# RESEARCH



# Connection between college students' sports activities, depression, and anxiety: the mediating role of self-esteem



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## Abstract

**Background and purpose** As mental health issues receive increasing global attention, particularly the prevalence of depression and anxiety symptoms among college students, exploring effective intervention measures becomes crucial. This study aims to investigate the impact of physical activity on depression and anxiety among college students and to delve into the mediating role of self-esteem in these impacts.

**Methods** A structured questionnaire was used to survey 326 undergraduates from three universities in Hainan Province. The questionnaire assessed their self-reported responses to physical activity, depression, anxiety, and self-esteem. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to analyze the data collected in this study.

**Results** The results indicate that physical activity significantly negatively affects students' depression ( $\beta = -0.262$ , t = 4.268, p < 0.001) and anxiety ( $\beta = -0.170$ , t = 2.849, p < 0.01). Furthermore, self-esteem partially mediates the relationship between physical activity and both depression ( $\beta = -0.081$ , t = 3.158, p < 0.01) and anxiety ( $\beta = -0.063$ , t = 2.806, p < 0.01).

**Discussion** In conclusion, the findings provide a theoretical basis for developing physical activity programs aimed at enhancing college students' mental health, suggesting that future interventions should focus on increasing participation in physical activities and enhancing self-esteem to alleviate depression and anxiety, thus comprehensively improving students' psychological well-being.

Keywords Physical activity, Depression, Anxiety, Self-Esteem

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#### Introduction

In today's society, college students face a range of unprecedented challenges. With intensified educational competition and an uncertain job market, academic pressure [1], interpersonal relationship challenges [2], and worries about potential career opportunities [3] have become real issues they must confront. This pressure extends beyond academic competition in and outside the classroom, encompassing comparisons and expectations on social media, economic pressures, and expectations from family [4, 5]. The aggregate impact of these elements has substantially raised the incidence of depression (DEP) and anxiety (ANX) symptoms in college students, drawing widespread attention from all sectors of society [6]. Given the severity of mental health issues among college students, finding effective interventions is particularly crucial. Physical activity (PA), as a holistic way to promote physical and mental health owing to their affordability and simplicity of dissemination, is considered a potent tool to tackle these challenges [7]. According to the emotional effects theory of Exercise Psychology, PA can improve and alleviate negative emotions such as DEP, ANX, and stress [8, 9]. Research has shown that regular PA not only improves physical health and enhances cardiorespiratory fitness but also effectively alleviates psychological stress and enhances mood, thus positively intervening in symptoms of DEP and ANX [10, 11].

Recent studies have highlighted the crucial role of regular PA in promoting mental health. PA combats DEP and ANX through various mechanisms, the most straightforward method involves the modulation of brain neurotransmitters (like serotonin and dopamine levels) [12], which are highly effective in countering DEP and anxious moods. Moreover, regular PA promotes cardiovascular health by improving cardiac efficiency and blood circulation, which enhances the delivery of oxygen and nutrients to the brain, supporting its optimal function and overall cognitive performance, including those related to emotion and stress management [13]. On a social level, participating in PA offers opportunities for interaction and building connections, which are vital for enhancing social support, reducing feelings of loneliness, and alleviating social ANX [7]. Finally, PA boosts individuals' self-efficacy and self-esteem (SE), additionally exerting a beneficial effect on mental health [14].

Although existing research has confirmed that PA can effectively alleviate DEP and ANX, there are still some gaps in the literature when exploring the complex relationship between PA and mental health. Specifically, studies on the connection between PA and SE, and how SE serves as a mediating variable between PA and mental health status, are relatively insufficient. The novelty of this study lies in its in-depth exploration of the positive effects of PA on the levels of DEP and ANX among college students. More importantly, it attempts to reveal the mediating role of SE in this process. Through this unique research perspective, the study emphasizes that SE is not only a crucial component of individual mental health but also a key bridge linking PA and the improvement of mental health outcomes. This suggests that PA may alleviate symptoms of DEP and ANX by enhancing an individual's sense of SE, and the unveiling of this mediating role provides a new theoretical perspective on how PA promotes mental health.

Therefore, this study aims to explore the relationship between college students' PA and their levels of DEP and ANX, and to delve into the mediating mechanism of SE. By comprehensively analyzing this relationship, the study hopes to provide systematic intervention ideas for the mental health construction of college students, and offer scientific evidence for universities and relevant policy makers to promote the overall development and mental health of college students.

# Literature review and research hypotheses *Physical activity and depression*

DEP is a common emotional disorder characterized by persistent sadness, a sense of hopelessness, and a loss of interest or pleasure in most activities [15]. C Chronic DEP affects daily life, work performance, and physical well-being [16]. Research shows that PA can alleviate DEP symptoms in college students [17]. PA enhances cognitive functions like mental agility, creativity, and memory, and accelerates brain cell responses [18]. It also activates the central nervous system and improves mood, making it a potential tool for combating DEP [19]. Xiao, et al. [17] explored the association between participation in PA and DEP among minority adolescents in China, finding that students who engage in PA weekly are least likely to suffer from DEP compared to those who never participate, indicating that PA significantly negatively affects DEP moods or symptoms in adolescents. The study suggests that individuals who frequently engage in PA possess high levels of self-assurance and values, resulting in enhanced life contentment and, subsequently, a reduction in DEP [20, 21]. A study of 1200 university students in Jiangxi, China, also found a significant negative effect of PA on DEP [7]. However, some studies suggest that intense PA may increase DEP symptoms, despite the antidepressant effects of aerobic exercise [22]. Based on the above analysis, this study hypothesizes:

H1: PA significantly negatively affects DEP in college students.

#### Physical activity and anxiety

ANX is an emotional state characterized by heightened worry about ambiguous or perceived threats [23]. Regular PA is a key protective factor in preventing and managing ANX symptoms or moods [24, 25]. According to the Social Withdrawal Theory, a lack of physical activity is directly associated with psychosocial issues [26]. Specifically, when physical activity is scarce or students engage in little to no physical activity, their levels of anxiety tend to increase [27]. For instance, PA helps reduce ANX levels in college students. Both qualitative and quantitative studies have confirmed that PA, particularly aerobic exercise, is negatively correlated with an individual's ANX symptoms or moods, because people who frequently engage in PA tend to have higher self-confidence and lower levels of ANX [28-30]. PA also triggers the release of catecholamines, promoting positive psychological states and reducing ANX [31]. Han, et al. [32] found that college students who participated in PA during the COVID-19 pandemic were less likely to experience ANX compared to those who did not engage in PA. Further studies show that both team and individual sports improve ANX and sleep quality, with team sports yielding greater improvements [33]. Based on the above analysis, this study hypothesizes:

H2: PA significantly negatively affects the ANX of college students.

#### The mediating role of Self-Esteem

SE is defined as an individual's subjective evaluation of their own worth [34]. SE plays a crucial role in maintaining the psychological health of college students, acting as a psychological buffer that prevents the development of despair or hostility [35]. According to The Vulnerability Model, low SE increases the risk of DEP and ANX, as individuals with negative self-views and limited coping resources are more vulnerable to these conditions [36]. Research by Alhumaid and Said [37] shows that PA is closely linked to SE in college students, with PA providing opportunities to challenge oneself and achieve goals, leading to higher levels of physical SE [38]. Regardless of gender, the SE and physical SE of college students are closely related to their level of participation in physical activities, with less PA associated with lower SE and body dissatisfaction [39].

By enhancing SE, college students may adopt a more positive outlook on themselves and the world around them, which in turn helps reduce levels of ANX and DEP. For instance, Wang, et al. [40] explored the impact of PA on the social physique ANX of college students and the mediating role of SE. The study found that PA was significantly negatively correlated with social physique ANX, and SE partially mediated the relationship between PA and social physique ANX. A recent cross-sectional study also analyzed the impact of PA on students' ANX, DEP, and SE, showing that PA was significantly negatively correlated with ANX and DEP, and positively correlated with SE. Additionally, PA could reduce levels of DEP and ANX by enhancing the SE of college students [41, 42]. Based on the above analysis, this study hypothesizes:

H3a: SE mediates the relationship between PA and DEP.

H3b: SE mediates the relationship between PA and ANX.

The proposed theoretical framework of this study is depicted in Fig. 1.

# Materials and methods

#### Participants

This study adopted a cross-sectional quantitative survey design to explore the relationships between physical activity, self-esteem, depression, and anxiety among



Chinese college students. A random sampling method was used to select students from three universities in Hainan Province (Hainan Vocational University of Science and Technology, Hainan Normal University, and Hainan College of Economics and Business), with data collected via the Sojump platform (www.Sojump.com). The data collection period was from January to March 2024, and the questionnaires were anonymous and confidential. To enhance the external validity and generalizability of the study results, the research team collaborated with department heads, who explained the purpose and significance of the survey to students and invited them to participate. All students participated voluntarily and filled out the questionnaires independently.

According to the sample size calculation method proposed by Kline [43], each questionnaire item requires at least 10 respondents. This study includes 31 items in the questionnaire. Considering an approximately 20% sample attrition rate, the required sample size was determined to be 372 participants (31 items × 10 respondents + 20% × 31 items  $\times$  10 respondents). To meet the research requirements, 480 questionnaires were distributed, and 478 were eventually returned. During the data cleaning process, 152 questionnaires were excluded for the following reasons: more than 20% of the questions left unanswered, or over 80% of the questions answered with extreme options (completely agree or completely disagree). Such response patterns could lead to significant data bias, known as floor or ceiling effects, which would affect the accuracy of data analysis [44]. Specific demographic data are shown in Table 1: 221 male participants (67.79%) and 105 female participants (32.21%); the majority were aged between 18 and 22 years, with 309 participants (94.79%); and most were in their first year of university, with 220 participants (67.48%). All participants signed an informed consent form prior to completing the questionnaire, ensuring the study complied with ethical standards and respected participants' privacy and autonomy.

#### **Measurement tools**

The questionnaire is divided into two parts: the first part covers participants' demographic information, while the

 Table 1
 Profile of the sample population

second part addresses the constructs involved in this study. The constructs used in the study were assessed through established scales, which were appropriately modified based on the research context and objectives. According to the recommendations of Hair Jr, et al. [45], this study required the external loadings of scale items to be greater than 0.7, and the AVE value to be greater than 0.5. Therefore, items with external loadings lower than 0.7 were removed to ensure that the scale's reliability and validity were within a reasonable range. All deleted items met the reliability and validity requirements, thus improving the measurement validity of the scale and ensuring the accuracy of the research results.

#### **Physical activity**

This study used the Physical Self-Concept Questionnaire developed by Marsh, et al. [46] to assess PA among college students. The full scale consists of 11 dimensions and a total of 70 items. Specifically, this study selected two scales from the questionnaire: PA and sports competence, consisting of 12 items in total, with the 2nd and 3rd items requiring reverse scoring. This scale typically uses a Likert five-point scoring method, ranging from 1 (strongly disagree) to 5 (strongly agree). The total score range is from 12 to 60, Higher scores indicate stronger PA capabilities. The scale has demonstrated good reliability and validity in the Chinese college student population [47]. In this study, the measurement model analysis of the physical activity capability scale showed that the external load scores of four items were below 0.708. After removing these four items, the remaining eight items exhibited good fit, with a Cronbach's  $\alpha$  of 0.940, indicating good reliability.

#### Depression

This study used the Depression Scale developed by Salokangas, et al. [48] and revised by Dhir, et al. [49] to assess the DEP of college students. The revised scale consists of 5 items, using a Likert five-point scoring system, ranging from 1 (strongly disagree) to 5 (strongly agree), with a total score range of 5 to 25. A higher total score indicates a higher level of DEP. The revised scale has demonstrated

Demographic Characteristics	Category	Quantity	Percentage (%)
Gender	Male	221	67.79
	Female	105	32.21
Age	Below 18 years old	10	3.07
	19–22 years old	309	94.79
	23 years and above	7	2.15
Grade	Freshman	220	67.48
	Sophomore	78	23.93
	Junior	22	6.75
	Senior	6	1.84

good reliability and validity in the college student population [49]. In this study, the Cronbach's  $\alpha$  of the scale was 0.930.

#### Anxiety

This study used the Chinese version of the Depression Anxiety Stress Scale (DASS-21), developed by Lovibond and Lovibond [50] and revised by Gong [51], to measure participants' emotional states over the past week. The full scale consists of 21 items, with 7 items each for the DEP, ANX, and stress subscales. This study focused on the ANX. The scale uses a 5-point Likert scale, with responses ranging from 1 (strongly disagree) to 5 (strongly agree), resulting in a total score range of 7 to 35. A higher total score indicates higher levels of ANX. The scale has been validated in the Chinese college student population and has demonstrated good reliability and validity [52]. In this study, the Cronbach's  $\alpha$  for the scale was 0.953.

#### Self-Esteem

This study utilized the Self-Esteem Scale developed by Rosenberg [53] to assess the SE of college students. The scale includes 10 items, with items 3, 5, 8, 9, and 10 scored in reverse. It employs a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), with a total score range of 10 to 50. A higher total score indicates a higher level of SE. The scale has been validated in the Chinese college student population and has demonstrated good reliability and validity [54]. In this study, the measurement model analysis showed that the external load scores of five items were below 0.708. After removing these five items, the remaining five items exhibited good fit, with a Cronbach's  $\alpha$  of 0.944, indicating good reliability.

#### Statistical processing

This study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the data. PLS-SEM offers several advantages: first, it is a predictiveoriented data analysis tool [55]; second, it is suitable for small sample sizes and performs well even in cases of non-normal distribution [55]; third, it is applicable to more complex models [56]. Therefore, PLS-SEM was considered appropriate for this study. The specific analysis steps include: first, data preparation and preprocessing, which involve handling missing values and outliers, as well as removing samples with excessively short response times or consecutive answers; second, testing the reliability and validity of the measurement model by evaluating Cronbach's α coefficient, composite reliability (CR), average variance extracted (AVE) values, and outer loading factors; third, evaluating the structural model, focusing on path coefficients, and conducting significance tests for these coefficients using the Bootstrapping method with 5000 bootstrap samples to calculate t-values and p-values. Through these steps, PLS-SEM analysis ensured the validity of both the measurement and structural models, providing a scientific basis for hypothesis testing.

#### Results

#### Structural equation model analysis

Following the recommendations of Hair Jr, et al. [45], the reliability and validity of the scales were assessed via analysis of the measurement model. Reliability indicators include the external loadings of items and the CR of the scales. According to the guidelines, item external loadings must exceed 0.70. Composite reliability was used to assess internal consistency reliability, and all values also needed to be above 0.700 [45]. In this study, the outer loadings for all constructs met or exceeded this threshold, ranging from 0.702 to 0.934, demonstrating high indicator reliability. Internal consistency reliability was assessed using CR, and all constructs exhibited CR values well above the required 0.700, with values of 0.942 for PA, 0.945 for DEP, 0.976 for ANX, and 0.951 for SE. Additionally, convergent validity was confirmed as the AVE for all constructs surpassed the minimum criterion of 0.5, with AVE values 0.709 for PA, 0.782 for DEP, 0.779 for ANX, and 0.817 for SE [45]. Discriminant validity was assessed using the heterotrait-monotrait (HTMT) ratio of correlations standard and the conventional Fornell-Larcker criterion [45]. The HTMT ratios for each construct pairing, such as PA-DEP (0.196), PA-ANX (0.110), and DEP-ANX (0.840), all fell beneath the critical limit of 0.85, confirming the constructs' distinctiveness. Additionally, the correlation coefficients between constructs, such as PA and DEP (0.181), ANX and DEP (0.884), were found to be lower than the square root of the AVE values, meeting the Fornell-Larcker criterion. Therefore, both HTMT and Fornell-Larcker methods indicate that all constructs have high discriminant validity.

#### Structural model

Initially, the variance inflation factor (VIF) values for the latent constructs were used to assess multicollinearity issues within the model. All VIF values for the latent constructs ranged from 1.000 to 1.091, all below the critical threshold of 3.3, indicating no multicollinearity issues in the results [45].

To evaluate the size and importance of the path coefficients in the model, a bootstrapping process with 5,000 subsamples was conducted [45]. Table 2 summarizes the results of the hypothesis testing. The results indicate that PA significantly negatively impacts both DEP levels ( $\beta$  = -0.262, *t* = 4.268, *p* = 0.000) and ANX levels ( $\beta$  = -0.170, *t* = 2.849, *p* = 0.004) among college students. Therefore, H1 and H2 are supported.

#### Table 2 Hypothesis testing results

Hypothesis	β	2.50%	97.50%	t	р	Results
$PA \rightarrow DEP$	-0.262	-0.385	-0.144	4.268	0.000	Supported
$\text{PA} \rightarrow \text{ANX}$	-0.170	-0.290	-0.056	2.849	0.004	Supported

Note: t represents the two-tailed t-test value; p represents the significance level; Path significance: \*\*\*p#x2009;<0.001; \*\*p < 0.01; \*p < 0.05.

Table 3 Mediation analysis

Relationship	Indirect Effect	t	р	Direct Effect	t	p	Mediation Type
$PA \rightarrow SE \rightarrow DEP$	-0.081	3.158	0.002	-0.262	4.268	0.000	CPM
$PA \rightarrow SE \rightarrow ANX$	-0.063	2.806	0.005	-0.170	2.849	0.004	CPM
$PA \rightarrow SE \rightarrow ANX$	-0.063	2.806	0.005	-0.170	2.849	0.004	CPM

Note: t represents the two-tailed t-test value; p represents the significance level; CPM stands for Complementary Partial Mediation.

#### Mediation effect analysis

To evaluate the mediating effect of SE in the relationship between PA and DEP, as well as ANX, mediation analysis was conducted. The mediation was assessed using methods based on PLS-SEM and employing bootstrapping to examine the significance of direct and indirect impacts and the sign of their product effects, aiming to ascertain the nature and magnitude of the mediation effect. Table 3 presents the mediation analysis results, which indicate that SE significantly mediates the indirect effects between college students' PA and both DEP ( $\beta$  = -0.081, *t* = 3.158, *p* = 0.002) and ANX ( $\beta$  = -0.063, *t* = 2.806, *p* = 0.005). Therefore, SE acts as a complementary partial mediator in the relationships between PA and both DEP and ANX, supporting H3a and H3b.

#### Discussion

This study focuses on the relationship between PA and DEP and ANX among college students, and attempts to uncover the potential mediating mechanisms. Via a thorough examination of current literature, this research hypothesized that PA has a significant negative impact on the levels of DEP and ANX among college students, and that SE mediates this relationship. Based on this, the study aimed to explore the relationship between PA and DEP and ANX among college students, investigate the mediating role of SE in this relationship, and discuss its impact on individual development, thus providing systematic intervention ideas for the mental health construction of college students.

PA significantly negatively impacts college students' DEP levels. This finding is consistent with the study by Xiao, et al. [17], which found that regular PA significantly reduces DEP symptoms, improves emotional states, and enhances quality of life. PA boosts positive neurotransmitters in the brain, which are crucial for mood regulation. It also reduces the body's stress response and lowers cortisol levels, promoting positive emotions and alleviating DEP [57]. Additionally, students who frequently participate in physical activities can interact with others in a less stressful environment, thereby helping to establish deeper interpersonal relationships [58]. This study

confirms the positive impact of PA on depression symptoms, revealing the physiological mechanisms involving neurotransmitters and stress hormones. However, future research should explore the specific effects of different types of PA on depression to further refine the theoretical framework in this area.

PA significantly negatively affects the ANX levels of college students. This result aligns with the research by Lin and Gao [28], which found that college students who regularly engage in physical activities exhibit lower levels of ANX. Physiologically, PA lowers ANX by promoting cardiovascular health, improving blood circulation, and enhancing the brain's ability to utilize oxygen and nutrients [12]. These changes improve nervous system functioning, enabling the brain to better process stress and ANX [59]. From a health behavior perspective, regular PA encourages college students to develop and maintain other healthy behaviors, such as regular sleep patterns, healthy eating habits, and avoiding excessive use of electronic devices. These healthy behaviors can significantly improve an individual's physical health, reduce the risk of lifestyle diseases, and a good physical health status and lifestyle habits can effectively alleviate psychological stress and ANX [60, 61]. This study confirms the positive impact of PA on ANX and offers new insights into how PA alleviates anxiety by enhancing mental health. However, individual differences may influence the relationship between PA and ANX. Future research should consider variables such as personality traits and social support to further explore this area.

SE partially mediates the relationship between PA and both DEP and ANX. This finding aligns with the studies by Wang, et al. [40] and Fu, et al. [41], which suggest that appropriate PA can increase college students' SE, thereby alleviating their levels of DEP and ANX. PA improves body image, physical capabilities, and sports achievements, fostering a positive self-image. Positive feedback from personal progress boosts self-worth, increasing SE. High SE helps individuals approach challenges with a positive attitude, reducing DEP and ANX associated with negative self-evaluation [41]. Students with high SE typically exhibit confidence, independence, and calmness, handling negative feedback rationally and filtering out negativity. As a tool for boosting SE, PA enhances their sense of control, helping them adapt to challenges and utilize social support to reduce the impact of DEP and ANX during stressful events [62]. This study verified the mediating role of self-esteem in the relationship between physical activity and mental health, offering a new perspective on how physical activity improves mental health by enhancing self-esteem. It also provides empirical support for personalized mental health intervention strategies, particularly when considering self-esteem and contextual factors. However, the relationship between physical activity and mental health may be moderated by contextual factors such as cultural background and social environment. Future research could explore additional potential mediating variables, such as social support and emotional regulation skills, to gain a more comprehensive understanding of this mechanism.

### Implications and limitations Implications

This study makes significant theoretical contributions by exploring the relationships between PA, SE, DEP, and ANX. It reinforces the role of PA in improving DEP and ANX among college students, confirming that regular PA reduces negative emotions through both physiological and psychological mechanisms. Additionally, by revealing SE as a mediator in the PA-DEP/ANX relationship, the research expands our understanding of psychological health interventions, highlighting SE enhancement as a key pathway linking PA to positive psychological outcomes.

Practically, the study offers strategies for promoting mental health among college students. Higher education institutions should encourage PA by improving sports facilities, organizing events, and offering diverse physical education classes. This would improve both physical health and mental well-being. Given SE's mediating role, mental health programs should focus on boosting SE, for example, by incorporating goal-setting in PA programs to foster achievement and progress. Schools can also offer workshops to strengthen SE and help students recognize PA's positive impact on self-worth. Lastly, the study emphasizes the importance of a multidimensional approach to student mental health, integrating PA and SE enhancement into broader educational strategies to improve overall quality of life.

#### Limitations and future research directions

This study advances our understanding of the relationships between PA, SE, DEP, and ANX among college students but has some limitations. First, the sample was limited to students from specific universities, which may affect the generalizability of the findings. Future research should include a more diverse sample across regions, cultures, and academic fields. Second, the cross-sectional design limits the ability to determine causal relationships. Longitudinal studies are needed to track changes in PA, SE, and DEP/ANX over time. Third, other factors, such as coping strategies, social support or emotion regulation, could also mediate these relationships and should be explored in future research. Lastly, the study did not analyze the specific effects of different types, intensities, and frequencies of PA on DEP and ANX. Future research could include these factors to better assess the multidimensional impact of PA, providing more precise support for targeted mental health interventions.

#### Conclusion

This study, through its investigation of the college student population, has clearly demonstrated the significant negative impact of PA on levels of DEP and ANX, while also revealing the mediating role of SE between PA and the improvement of psychological health. These findings not only offer theoretical backing for the use of PA in mental health contexts interventions but also highlight the enhancement of SE as a crucial intervention target. Furthermore, this research offers valuable insights and evidence for higher education institutions in designing PA and mental health intervention measures that promote the physical and psychological well-being of students.

#### Author contributions

B.Z. writing—original draft preparation; X.D. Conceptualization and methodology; Z.Z. investigation and data curation.

#### Funding

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#### Data availability

The data supporting the findings of this study are available within the article.

#### Declarations

#### Ethics approval and consent to participate

The studies titled "Connection Between College Students' Sports Activities, Depression, and Anxiety: The Mediating Role of Self-Esteem" involving human participants were reviewed and approved by Hainan Vocational University of Science and Technology. The patients/participants provided their written informed consent to participate in this study.

#### **Consent for publication**

Not applicable.

#### Competing interests

The authors declare no competing interests.

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