 |
| | | ANOVA | F | - | - | - | - | 0.076 | 2072 |
| | | | p | - | - | - | - | 0.785 | 0.163 |
| Group C (control) | Physical Health | Regression | $R^2$ | 0.547 | 0.453 | 0.396 | 0.202 | 0.521 | 0.374 |
| | | ANOVA | F | 27,762 | 19,084 | 15,057 | 5827 | 24,996 | 13,727 |
| | | | p | <0.001 | <0.001 | <0.001 | 0.024 | <0.001 | 0.001 |
| | Psychological Health | Regression | $R^2$ | - | - | 0.639 | 0.284 | 0.290 | 0.197 |
| | | ANOVA | F | - | - | 40,672 | 9110 | 9415 | 5628 |
| | | | p | - | - | <0.001 | 0.006 | 0.005 | 0.026 |
| | Social Relationships | Regression | $R^2$ | - | - | - | - | 0.334 | 0.261 |
| | | ANOVA | F | - | - | | - | 11,541 | 8122 |
| | | | p | - | - | - | - | 0.002 | 0.009 |

$R^2$ R square, *p* level of probability.

In Group B, the most substantial relationships were recorded between the Psychological Health variable and the Social Relationships predictor, where $R^2 = 55.4\%$, ($F = 30.830$, $p < 0.001$). For Group C (control), we found statistically significant relationships between all variables and predictor indicators of WHOQOL-BREF, both in the initial and final tests. For Group C, the most notable results were identified between the Psychological Health variable and the Social Relationships predictor, with $R^2 = 63.9\%$, ($F = 40.672$, $p < 0.001$), as well as between Physical Health and Psychological Health, with $R^2 = 54.7\%$, ($F = 27.762$, $p < 0.001$).

## Discussion

The primary objective of this research was to evaluate the contribution of a structured CrossFit intervention to the mental and physical well-being of first-year law students. The findings, analyzed using a combination of paired t-tests, ANOVA with Tukey HSD post-hoc tests, and a LMM, provide consistent evidence that both indoor and outdoor CrossFit training significantly improved participants' outcomes across most domains measured by the DASS-21 and WHOQOL-BREF scales. The LMM, in particular, allowed for a more nuanced interpretation by accounting for intraindividual variability and repeated measures, strengthening the robustness and validity of the observed effects.

While both active groups showed significant improvements in physical and mental health, differences between the indoor and outdoor formats were generally non-significant, with one notable exception: the environmental health domain (WHOQOL-BREF Domain 4), where outdoor training yielded significantly superior outcomes ($p < 0.01$). This suggests that while CrossFit is beneficial in any context, environmental factors may amplify its impact. Importantly, baseline (pre-intervention) assessments confirmed the statistical equivalence of the groups across all domains except for a minor difference in depression between Groups B and C, which did not persist post-intervention and was not reflected in the other comparisons.

**Depression and anxiety**. The results demonstrate that both indoor and outdoor CrossFit training significantly alleviate symptoms of depression and anxiety compared to the control group (Lovibond and Lovibond 1995; American Psychiatric Association 2013). This suggests that engaging in CrossFit can provide substantial mental health benefits, likely due to its combination of physical exertion, structured routines, and intrinsic motivation. Notably, the absence of significant differences between indoor and outdoor settings underscores the adaptability of CrossFit in promoting mental health improvements regardless of the environment.

These improvements can be interpreted within the biopsychosocial model (Keyes 2007; Park et al. 2023), which posits that health outcomes are the result of interactions between biological, psychological, and social factors. From a biological perspective, high-intensity physical activity such as CrossFit stimulates the release of endorphins and other neurochemicals associated with mood regulation (Barlow 2002). Psychologically, structured routines and goal-setting promote self-efficacy and mental resilience (Chen and Yao 2022). Socially, even when not explicitly team-based, such interventions provide shared experiences and routines that may combat isolation (Bagozzi 2020).

**Stress**. Stress levels were significantly reduced in both intervention groups, supporting the stress-buffering role of physical

exercise as discussed by Selye (1976) and corroborated in recent findings by Piepiora et al. (2025). These findings are consistent with law school-specific research that identifies chronic stress as a primary barrier to student well-being (Bergin and Pakenham 2015; Wilczek-Rużyczka 2024). The biopsychosocial framework again offers insight into these mechanisms: biologically, exercise downregulates the HPA axis; psychologically, it offers distraction and routine; socially, it fosters a sense of achievement and engagement (Guo et al. 2024; Cao et al. 2024).

**Physical and psychological health**. The post-intervention results for physical and psychological health domains further support the value of CrossFit training (Meier et al. 2023). Participants in both intervention groups exhibited significantly better outcomes compared to the control group, reinforcing the holistic benefits of CrossFit. Piepiora (2024) notes that high-intensity, functional training not only enhances physical endurance but also cultivates perseverance, confidence, and stress tolerance—traits closely tied to psychological health. These improvements reflect the interconnection between mind and body emphasized in integrative psychological models (Liu et al. 2024; Lin et al. 2024).

**Social relationships**. In contrast, no significant improvements were observed in the domain of social relationships. This indicates that while CrossFit offers individual physical and mental health benefits, it may not inherently foster enhanced social connections unless specific collaborative activities are integrated. This limitation highlights a gap in the intervention design that future research could address by incorporating team-based exercises or group challenges to strengthen interpersonal ties and social well-being (Zhang et al. 2024).

**Environmental health**. Outdoor CrossFit training had a significantly greater impact on environmental health compared to indoor training and the control group. This aligns with research linking green exercise to increased well-being (Park et al. 2023), and with the environmental component of WHOQOL-BREF (Harper and Power 1998). These results support ecological theories of mental health, which emphasize the restorative effects of natural environments (Hong et al. 2024).

Although the environmental domain showed significant improvements for the outdoor group, it is important to note that this study did not control for external environmental variables such as temperature, humidity, air quality, or noise levels. These unmeasured factors may have influenced participants' perceptions of environmental health and well-being. Future research should consider monitoring and recording such environmental metrics during each training session, in order to better isolate the effects of the physical activity intervention from contextual and atmospheric conditions (Deng and Wang 2024; Lin et al. 2024; Liu et al. 2024).

This study supports findings by Cansler et al. (2023), who demonstrated that CrossFit participation significantly reduces depression, anxiety, and stress. Piepiora (2024) connects such outcomes to personality traits fostered by athletic involvement, while CrossFit.com (2021) emphasizes physiological and social mechanisms underpinning emotional gains. Chen and Yao (2022) report that physical activity enhances optimism and self-efficacy, complementing our findings. Similarly, Hofstra Law (2022) demonstrates that incorporating structured fitness into legal education can positively affect student well-being.

Although much of the existing literature focuses on general populations, our study contributes novel insights by addressing a specific high-risk academic group—law students—using validated psychological assessments (Lovibond and Lovibond 1995; WHO 1996). In doing so, it adds depth to recent studies on student mental health and contextualizes findings within legal education (Lin et al. 2024; Deng and Wang 2024). Moreover, unlike previous studies that overlook the influence of training environments, our research differentiates between indoor and outdoor settings, offering evidence that context influences perceptions of well-being—particularly in environmental domains (Lin et al. 2024; Wang et al. 2024).

By integrating interdisciplinary evidence from psychology, exercise science, and education, this study not only bridges existing gaps in literature but also provides practical guidance for the implementation of physical activity interventions in academic settings. The general comparability of indoor and outdoor CrossFit outcomes indicates its flexibility and scalability across diverse institutional contexts.

From a practical standpoint, these results highlight the potential of CrossFit to address the mental health challenges widely reported among law students, who often face elevated levels of stress and are hesitant to seek help (Organ et al. 2016; Jaffe et al. 2021). Embedding accessible and structured physical activity programs—particularly during high-pressure periods such as exams—could support emotional well-being and academic success (Ayres et al. 2017; Rosky et al. 2022).

**Limitations**. This study, while providing valuable insights into the effects of a CrossFit intervention on law students' mental and physical health, has several limitations that should be acknowledged.

The study involved a relatively small sample of 75 students, which may limit the generalizability of the findings. A larger, more diverse sample could provide a more comprehensive understanding of how CrossFit impacts various populations of students, particularly those from different academic disciplines or age groups. The intervention lasted only four weeks, which may not have been long enough to capture the full extent of long-term changes in mental and physical health. Future research could benefit from longer-term interventions to examine sustained effects over time. The use of self-reported questionnaires, such as the DASS-21 and WHOQOL-BREF, may introduce bias, as participants could underreport or overreport their symptoms and well-being. Future studies might incorporate objective measures or third-party assessments to supplement self-reported data. The study did not find significant changes in the social relationships domain (WHOQOL-BREF Domain 3), but this may have been due to the short duration of the intervention or the nature of the group activities. Further research should explore interventions specifically designed to enhance social interactions, possibly by including collaborative or team-based exercises.

While the outdoor group showed superior results in the environmental health domain, other environmental factors (e.g., weather conditions, air quality, noise levels, and access to green spaces) were not systematically measured or controlled during the study. These uncontrolled environmental variables could have influenced participants' experiences and outcomes. Future research should aim to monitor and document such environmental parameters using standardized metrics—for example, recording temperature, humidity, air quality index, and noise exposure during each session. This would allow for better control of confounding variables and a more accurate attribution of effects to the CrossFit intervention itself.

Lastly, the study focused exclusively on first-year law students, a population known to experience high levels of stress and anxiety. While the results are relevant for this group, they may not be entirely applicable to students in other fields or in later years of study.

To advance understanding of how CrossFit influences well-being and mental health, future research should address the current study's limitations by including larger and more diverse student populations. Investigations could also explore the long-term sustainability of observed benefits and assess how they manifest across different academic, demographic, and cultural contexts. Given the limited impact on social relationships, upcoming interventions may benefit from incorporating structured social interaction elements, such as team-based challenges or peer support mechanisms. Furthermore, applying comprehensive theoretical models like the biopsychosocial framework and employing multidimensional assessment tools would allow for a more nuanced analysis of the intricate relationship between physical activity and mental health outcomes.

Future programs may further optimize outcomes by incorporating team-based or cooperative elements to foster social connectedness and psychological resilience (Strevens and Field 2019; Duncan et al. 2020). Holistic wellness strategies that integrate physical activity with evidence-based mental health support may offer a sustainable model for cultivating well-being in academic environments (Chafouleas et al. 2023; Liu et al. 2024).

## Conclusions

The present study demonstrates that a four-week CrossFit intervention produces statistically significant effects on both physical and mental health in first-year law students. Key findings from the study include:

1. Physical Health Improvement- the CrossFit intervention led to significant improvements in physical health ($p < 0.05$) as measured by WHOQOL-BREF. Participants in both the outdoor and indoor groups exhibited enhanced physical well-being, highlighting the effectiveness of CrossFit as a tool for improving physical fitness in a relatively short period.

2. Mental Health Enhancement -CrossFit also had a significant positive impact on mental health. The results of the DASS-21 test demonstrated reductions in depression, anxiety, and stress across all components. Additionally, improvements in psychological well-being were observed in WHOQOL-BREF Domain 2 (Psychological Health), confirming the role of physical exercise in fostering mental resilience.

3. Comparison of Outdoor and Indoor CrossFit -no significant differences were found between the effects of outdoor and indoor CrossFit interventions, except in Domain 4 of WHOQOL-BREF (Environmental Health), where outdoor training yielded superior results ($p < 0.01$). This suggests that while both forms of CrossFit are effective, outdoor settings may provide added environmental benefits, likely due to the positive impact of natural surroundings on mental health.

4. Social Relationships Unaffected -contrary to the other domains, social relationships (measured by WHOQOL-BREF Domain 3) were not significantly influenced by the CrossFit intervention. This finding indicates that while physical activity can enhance individual well-being, it may not directly impact social interactions within the timeframe and structure of this study.

CrossFit is an effective intervention for improving both physical and mental health in law students, with no significant differences between outdoor and indoor formats except for environmental health. These findings underscore the potential of structured physical activity programs, like CrossFit, to enhance overall well-being in student populations, especially those exposed to high levels of stress. Further research could explore longer-term interventions and additional social factors to better understand the broader impact of CrossFit on well-being.

## Data availability

Datasets and materials used are available from the corresponding author upon request.

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## Author contributions

Valentina Stefanica conceived and designed the experiments, analyzed the data, authored or reviewed drafts of the article, writing—original draft preparation, writing—review and editing, and approved the final draft. Daniel Rosu conceived and designed the experiments, performed the experiments, authored or reviewed drafts of the article, writing—original draft preparation, and approved the final draft. Liviu Mihailescu conceived and designed the experiments, analyzed the data, authored or reviewed drafts of the article, writing—original draft preparation, and approved the final draft. Dana Badau analyzed the data, authored or reviewed drafts of the article, approved the final draft. Marko Joksimović performed the experiments, prepared figures and/or tables, project administration, and approved the final draft. Halil İbrahim Ceylan performed the experiments, prepared figures and/or tables, project administration, and approved the final draft.

## Competing interests

The authors declare no competing interests.

## Ethical approval

This study was performed in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments. Ethical approval was granted by the Ethics Committee of the Doctoral School of Physical Education and Sport Science, West University of Timișoara (Approval No. 08/21.03.2023). The approval covers all procedures involving human participants as described in the manuscript.

## Informed consent

Written informed consent was obtained from all individual participants prior to their inclusion in the study. The consent process was conducted by the principal investigator Valentina Stefanica, between 17 and 24 April 2023, after providing each participant with detailed written information about the study's purpose, procedures, potential risks and benefits, data confidentiality, and their right to withdraw at any time without penalty. The consent covered participation in the study, use of anonymised data for analysis, and publication of results. All participants were assured of the confidentiality and anonymity of their responses. No personally identifiable information, images, or sensitive data has been disclosed or published.

## Declaration of AI use

In preparing this paper, the authors used the ChatGPT model 4 on April 24, 2025, to revise some passages of the manuscript, to double-check for grammar mistakes or improve academic English only. After using this tool, the authors have reviewed and edited the content as necessary and take full responsibility for the content of the publication.

## Additional information

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