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Original Article

Effect of Tai Chi Exercise on Fall Prevention in Older Adults: Systematic Review and Meta-analysis of Randomized Controlled Trials[☆]



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SUMMARY

Background: Falls among the elderly is a major public health concern. Tai Chi exercise appears to prevent the risk of falls among the elderly. Previous reviews found that there is insufficient evidence to conclude whether Tai Chi is effective in fall prevention. Our review was performed to update the current evidence on the effect of this intervention.

Methods: We systematically searched Medline, PubMed, Embase, and Cochrane Library for studies published up to 2013. Randomized controlled trials that examined the effect of Tai Chi exercise on fall reduction were included. The quality of included studies was assessed using the Physiotherapy Evidence Database scale. Random effects meta-analysis was performed.

Results: Ten trials involving 2850 participants were eligible for meta-analysis. Compared with the control group, Tai Chi exercise showed a significant reduced risk of falls (odds ratio = 0.70; 95% confidence interval, 0.59 to 0.84). Subgroup analysis found no evidence of differential effects by training duration or Tai Chi style.

Conclusion: Our findings demonstrate that Tai Chi exercise has a significant protective effect on fall risk among older adults. Further studies are warranted to develop optimal Tai Chi training programs (training intensity, duration, and frequency, etc.) for older adults.

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1. Introduction

Falls are a major public health concern and serious problem facing older adults, which may result in reduced functional ability, nursing home admissions, high medical costs, and even mortality^{1,2}. About one-third of adults fall each year, and the incidence increases with aging. Falls also have an adverse psychological and social impact on elderly people, such as fear of falling, loss of confidence, and restriction of social activities.

Many preventive programs based on the risk factors for falls are available to older adults^{3,4}. Tai Chi, which originated in China as a form of martial art and exercise, has been practiced to promote

mental and physical health and to prevent many conditions associated with age worldwide recently⁵. Poor balance function and lower leg weakness are risk factors for falls. Tai Chi exercises, which incorporate a series of weight shifting, body rotations, and semi-squat positions, can improve lower limb strength and balance function⁶. Many studies have demonstrated the advantages of Tai Chi exercise on balance function and strength^{7,8}. Meanwhile, Tai Chi is a low-impact, slow-motion exercise, making practicing Tai Chi for older adults a perfect addition to their daily routines^{9,10}. Therefore, Tai Chi is a suitable exercise training for prevention of accidental falls among older adults.

Several trials have reported the positive effect of Tai Chi exercise on the prevention of falls in older adults, but some studies showed negative findings. Two meta-analyses have been published on the effect of the Tai Chi exercise for the prevention of falls, and they revealed that there is insufficient evidence to conclude whether Tai Chi is effective in fall prevention^{11,12}. As many randomized

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controlled trials have been published recently^{13,14}, a review update is needed to document evidence regarding the effect of Tai Chi exercise on fall prevention. To synthesize the latest trial reports with the older data, we have performed this systematic review and meta-analysis of all randomized controlled trials of the effectiveness of Tai Chi on the risk of falls among older adults.

2. Methods

A systematic literature search was conducted in several major databases including Medline, PubMed, Embase, and Cochrane Library between the inception dates and June 30, 2013, with no language restrictions. The references lists provided in the retrieved studies were further checked to identify additional potential eligible studies. The key words used in the search were Tai Chi, TaiChi, Tai-ji, Taiji, taichiquan, taijiquan, and tai ji with fall, falls, falling, and accidental falls.

The inclusion criteria for trials were as follows: (1) the type of trial was a randomized controlled trial; (2) participants were older adults (age ≥ 65 years); (3) one of the interventions was a form of Tai Chi exercise training; and (4) the outcomes included falls. The studies on Tai Chi exercise were compared with other studies in which control intervention (health education or exercise) or nonintervention groups were included.

Two authors independently evaluated all potential articles eligible for inclusion; for each article, data related to the characteristics of the trials and details of outcome measurements were extracted. The Physiotherapy Evidence Database (PEDro) scale was used to assess the quality of the randomized controlled trials¹⁵. The PEDro scale

rates randomized controlled trials from 0 to 10, with 6 representing the cutoff score for high-quality studies. The ratings were obtained independently by two authors. Any discrepancies in data extraction or quality assessment were resolved by discussion and consensus.

We allowed for diversity among the studies in terms of content, frequency, intensity, duration of Tai Chi exercise program, inclusion and exclusion criteria of samples, and outcome definitions. We used a random-effects model to combine the effect sizes of the included studies. The primary outcome was the incidence of falling. For the risk of falls, a dichotomous outcome, we used an odds ratio as the treatment effect. We report the pooled treatment effect, presented as odds ratios, for each trial, along with 95% confidence intervals (CIs). The statistical heterogeneity among trials was evaluated using both Cochran's Q and I^2 statistics¹⁶. Subgroup analyses and metaregression were applied to determine if pre-specified covariates (Tai Chi training style, volume of Tai Chi training, and the form of control group) might explain the heterogeneity of results among the studies. Funnel plot and Egger's test were calculated to investigate any potential publication bias¹⁷. All analyses were conducted using Stata 11.0 software (Stata, College Station, TX, USA).

3. Results

A total of 285 potential relevant articles were identified through a comprehensive database search. Overall, 124 articles remained after the duplicates were removed. After screening the titles and abstracts, 39 articles were assessed by full-text reading. Eventually, 10 articles were included in this systematic review (Figure 1).

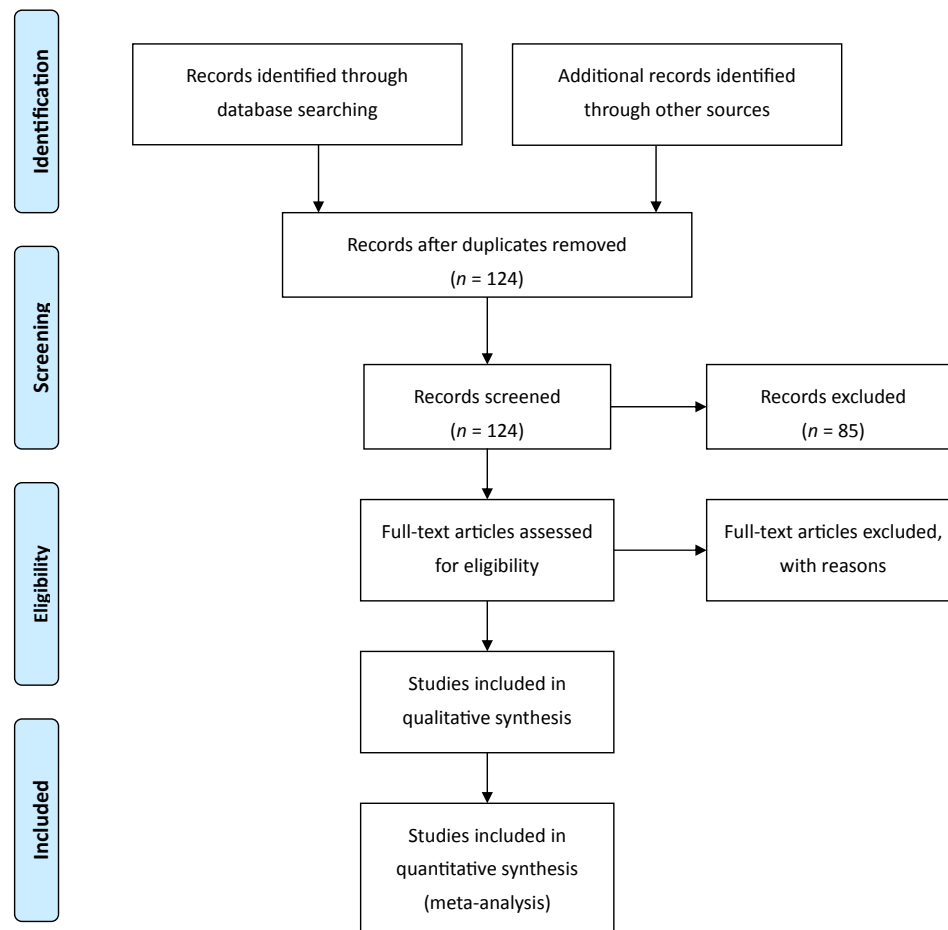


Figure 1. The literature search and selection process.

3.1. Characteristics of included studies and interventions

The 10 studies_ENREF_1 in the meta-analysis included a total of 1540 participants randomized in the Tai Chi exercise groups and 1310 randomized in the control groups, with sample sizes ranging from 59 to 684 participants^{13,14,18-25}. The mean age of all participants ranged from 68 years to 84 years. All the studies involved community living elderly adults except for three studies that involved elderly adults from long-term care facilities^{20,23,24}.

Across all studies, the interventions were heterogeneous with respect to the style of Tai Chi exercise training, and to the frequency and duration of the exercises being undertaken. The dose and duration of Tai Chi exercise programs ranged from 16 h/wk to 120 h/wk and 6 months to 12 months, respectively. Of the 10 trials, eight used a nonexercise control intervention and two used an exercise control group^{14,21}. One study compared two different Tai Chi exercise interventions with a single control group¹³. In the analysis, the control group was split into two groups to make two pairwise comparisons. Figure 1 summarizes the characteristics of the included studies.

Figure 2 shows the forest plots of the Tai Chi exercise training on the risk of falls; the pooled estimated odds ratio was 0.70 (95% CI, 0.59 to 0.84; $I^2 = 18.8\%$, $p = 0.26$).

3.2. Subgroup analysis

First, the 10 trials were grouped according to the length of intervention (≥ 6 vs. < 6 months). In the two subgroups, the effect of Tai Chi exercise on prevention of fall risks were 0.80 (95% CI, 0.66 to 0.96; < 6 months) and 0.52 (95% CI, 0.38 to 0.71; ≥ 6 months). Then, the trials were grouped according to the Tai Chi style used. The effect of Tai Chi exercise on the prevention of fall risks was measured as 0.57 (95% CI, 0.33 to 0.99) for the Yang style, 0.79 (95% CI, 0.62 to 0.99) for the Sun style, and 0.68 (95% CI, 0.50 to 0.93) for the modified or unspecified style.

The results for each subgroup were still in favor of the intervention group (Figures 3 and 4). While conducting metaregression to explore the relation between the training dose and the effects, the regression coefficient of our analysis was -0.0017 (95% CI, -0.0066 to 0.0032), indicating that increased weekly training dose may be associated with favoring protective effect (Figure 5). However, this observed association was not statistically significant (Figure 6).

Most studies were of fair to good quality and ranged from 5 to 7 (out of 10) on the PEDro scale. No study involved blinded participants or therapists because of the nature of the interventions. All studies reported between-group statistical comparisons and point measures and measures of variability and measured outcomes in the treatment and control groups for at least one primary outcome. There was low evidence of publication bias. Funnel plot analysis showed a barely symmetrical scatter (Egger's test, $p = 0.18$).

4. Discussion

This systematic review examined and statistically synthesized the evidence of the effect of Tai Chi exercise on the risk of falls. On the basis of the available evidence, our review found that Tai Chi exercise seems to be effective in reducing the incidence of falls in older adults, regardless of the style and duration of Tai Chi exercise training. Two systematic reviews evaluating the effect of Tai Chi exercise on the prevention of the risk of falls have been published. A review of two trials presented by Leung et al¹² revealed that Tai Chi exercise seems to be effective in prevention of falls risk at the 24th week (odds ratio = 0.85; 95% CI, 0.63 to 1.17). Logghe et al¹¹, based on five studies, found no improvement among Tai Chi participants in terms of fall rates compared with nonexercise controls (rate ratio, 0.79; 95% CI, 0.60–1.03). Our review summarized recent lines of evidence showing that Tai Chi exercise can significantly reduce the risk of falls in elderly adults.

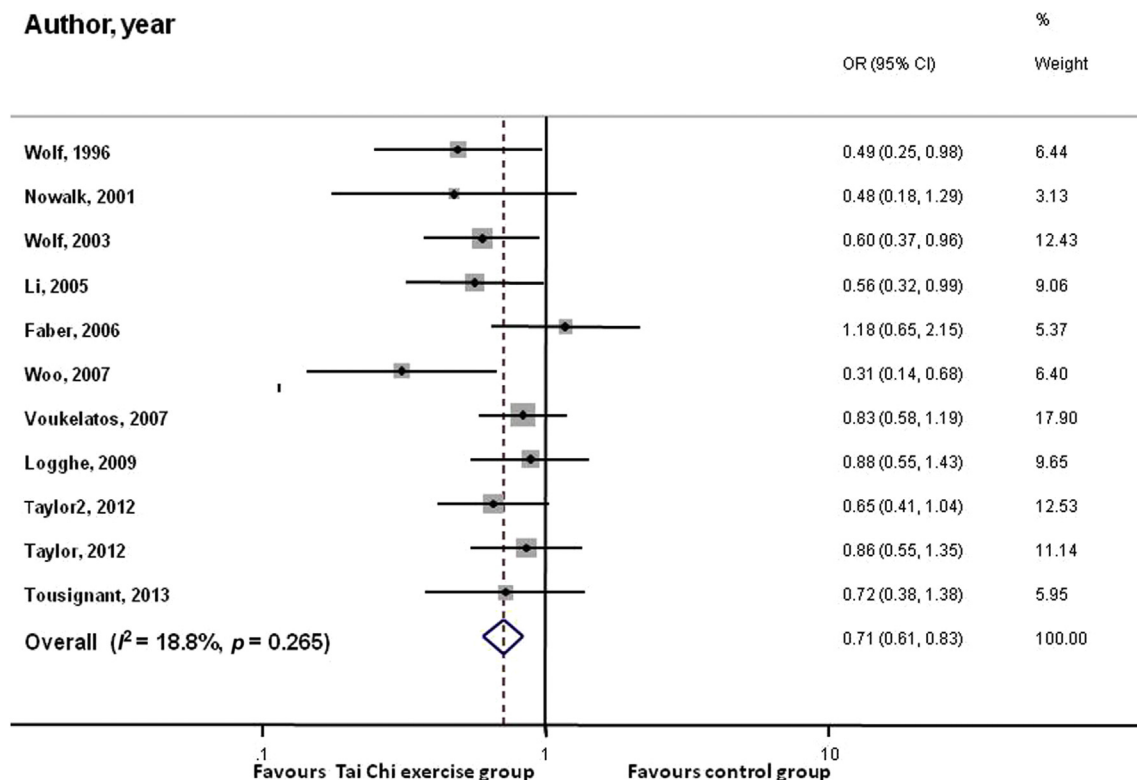


Figure 2. Meta-analysis of the effect of Tai Chi exercise on the risk of falls in older adults. CI = confidence interval; OR = odds ratio.

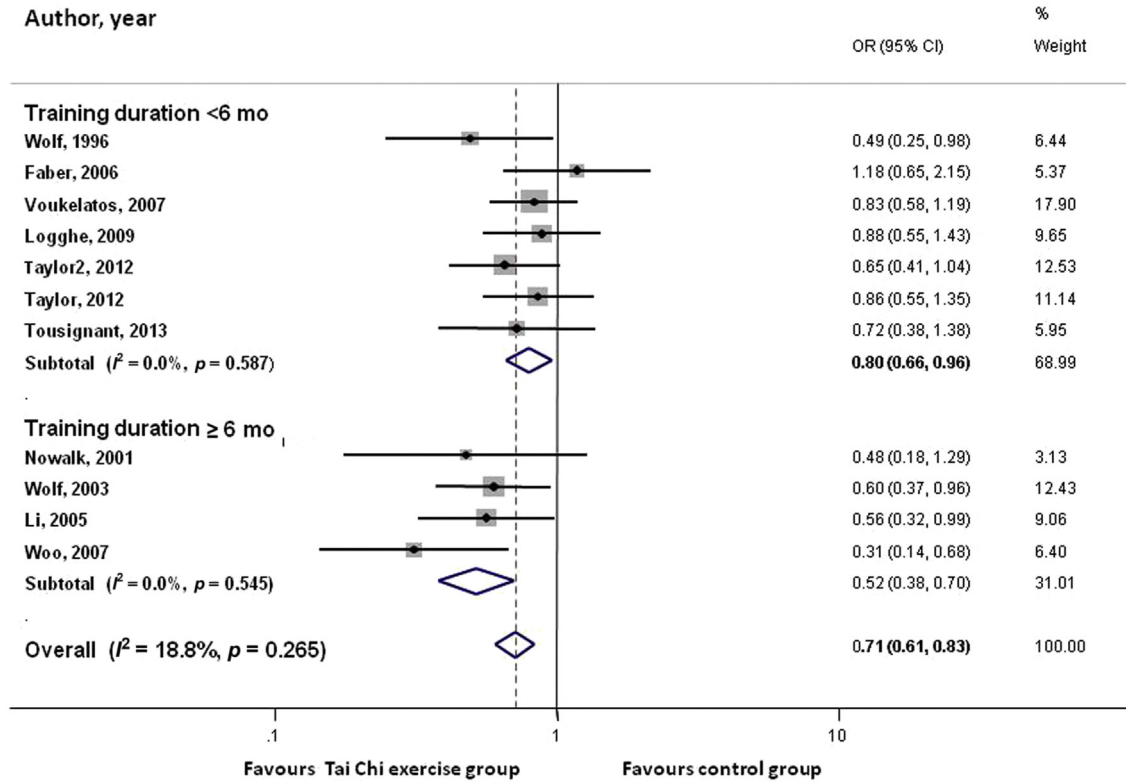


Figure 3. Subgroup analyses of Tai Chi exercise on the risk of falls by training duration. Odds ratio (OR) and corresponding confidence intervals (CI) for from individual trials were pooled and interactions were evaluated by random-effects meta-analyses.

Assuming Tai Chi exercise can decrease the risk of falls among older adults, the true underlying mechanisms remain largely uncertain. It may be the integration of muscular, skeletal, and neural functions in the execution of Tai Chi exercise. Researchers have

speculated that Tai Chi exercise practitioners show better visual, vestibular, and proprioceptive functions compared with the control group^{26–28}. Previous studies have also revealed that Tai Chi exercise can significantly increase the knee extensor and flexor muscle

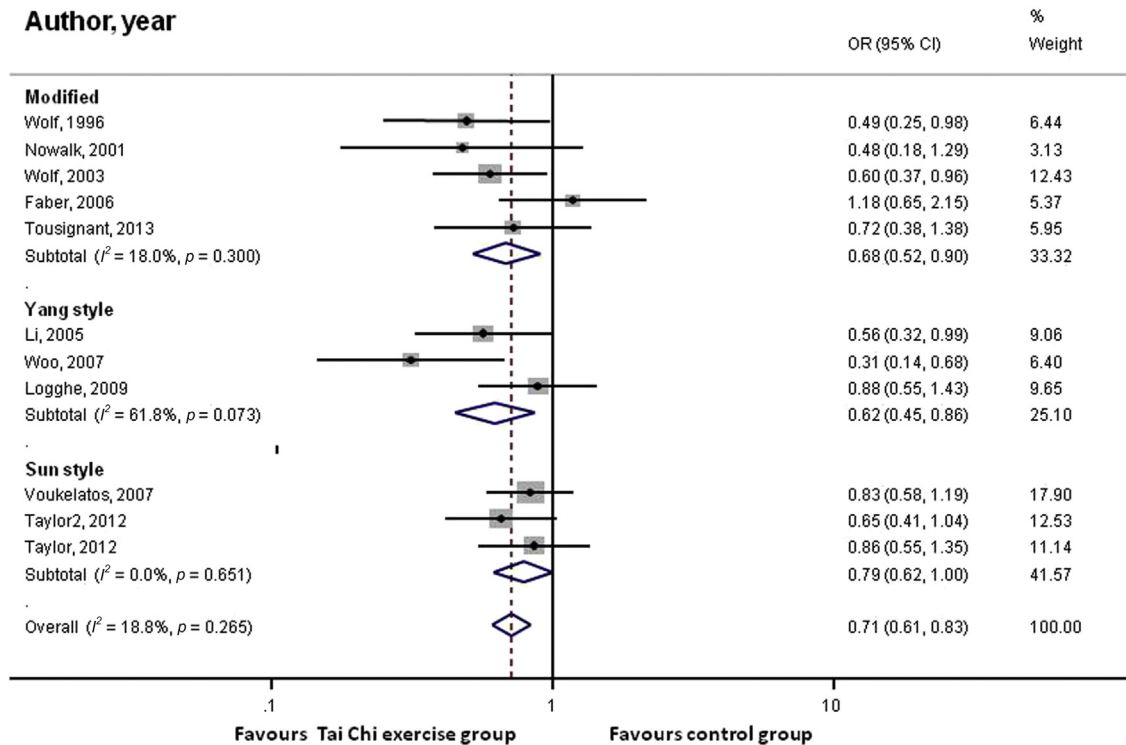


Figure 4. Subgroup analyses of Tai Chi exercise on the risk of falls by training styles. Odds ratio (OR) and corresponding confidence intervals (CI) for from individual trials were pooled and interactions were evaluated by random-effects meta-analyses.

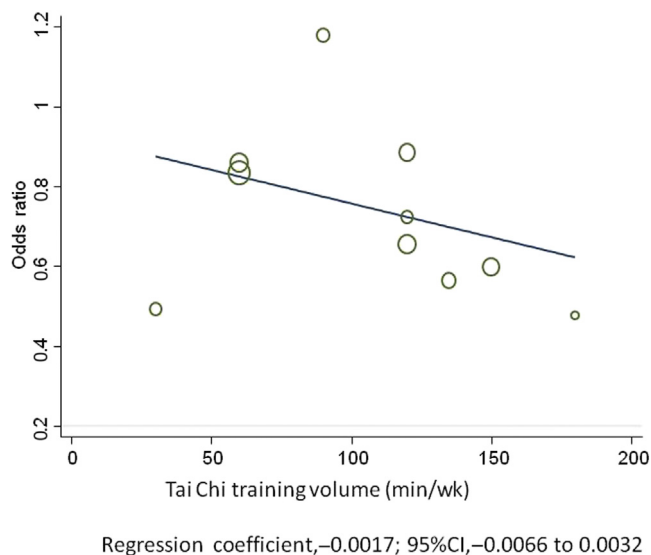


Figure 5. Metaregression for training volume (min/wk) on the risk of falls.

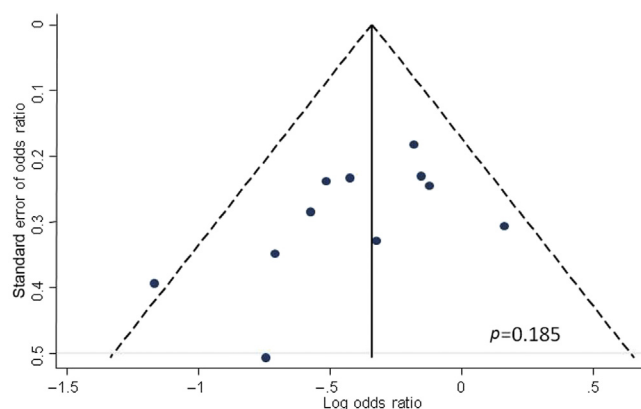


Figure 6. Funnel plot of the studies included in this meta-analysis.

strength and bone mineral density among older adults^{29–31}. However, further studies are necessary to verify and support these proposed mechanisms.

Tai Chi exercise has the potential to reduce falls or fall risks among the elderly. However, the effectiveness of Tai Chi intervention may be affected by the training variables. Some authors believe that it takes at least 1 year of 3 times/week of practice to learn Tai Chi, but many trials with short training duration have shown favorable effects²⁴. Tai Chi is practiced in many styles, such as Yang, Wu, and Sun styles. Yan style may be a good exercise for strengthening muscle, whereas Wu style may be a better exercise for improving balance³². Many trials used modified Tai Chi, which is actually not the traditional complex practices that match the formal definition of traditional Tai Chi. The modifications generally simplify the practice, making the movements more health-oriented³³. However, our study found that Tai Chi styles and training duration had a small influence on the intervention effect.

This review may be subject to several limitations. First is the potential incompleteness of the evidence reviewed. Second, the data for outcome measures were self-reported, which means that it is subject to bias. Lastly, although it would have been ideal to include training variables as a subgroup, this was not possible given the lack of information provided by a number of studies.

5. Conclusion

Our review, based on current available evidence, suggest that Tai Chi exercise is an effective intervention to prevent the risk of falls among older adults. Future trials are warranted to determine the optimal duration and frequency of Tai Chi programs and identify the optimal style for older adults.

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