Journal of Coaching and Sports Science
Volume 5, Issue 1, 29-40.
e_ISSN: 2963-1483
https://www.journal.foundae.com/index.php/jcss/index
DOI: 10.58524/jcss.v5i1.869

Time pressure and player disadvantage: Effects on jump performance in simulated matches of well-trained amateur handball players

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Article Info

Article history:
Received: Augst 25, 2025
Revised: Sept 15, 2025
Accepted: Nov 3, 2025

Keywords:
Time pressure;
Simulation training;
Psychological stress;
Fatigue;
Jump performance.

Abstract

Background: At the end of a handball match, when players are physically disadvantaged and pressured by time, their overall fitness declines. This primarily affects their jumping ability, a key skill for scoring points.
Aims: This study examined the effects of late-match time pressure and player disadvantage on the jumping performance of well-trained amateur handball players under simulated competition conditions.
Methods: Twenty-eight amateur handball players (14 males and 14 females; age 20.00 ± 0.86 years, weight 65.32 ± 11.18 kg, height 169.68 ± 9.56 cm, experience 4.79 ± 2.63 years, and VO2max 40.89 ± 7.67 ml/kg/min) participated in a simulated handball match that replicated the intensity of a simulated game. The match was simulated with a player disadvantage and a score of less than 1 point in the final five minutes. Height jump (HJ), Rate of force development (RFD), and Power (PW) were analyzed using countermovement jumps (CMJ) pre and post competition, along with average heart rate (HR) during the game.
Results: HJ, RFD, and PW increased significantly after the competition ($P < 0.05$), regardless of whether the athlete was on the favored or disadvantaged team. However, no significant differences were found between favored and disadvantaged teams in any of the variables.
Conclusion: Jumping performance did not consistently decrease in situations with fewer players and scoring pressure. Furthermore, neuromuscular fitness temporarily increased after intense exercise and a short recovery period.

To cite this article: Panichram, T., Khumsingsan, K., & Khamros, W. (2026). Time pressure and player disadvantage: Effects on jump performance in simulated matches of well-trained amateur handball players. *Journal of Coaching and Sports Science, 5*(1), 29-40. https://doi.org/10.58524/jcss.v5i1.869

INTRODUCTION

Handball is an intermittent activity that alternates between low-intensity walking and high-intensity acceleration and multidirectional movement, both offensive and defensive (Michalsik, 2018). Heart rate intensity in most games averaged 80%–85% MHR or higher (Karcher & Buchheit, 2014; Póvoas et al., 2012; Ziv & Lidor, 2011). However, the intensity of the game primarily occurred during certain phases, such as running and defensive play (Manchado et al., 2021; Póvoas et al., 2012), or in certain player positions, particularly wingers, who moved at higher speeds than other positions (Karcher & Buchheit, 2014). Players, therefore, needed to possess high levels of physical fitness, including the ability to exert high-intensity effort, sprint, and produce muscular power for shooting, jumping, and changing direction, as well as clashing with opponents (Michalsik, 2018), which resulted in accumulated fatigue as time passed during the competition.

Performance declined progressively during each phase of competition, particularly towards the end of the game (García-Sánchez et al., 2023; Michalsik, 2018; Dastjerdi et al., 2025) due to the accumulation of relatively high levels of competition fatigue, which resulted in a corresponding decrease in skill accuracy (Ziv & Lidor, 2011). In the context of late-game competition, players experienced relatively high levels of accumulated fatigue. A

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disadvantageous situation could further negatively impact performance (Prieto et al., 2015). These situations directly impacted athletes' performance due to the increased time pressure (Kostrna, 2022). Past studies demonstrated the effects of fatigue on physical performance late in a match (Aquino et al., 2022; Michalsik, 2018). Athletes experienced higher fatigue levels, and physical factors such as muscle power, RFD, and other key performance indicators were affected, along with mental fatigue (Behrens et al., 2023). In particular, mental fatigue, exacerbated by reduced time, led to decreased motivation and a lack of enthusiasm (Russell et al., 2019). Such factors led to declines in athletes' physical performance and in tactical effectiveness (Thorlund et al., 2007; Martins et al., 2024). This also increased the likelihood of errors during crucial moments of the match (Vázquez-Diz et al., 2019), potentially influencing the match outcome.

Although several previous studies had documented a decrease in performance towards the end of a match, combined with player disadvantage and reduced time pressure towards the end of the game, however, if athletes were provided with a short rest period after intense or explosive competition, it might have improved their physical performance (Boullosa et al., 2013; Chen et al., 2023; Ciocca et al., 2021; Li et al., 2024). These approaches might have helped coaches integrate these results into their competitive tactics, taking into account the relationship between these time periods and their use (Prieto et al., 2015; Prieto, et al., 2015). By applying these results to reduce the disadvantageous player situations and limited remaining competition time towards the end of the game, players could perform as close to their optimal performance as possible. This was examined through jumping performance, which was considered an essential physical performance indicator for evaluating competition fatigue (Claudino et al., 2017; Martins et al., 2024) and a key movement pattern in handball players.

Previous studies had shown that fatigue significantly affected physical performance, leading to a decrease in athletic performance. However, in the context of well-trained amateur handball players, it remained unclear whether adequate rest periods would reduce physical performance. Therefore, this study focused on the effects of time pressure and player disadvantage on jumping performance in well-trained amateur handball players. This study aimed to examine jumping performance, a key performance assessment variable that could inform and develop coaches' tactics.

METHOD

Research Design

This research uses a within-subjects crossover design, with the same sample group participating in the test under both advantageous and disadvantageous conditions, to compare participants' performance in each condition within the same individual. This study was approved by the Human Research Ethics Committee of Sirindhorn College of Public Health, Yala Province (Approval No. SCPHYLIRB-2568/291). It was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Participant

The participants consisted of 28 well-trained amateur handball players selected through a purposive sample (14 males and 14 females: age 20.00 ± 0.86 years, height 169.68 ± 9.56 cm, weight 65.32 ± 11.18 kg, experience 4.79 ± 2.63 years, and VO2max from YoYo-IR1 40.89 ± 7.67 ml/kg/min) as shown in Table 1.

Table 1. Descriptive Characteristics of Participants (N=28)

Physical Characteristics	Mean ± SD
Age (yr)	20.00 ± 0.86
Height (cm)	169.68 ± 9.56
Weight (kg)	65.32 ± 11.18
Experience (yr)	4.79 ± 2.63
VO2max (YoYo-IR1) (mi/kg/min)	40.89 ± 7.67

The inclusion criteria are that all participants must have trained regularly at least 3 times per week for three consecutive months and have no history of serious injuries to muscles, tendons, or bones in the past 2 years. Data collection comprised three main parts: baseline assessment, competition simulation, and post-competition physical fitness measurement. In the first phase, the subjects were measured for weight, height, body mass index (BMI), and maximum oxygen consumption (VO2max) test results. The competition was divided into teams of seven men and seven women, with each team's participation determined by the results of the Yo-Yo Intermittent Recovery Level 1 (Yo-Yo IR1) test, and a paired grouping method was used to determine the competing teams.

Instrument

Jump Performance Test

The jump test used a free-arm counter movement jump. The test was conducted using the Opto Jump Next (Microgate, Italy), which measured jump variables using an optical measurement system. This device has high levels of validity and reliability (Comyns et al., 2023). The participant performed two jumps, and the average value was calculated to reduce the error in the test results. The Countermovement Jump test was administered 4–8 minutes after the competition to ensure that the athletes were still in a state of fatigue from the match, but not too soon or too late after the competition. The outcome variables included the height jump (HJ), rate of force development (RFD), and Power (PW).

Procedures

Protocols

The experiment was conducted using a YoYo-IR1 score and a matching-groups design to ensure similar physical ability levels. The participants were divided into two teams (two male and two female teams). In total, the experiment consisted of four simulated matches: two male and two female. Each participant was assigned to both conditions (advantage/disadvantage). The experiment began at the same time each day, simulating indoor competitions to avoid the variability of outdoor weather conditions.

A handball match simulation was conducted under international rules, consisting of two 30-minute halves with seven players per side. In this experiment, a specific time-pressure situation was established at the end of the match, with one team down by 1 point. The team with fewer players was placed behind by one point in the final five minutes to simulate the pressure of competition under these circumstances. Both teams were provided with coaches to offer encouragement and direction from the sidelines. Players randomly excluded from the match were selected using a simple random-number generator for each game.

Data from goalkeepers and players who were excluded late in the match were not analyzed. Throughout the game, all athletes wore Polar H10 heart rate monitors (Polar Electro Oy, Kempele, Finland) to measure their average heart rate (HR). After the match, athletes rested for 4–8 minutes before having their jumps measured with an Opto jump Next (Microgate, Italy) to assess their performance under match conditions.

Analysis Plan

Statistical Analysis

Data analysis was presented with mean and standard deviation. The data obtained from the measurements were analyzed using nonparametric statistics because the sample size and data distribution were not normally distributed. To compare within-group values (before and after the competition), the Wilcoxon Signed-Rank Test was used for HJ, RFD, and PW. To compare the groups (teams with advantages and disadvantages in player numbers), the Mann–Whitney U Test was used to compare post-competition values of HJ, RFD, PW, and HR.

Scope and/or Limitations

This study aimed to analyze the effects of time pressure and player disadvantage on the jumping performance of well-trained amateur handball players in a simulated competition setting. The results of this study were limited to a group of amateur athletes engaged in continuous training and may not have been generalizable to professional or youth athletes. This study measured only jumping performance and heart rate, without accounting for other physical or psychological factors. Future research should have increased the sample size, expanded the set of performance variables, and been conducted in a realistic competition setting to enhance the validity and generalizability of the study's results.

RESULTS AND DISCUSSION

Results

This study presented descriptive statistics, including the mean and standard deviation, for data from an experiment involving 28 well-trained amateur handball players. The Mann–Whitney U-Test (Table 2) was used to compare conditions between advantages and disadvantages, showing that after the competition, the height jump, rate of force development, power, and average heart rate of the players in the disadvantage team and the players in the advantage team showed no statistically significant differences in any variables ($p > 0.05$). The average height jump for the players in the disadvantage team was 36.32 ± 10.23 cm, and was 36.82 ± 10.44 cm for the advantage team. The rate of force development was 64.08 ± 18.75 N/kg/s for the disadvantage team and 66.18 ± 18.75 N/kg/s for the advantage team. The average power for the players in the disadvantage team was 60.80 ± 19.68 W/kg, and for the advantage team was 64.40 ± 20.07 W/kg. Their average heart rates were 88.37 ± 4.14% and 89.08 ± 4.24%, respectively. These results indicated that players' advantage or disadvantage in the game did not affect their post-game physical performance in terms of height jump, rate of force development, power, or average heart rate.

Table 2. Mann-Whitney U Test Statistical Analysis Results of the Counter Movement Jump Test and Average HR After the Match of the Advantaged and Disadvantaged Teams

Variable	Group	Mean ± SD	Mean Rank (Ctrl)	U-value	Z-value	p-value	Statistical Significance
Hight Jump (cm)	Disadvantage	36.32 ± 10.23	28.02	378.500	-0.221	0.825	No significant
	Advantage	36.82 ± 10.44	28.89				
Rate of Force Development (N/kg/s)	Disadvantage	64.08 ± 18.75	27.68	369.000	-0.377	0.706	No significant
	Advantage	66.18 ± 18.75	29.32				
Power (W/Kg)	Disadvantage	60.80 ± 19.68	27.14	354.000	-0.623	0.533	No significant
	Advantage	64.40 ± 20.07	29.86				
Average Heart rate (%)	Disadvantage	88.37 ± 4.14	18.58	161.500	-0.542	0.588	No significant
	Advantage	89.08 ± 4.24	20.53				

The results of the Wilcoxon Signed Ranks Test (Table 3) comparing before and after the competition of the countermovement jump test showed that after the competition, the players' height jump increased significantly compared to before the competition (p = 0.001), with the average jump height increasing from 34.82 ± 9.47 cm to 36.57 ± 10.25 cm. In addition, the Rate of Force Development (RFD) also increased significantly (p = 0.031) from 60.48 ± 20.09 N/kg/s to 65.13 ± 19.54 N/kg/s, as well as the power, which increased significantly (p = 0.012) from 58.23 ± 17.13 W/kg to 62.60 ± 19.78 W/kg. Figure 1 shows the differences in jumping variables pre- and post-competition. These results indicated that all variables of the athletes' jumping performance increased after the competition.

Table 3. Wilcoxon Signed Ranks Test Analysis Results of the Countermovement Jump Test Pre- and Post-Competition

Variable	Mean ± SD (Pre)	Mean ± SD (Post)	Z-value	p-value	Statistical Significance
Hight Jump (cm)	34.82 ± 9.47	36.57 ± 10.25	-3.901	*0.001**	Significant
Rate of Force Development (N/kg/s)	60.48 ± 20.09	65.13 ± 19.54	-2.162	*0.031**	Significant
Power (W/Kg)	58.23 ± 17.13	62.60 ± 19.78	-2.516	*0.012**	Significant

*P<0.05

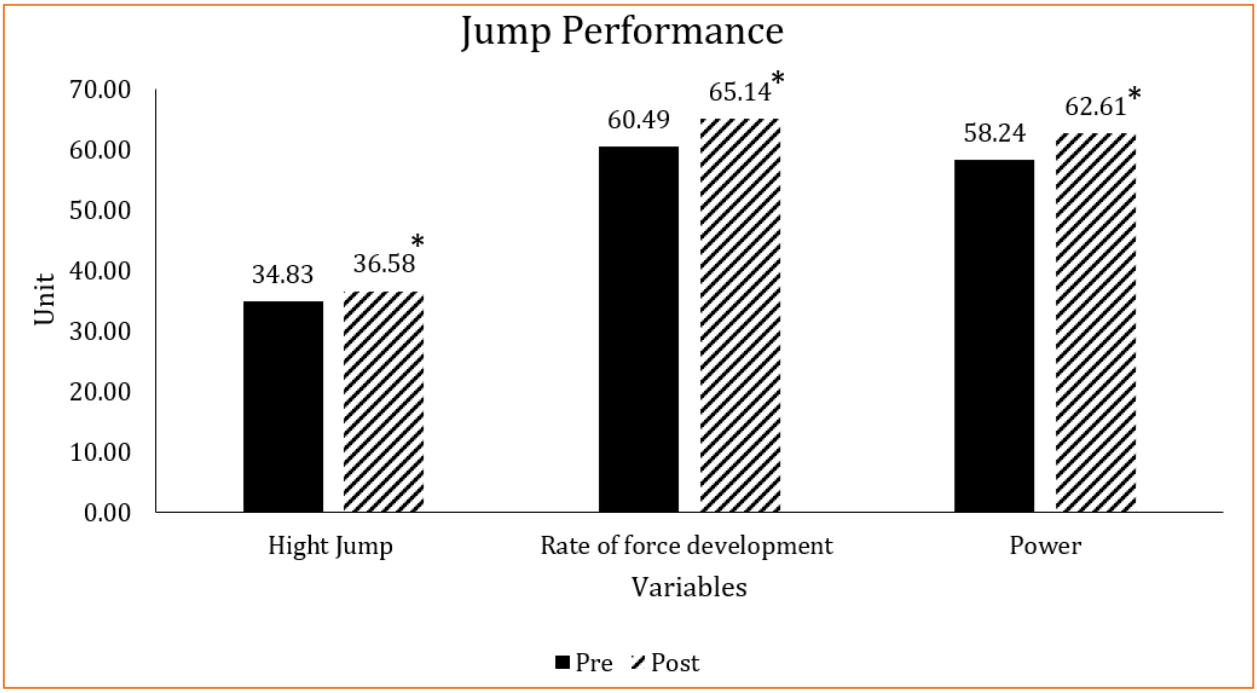

Figure 1. Jump Performance Before and After a Simulated Handball Match
*P<0.05

Discussion

Implications

The study results showed that the jump performance and heart rate of players in the advantage team tended to be slightly higher than those in the disadvantage team, but the performance difference was not significant. These results suggested a trend toward tactical advantages affecting physical performance, as reflected in the player advantage in the game (Prieto et al., 2015). In a competitive context, players in the advantage team tended to experience less physical and mental fatigue than players in the disadvantage team, even though both teams' performance levels decreased towards the end of the game (Teoldo et al., 2024). Players in the advantage team tended to focus on attacking play to create more scoring opportunities (Ferrari et al., 2022; Manchado et al., 2021) to gain an advantage in such situations. This was evidenced by their significantly higher average heart rate than players in the disadvantaged team, despite having a greater player advantage. In a competitive context, they may have perceived their opponents' disadvantages. This gave them a more controlled advantage and allowed them to focus more on the competition and have a better chance of success in many dimensions (Kostrna, 2022; Prieto et al., 2015).

Conversely, a player with a disadvantaged team, with fewer players and limited time remaining, is at a disadvantage in all aspects of the game and under increased pressure. In transition games, notably the transition from defense to offense, which required relatively high physical demands (Manchado et al., 2021), players were also forced to live in conditions with fewer players, resulting in higher physical demands (Michalsik, 2018). These factors may have contributed to a potential disadvantage in terms of physical performance, although they were not statistically different. Excessive pressure and competitive context could have led to confusion and anxiety, affecting perception (Eysenck et al., 2007) and potentially requiring longer decision-making times in real-time competitive situations (Lenzen et al., 2009; Weinberg et al., 2025).

Furthermore, mental fatigue might have occurred more frequently in players with a disadvantaged team (Ponce-Bordón et al., 2022), potentially impairing technical

performance, movement quality, reaction time, and decision-making quality (Russell et al., 2019; Wu et al., 2024) if they had not previously trained, particularly in the context of non-professional athletes and those of different genders (Kostrna, 2022; Vázquez-Diz et al., 2019). However, these effects might have differed for professional athletes, who were better able to handle various situations (Nicolosi et al., 2023) due to their higher physical and mental abilities than amateur athletes. This suggested that differences in game context significantly impacted game style, performance, and tactics, both physically and mentally (Ferrari et al., 2019). Coaches were therefore adapting game styles to mitigate competitive disadvantages and ensured athletes' physical and mental performance was at a competitive level in all situations through training planning and tactics.

In terms of physical performance, players' jumping performance increased on average after 4–8 minutes of competition across all variables, including player-team disadvantage and player-team advantage. This might have been consistent with the Post-Activation Performance Enhancement (PAPE) theory, which describes an increase in physical performance following high-intensity competition (Chen et al., 2023; Ciocca et al., 2021). This might have been consistent with the context of handball, which was an intermittent sport characterized by short periods of high energy expenditure (García-Sánchez et al., 2023; Póvoas et al., 2012). Furthermore, when players had approximately 4–8 minutes of rest after the competition before the jump test, a transient PAPE mechanism might have been induced, resulting in a positive effect on jump performance (De Souza et al., 2012; Li et al., 2024; Sun & Yang, 2023). It was possible that competition fatigue might not have been as high due to the intermittent intensity throughout the game, allowing for a short recovery period. This mechanism was induced after a short period of competition, consistent with the explanation for improved muscular explosive power after submaximal stimulation (Gervasi et al., 2018). However, further in-depth studies were needed to elucidate these effects in practice.

Furthermore, an additional contributing factor was that, despite the high heart rate intensity of both disadvantaged and advantaged players, the discontinuous movement resulted in relatively little accumulated fatigue and might not have been sufficient to impair performance (Claudino et al., 2017). Therefore, negative changes in performance might not have occurred (Aldhabi et al., 2024). However, this study differed from Martins et al. (2024), which found a decrease in physical performance in youth players 24 hours after competition. A key difference from previous studies was that this study was conducted in a sample of players who had been training regularly. Although not a professional athlete, physical performance might have been at a relatively good level (Hermassi et al., 2019). In the current study, testing was performed immediately after the competition without a 24-hour rest, which might have triggered an inflammatory response and led in physical fatigue lasting up to 24 hours (Chatzinikolaou et al., 2014). The increase in performance occurred in PAPE within only 4–16 minutes (Ciocca et al., 2021). The results of the two studies might therefore have been different.

Research contribution

This study added context to the specific competitive-situation simulation (Prieto et al., 2015) by introducing Time Pressure and Player Disadvantage conditions into the game to examine their effects. The results clearly showed that there was no difference between the player-advantage and player-disadvantage teams after the match. However, there was a trend towards positive jumping performance for the player advantage team after the match. These results demonstrated that being in a disadvantageous situation could have significantly impacted physical performance. The player advantage team should have made the most of this opportunity, and the player disadvantage team should have been able to

cope with such situations. Furthermore, not only physical jumping performance, but also other aspects of physical performance, including psychological performance, might have been affected. Future studies should have explored these details in more depth.

After the competition simulation, jumping performance was significantly higher than before. These results had been discussed in experimental studies of the PAPE mechanism (Boullosa et al., 2013; Chen et al., 2023; Ciocca et al., 2021; Li et al., 2024). However, in the context of competition simulation, there had been little research on this issue, as it was often focused on non-intermittent sports. This study, therefore, attempted to demonstrate the different results in terms of application in competition. Furthermore, the results not only showed an increase in post-match performance within the 4–8 minute period, but also demonstrated that coaches could have enhanced tactics to minimize disadvantages during various stages of the match, reducing physical and mental fatigue and preventing tactically prolonged play through the coach's Team Timeout (TTO) tactic, which was considered an effective strategy in handball (Jetzke & Winter, 2022). Reducing physical performance fatigue and resting to allow the PAPE mechanism to function positively impacted athletic performance, particularly in explosive power sports (Kasicki et al., 2024; Villalon-Gasch et al., 2022). This study aimed not only to describe results indicating improvement or deterioration after the match, but also to analyze them and apply them to practice.

Limitations

Although the intensity of the simulated competition was controlled to resemble a real one, it could not have perfectly replicated the psychological and environmental factors of a real competition, such as spectator pressure or the competition's importance. This study had several limitations, including: the inclusion of scores based on competition conditions, which were not considered; the measurement of multiple physical performance variables such as speed and player load in the game; the examination of specific skill variables and psychological variables that were not measured in this study; and the examination of time periods in conjunction with assessments of player fatigue in different situations. Furthermore, the crossover design might have influenced participants' learning or adaptation during the test, even after controlling for these effects. To obtain comprehensive data, a larger sample size, more official matches, or more games might have facilitated interpretation.

Suggestions

This study only examined the effects of time pressure and player disadvantage on jumping performance in well-trained amateur handball players. General interpretations might not have been comprehensive for all levels of players and might have measured only jumping performance and heart rate. Applications should have been incorporated into training to develop competitive tactics to prevent athlete performance from degrading under time pressure and player disadvantage in competition, or to develop winning playing styles in situations where the player had an advantage. Further in-depth research was needed to increase data diversity.

CONCLUSION

This study demonstrated that either Player Advantage or Player Disadvantage influenced athletes' jumping performance. Although the results were not statistically significant, a positive trend was observed for the Player Advantage Team, which showed slightly higher jumping performance and heart rate, reflecting a tactical advantage and reduced fatigue compared to the Disadvantage Team. On the other hand, the Player Disadvantage Team faced greater pressure due to disadvantageous conditions, which may

have affected movement efficiency and technical quality. Furthermore, the increased jumping performance after a 4–8-minute break was consistent with the Post Activation Performance Enhancement (PAPE) mechanism, which describes the increase in performance after a short period of high-intensity activity, a characteristic of handball, which features intermittent rest periods between plays and high energy expenditure. However, the results should have been interpreted with practical applications for coaches, such as planning rest tactics or Team Timeout (TTO) to reduce fatigue in athletes and enable them to maintain physical performance during competition. Therefore, this research highlighted the importance of understanding the context of time pressure and Player Disadvantage in affecting athlete performance, both physical, mental, and tactical, which could have been used to design strategic training to prepare for real competition situations, and further studies were recommended to expand the results to other variables related to sports performance more comprehensively.

ACKNOWLEDGMENT

This research was supported by funding from Thailand National Sports University. The authors would also like to thank Srinakharinwirot University for providing laboratory facilities and academic support throughout the study.

AUTHOR CONTRIBUTION STATEMENT

Contributions to the research work: TP, WK, and KK drafted the manuscript and designed the research; TP and KK collected data; WK analyzed the data; TP and WK wrote the discussion. All authors approved the manuscript.

AI DISCLOSURE STATEMENT

The author used QuillBolt during the preparation of this work for correct grammar. After using the tool/service, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the publication's content.

CONFLICT OF INTEREST

The authors declared that they had no conflicts of interest related to the conduct, analysis, or publication of this study.

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