

Original Research

Factors Associated with Injuries and Gender Differences in Japanese Adolescent Athletes Returning to Sports Following the COVID-19 Restriction

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Submitted: 14 March 2022 Revised: 18 April 2022 Accepted: 5 May 2022 Published: 12 August 2022

Abstract

Background: Because the worldwide spread of coronavirus disease 2019 has forced a moratorium on student sports activity in Japan, reports on its impact on sports injuries are limited given its novelty. This study aimed to determine the characteristics and gender differences of injuries in adolescent athletes after returning to sport following restriction of club activities due to the coronavirus pandemic. **Methods:** An online retrospective questionnaire was distributed to 500 adolescent athletes who belong to school sports clubs in Japan from March 1–19, 2021. An anonymous questionnaire was created before and after the restriction of sports activities following the declaration of the first state of emergency of the COVID-19 pandemic in Japan. Subsequently, 258 valid responses were obtained, and injury-related characteristics were compared between injured and non-injured athletes after returning to sports and between genders for injured athletes. There were no differences in the body areas of sports injuries between males and females. **Result:** We found that injury experience before club activity restriction was significantly associated with injury after returning to sports ($p < 0.001$). Moreover, practice time increased before and after the restriction in the injury group ($p = 0.038$). The injury rate was higher in females ($p < 0.024$), and the trauma rate was higher among males ($p = 0.016$). There were no differences in the body areas of sports injuries between males and females. **Conclusions:** Our results provide gender-differentiated ideas and suggestions as they relate to injury prevention once in adolescent athletes returning to sports after the coronavirus disease 2019 induced restriction of club activities. We show the need for injury rehabilitation and practice time control in adolescent athletes in the coronavirus disease 2019 setting.

Keywords: coronavirus pandemic; COVID-19 restrictions; sports injuries; adolescent athletes; returning to sports; injury experience; training time; gender difference; Japan

1. Introduction

The coronavirus disease 2019 (COVID-19) has spread worldwide since it was first reported in December 2019 [1]. In Japan, the first nationwide declaration of a state of emergency in response to the COVID-19 pandemic was issued on April 16, 2020 [2]. The Ministry of Education, Culture, Sports, Science, and Technology instituted a blanket closure of many schools, including high schools [3], and many universities switched to online classes. As a result, club activities were restricted, causing many adolescent athletes to face unexpected restrictions on their sports activities. Athletes were subjected to fairly severe restrictions that prohibited athletes from meeting at school as a club activity, and all sporting events such as games and competitions were canceled. For athletes, this prolonged absence of competition-related specific loading negatively affects the neuromuscular system, which may expose them to a higher risk of injury and reduced performance after returning to sport [4].

Short-or long-term interruptions of athletic training have been reported to cause changes in body composition

and cardiovascular efficiency, resulting in an increased risk of injury [5]. These dysfunctions may also be caused by the restricted sports activities due to the COVID-19 lockdown. Notably, unlike the typical off-season period, return to sports after COVID-19 lockdown has been shown to have a significant impact on injury rates by increasing the ratio of acute versus chronic workload due to physiological and psychological constraints associated with sports activity restriction [4,6]. A study conducted before and during the COVID-19 restrictions reported that students significantly reduced the intensity and frequency of individual practice due to the loss of goals caused by the cancellation of the competition, resulting in a significant reduction in the incidence of their injuries during the restriction [7]. Chronic injuries caused by overuse are more common than acute injuries among young athletes [8], especially in student sports, soft tissue injuries may be induced if practice time is not properly managed after the restriction of club activities [6]. According to Andersen *et al.*'s [9] stress-sport injury model, stressor history, individual characteristics, and coping resources, such as past injuries and life



stresses, influence the stress response, leading to sports injuries. Additionally, because the psychological stress levels of the COVID-19 lockdown differ between males and females, the mode of injury that occurs after returning to sports may also vary [10]. Particularly in student sports, soft tissue injury may be induced if the practice time after the restriction of club activities cannot be appropriately managed [6]. Therefore, it is necessary to understand the characteristics of injury occurrence in adolescent athletes when returning to sports after the restriction due to COVID-19 to better understand and provide information for the prevention of future sports injuries. However, knowledge of sports restrictions and injury occurrence after return to sports due to newly emerging epidemic infectious diseases is quite limited.

The purpose of this study was to identify the factors that lead to injury in adolescent athletes after returning to sports restricted by the COVID-19 epidemic and to investigate gender differences.

2. Materials and Methods

2.1 Design and Participants

An anonymous online survey was conducted retrospectively from March 1–19, 2021, via Google Forms (Alphabet, Mountain View, CA, USA). The target participants were Japanese high school and university athletes from sports clubs. The recruitment method for targeted athletes is shown in Fig. 1. Athletes were recruited by the supervisors of the sports clubs. An email with a link to the survey was sent to the supervisors, who then distributed it to athletes. Finally, questionnaires were distributed to a total of 500 athletes: 300 high school students (male: 170, female: 130) and 200 college students (male: 100, female: 100). The athletes were informed on the first page of the questionnaire that it would be anonymous, and multiple responses were not allowed. The inclusion criteria for participants were (a) 16–22 years old, (b) enrolled in high school or university, (c) living in Japan during the COVID-19 pandemic, and (d) providing informed consent. Informed consent was obtained via a consent statement and a checkbox on the second page of the online questionnaire. Participants were excluded if they (a) had not continued sports activities for more than a year and (b) did not play the same sport before and after the declaration of the first wave of emergency due to COVID-19.

This study was conducted in accordance with the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [11].

2.2 Questionnaire Contents

The questionnaire was designed for the periods before and after the restriction of sports activities associated with the declaration of the first state of emergency of the COVID-19 pandemic in Japan. Our online survey form included the following sociodemographic information: age,

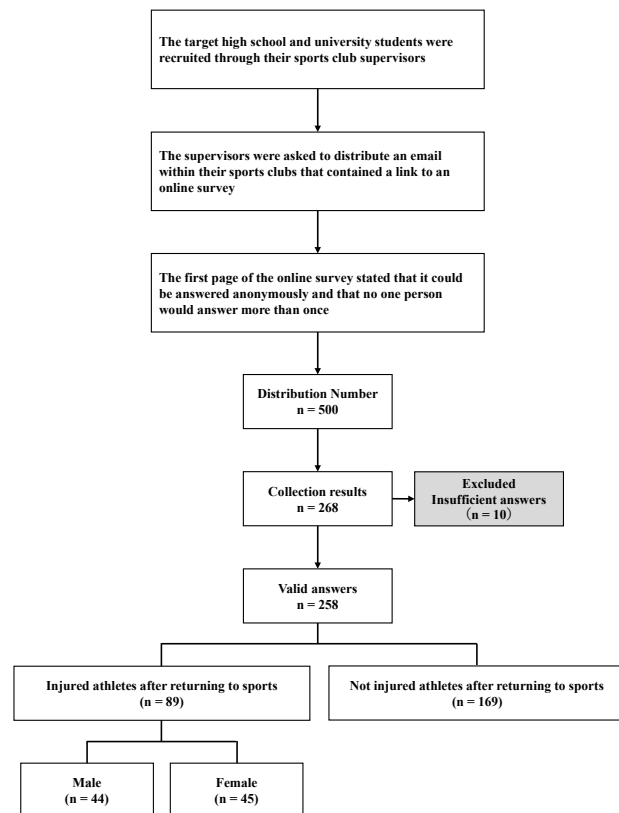


Fig. 1. Flowchart of the target recruitment method and analysis procedure.

gender (male/female), height, weight, and body mass index.

The following items were also included: injury experience within the year before the sports restriction, practice time on weekdays and holidays before and after the sports restriction, sports restriction duration at their sports clubs, self-training during sports restrictions, and injury reports after returning to sports from the restriction. The practice time on weekdays and holidays before and after the shutdown were scored on a 0–10 scale as follows: 0 (0.0–0.5 hours), 1 (0.5–1.0 hours), 2 (1.0–1.5 hours), 3 (1.5–2.0 hours), 4 (2.0–2.5 hours), 5 (2.5–3.0 hours), 6 (3.0–3.5 hours), 7 (3.5–4.0 hours), 8 (4.0–4.5 hours), 9 (4.5–5.0 hours), and 10 (more than 5.0 hours). For the sports restriction duration, we asked respondents to indicate the days on which the activities of their sports clubs were suspended due to the COVID-19 pandemic and the days they resumed and calculated the difference between the two days. Additionally, the respondents answered whether they performed self-training during the shutdown. The injury report consisted of the following six items: mode of onset for injuries (acute trauma and overuse injury), 4 regions (head and neck, upper limb, trunk, and lower limb) with 18 body areas for injuries (head, neck, shoulder, elbow, forearm, wrist, hand, chest, thoracic spine, lumbosacral, abdomen, hip or groin, thigh, knee, lower leg, ankle, and foot) [12], situation of injury (sports, physical education class of school, and other),

hospital visit (Yes or No), the severity of the injury (number of days of restraint from the sport; 0 days, 1–7 days, 8–28 days, more than 28 days) [13], and re-injury in the same body area (Yes or No). These were based on the International Olympic Committee Consensus Statement in epidemiological reports of sports injuries [9]. The definition of injury is based on musculoskeletal pain plus one or more of the following three criteria: (a) complete absence from sports and daily outdoor activities for more than one week; (b) altered duration or intensity of normal training; (c) physical infirmity that requires a visit to a medical professional [14].

2.3 Statistical Analysis

The analysis was conducted in two phases. First, the characteristics of the groups of those injured after returning to sports from restrictions owing to the COVID-19 pandemic and those who were not were compared. The Shapiro-Wilk test was used to ensure normality. The demographics of injured and non-injured players after sports restriction were compared using the chi-square test and Mann-Whitney U-test. Logistic regression analysis was performed to examine the factors that affected athletes injured after returning to sports. The backward stepwise method (Wald) was applied to simplify the model by omitting variables with $p > 0.05$. Odds ratios (ORs) and 95% confidence intervals (CIs) were also calculated for the dependent variable. Variance inflation coefficients were estimated to assess the possibility of multicollinearity of the independent variables in the multivariate regression analysis. In the next phase, gender differences in injury reports were compared.

Prior studies have recommended that the number of subjects per variable should be ten or more [15]. The study sample size of the logistic regression analysis was decided a priori with five independent parameters, suggesting that a tenfold increase in the number of subjects in the study was necessary. Thus, it was essential to obtain a sample of at least 50 subjects in each group (injured and non-injured athletes after returning to sports following the COVID-19 restriction). Data were analyzed using IBM SPSS Statistics for Mac OS X (version 27.0; IBM Corp., Armonk, NY, USA). The significance level was set at $p < 0.05$.

3. Results

A total of 268 responses were received, and ten were excluded as inappropriate responses due to missing information. Finally, 258 were accepted as valid responses and included in the analysis. The comparison of athletes injured after returning to sports following COVID-19 restrictions and those who were not are shown in Table 1. There was a significant gender difference ($p = 0.024$) in the percentage of injured athletes (55.1% male and 44.9% female) and non-injured athletes (69.2% male and 30.8% female). Most (71.0%) non-injured athletes after returning to sports

had no history of injury before the sports restrictions by the COVID-19 pandemic, while most (85.4%) athletes injured after returning to sports had injury experiences before the sports restrictions ($p < 0.001$). Regarding the practice time on weekdays, the group of injured athletes practiced significantly longer than non-injured athletes ($p = 0.002$). Additionally, more injured athletes reported an increase in weekday practice time from before to after sports restriction than the non-injured athletes (31.5% vs. 18.3%, $p = 0.038$). Regarding practice time during holidays, the injured athlete group practiced significantly longer than the non-injured athlete group, both before and after sports restriction ($p = 0.038$ and $p < 0.001$, respectively).

Multiple logistic analysis was conducted to explore the factors leading to injury after returning to sports due to restrictions caused by COVID-19 (Table 2). Experience of injury before sports restriction was significantly associated with the presence of injury after sports restriction ($\beta = -2.625$, $p = 0.000$, OR = 0.072, 95% CI = 0.037–0.143). There were no significant associations between the other dependent variables.

We compared gender differences in injury reports among the group of injured athletes after sports restriction (Table 3). Overall, the proportion of patients with acute trauma was high (67.4%), with the ankle (24.7%), knee (13.5%), and thigh (10.1%) being the most common body areas of injury. Sports-related injuries frequently occurred (72.0%); however, the percentage of athletes who visited the hospital was low at 19.1%. Males were found to have a significantly higher rate of acute trauma than females after returning to sports from COVID-19 restriction (79.5% vs. 55.6%, $p = 0.016$). No statistically significant gender differences were found in body areas for injuries, the situation of the injury, hospital visits, severity (number of days of sports restriction), and re-injury in the same body area. There were no gender differences in weekday and holiday practice time both before and after sports restrictions.

4. Discussion

The COVID-19 pandemic has limited the professionals' and students' sports activities. This study focused on the factors of adolescent athletes' injuries from restricted sports activities since the first emergency declaration in Japan on adolescent athletes. Experience of injury before sports restriction was a risk factor for injury after returning to sports. In the group injured after returning to sports, the practice time increased after sports restriction compared to before restriction. Male athletes were more likely to experience acute trauma than female athletes. This is the first sports injury study on adolescent athletes before and after the restriction of club activities following the COVID-19 pandemic. Investigating the impact of epidemics of infectious diseases on the sports industry can assist in developing injury prevention strategies for adolescent athletes returning from restricted club activities.

Table 1. Comparison of injured and non-injured athletes after returning to sports following the COVID-19 restrictions.

	Injured athletes	Not injured athletes	p value
	(n = 89)	(n = 169)	
Age (y)	17.6 ± 1.9	17.9 ± 2.0	0.432
Gender			0.024 [†]
Male	49 (55.1)	117 (69.2)	
Female	40 (44.9)	52 (30.8)	
Height (cm)	166.9 ± 8.5	167.8 ± 7.5	0.352
Weight (kg)	60.9 ± 11.2	60.3 ± 8.2	0.808
Body mass Index	21.7 ± 2.2	21.3 ± 2.0	0.223
Injury experience before sports restriction			0.000 [†]
Not injured	13 (14.6)	120 (71.0)	
Injured	76 (85.4)	49 (29.0)	
Sports restriction duration	60.0 ± 31.6	74.6 ± 55.5	0.271
Self-training during sports restriction			0.129
Yes	9 (10.1)	29 (17.2)	
No	80 (89.9)	140 (82.8)	
Weekday practice time			
Before sports restriction	4.0 [3.0–5.0]	4.0 [3.0–5.0]	0.106
After sports restriction	4.0 [3.0–5.0]	3.0 [3.0–4.0]	0.002*
Changes before and after sports restriction			0.038 [†]
Decreased from before sports restriction	19 (21.3)	34 (20.1)	
No change	42 (47.2)	104 (61.5)	
Increased from before sports restriction	28 (31.5)	31 (18.3)	
Holiday practice time			
Before sports restriction	5.0 [3.0–6.0]	4.0 [3.0–6.0]	0.038*
After sports restriction	5.0 [3.8–6.0]	4.0 [3.0–5.0]	0.000*
Changes before and after sports restriction			0.145
Decreased from before sports restriction	14 (15.7)	44 (26.0)	
No change	55 (61.8)	96 (56.8)	
Increased from before sports restriction	20 (22.5)	29 (17.2)	

Data are shown as mean ± SD, n (%), and medians [interquartile range]. [†] indicates the result of the chi-square test, and * indicates the result of the Mann-Whitney U-test.

Table 2. Multiple logistic analysis.

Variables	β	SE	Wald	df	p value	Odds ratio	95% CI	
							Lower	Upper
Gender	0.355	0.326	1.188	1	0.276	1.427	0.753	2.704
Injury experience before sports restriction	-2.625	0.346	57.455	1	0.000*	0.072	0.037	0.143
Weekday practice time after sports restriction	0.002	0.159	0.000	1	0.990	1.002	0.734	1.368
Holiday practice time before sports restriction	-0.037	0.086	0.191	1	0.662	0.963	0.814	1.139
Holiday practice time after sports restriction	0.122	0.119	1.038	1	0.308	1.129	0.894	1.427

Wald: A backward stepwise methods. *: $p < 0.05$.

We found that the factor associated with injury after returning to sports from restricted club activities due to COVID-19 was injury experience before restriction. Madison *et al.* [16] showed that previous injury was positively correlated with injury rate, and inappropriate rehabilitation and inadequate recovery can be potent endogenous risk factors for re-injury after returning to sports [17]. The sudden suspension of club activities due to COVID-19 may have diverted the focus from injury rehabilitation and made it

difficult for athletes to return to sports after long-term activity restrictions. The environmental change caused by the COVID-19 pandemic may have negatively impacted students' mental health [18], interfering with their opportunity to focus on recovering from their injuries. The psychological aspects reported as risk factors for re-injury, including re-injury anxiety, confidence, and attention, may explain this [19]. Further, the increased practice time in club activities after the COVID-19 regulation may also have syner-

Table 3. Gender differences in injury reports.

	Overall (n = 89)	Male (n = 44)	Female (n = 45)	<i>p</i> value
Mode of onset for injuries				0.016 [†]
Acute trauma	60 (67.4)	35 (79.5)	25 (55.6)	
Overuse injury	29 (32.6)	9 (20.5)	20 (44.4)	
Body regions and areas for injuries				0.328
Head and Neck	3 (3.4)	1 (2.3)	2 (4.4)	
Head	0 (0.0)	0 (0.0)	0 (0.0)	
Neck	3 (3.4)	1 (2.3)	2 (4.4)	
Upper limb	22 (24.7)	13 (29.5)	9 (20.0)	
Shoulder	6 (6.7)	2 (4.5)	4 (8.9)	
Upper arm	1 (1.1)	1 (2.3)	0 (0.0)	
Elbow	4 (4.5)	4 (9.1)	0 (0.0)	
Forearm	0 (0.0)	0 (0.0)	0 (0.0)	
Wrist	4 (4.5)	3 (6.8)	1 (2.2)	
Hand	7 (7.9)	3 (6.8)	4 (8.9)	
Trunk	11 (12.4)	3 (6.8)	8 (17.8)	
Chest	2 (2.3)	1 (2.3)	1 (2.2)	
Thoracic spine	1 (1.1)	0 (0.0)	1 (2.2)	
Lumbosacral	8 (9.0)	2 (4.5)	6 (13.3)	
Abdomen	0 (0.0)	0 (0.0)	0 (0.0)	
Lower limb	53 (59.6)	27 (61.4)	26 (57.8)	
Hip/groin	4 (4.5)	2 (4.5)	2 (4.4)	
Thigh	9 (10.1)	4 (9.1)	5 (11.1)	
Knee	12 (13.5)	8 (18.2)	4 (8.9)	
Lower leg	4 (4.5)	0 (0.0)	4 (8.9)	
Ankle	22 (24.7)	12 (27.3)	10 (22.2)	
Foot	2 (2.3)	1 (2.3)	1 (2.2)	
Situation of injury				0.148
Sports	64 (72.0)	35 (79.5)	29 (64.4)	
Physical education class of school	15 (16.9)	4 (9.1)	11 (24.4)	
Other	10 (11.1)	5 (11.4)	5 (11.1)	
Visit a hospital				0.195
Yes	17 (19.1)	6 (13.6)	11 (24.4)	
No	72 (80.9)	38 (86.4)	34 (75.6)	
Severity (Number of days of time loss from sport)				0.195
0 days	30 (33.7)	10 (22.7)	20 (44.4)	
1–7 days	28 (31.5)	16 (36.4)	12 (26.7)	
8–28 days	24 (27.0)	14 (31.8)	10 (22.2)	
More than 28 days	7 (7.9)	4 (9.1)	3 (6.7)	
Re-injury in the same body area				0.564
Yes	33 (37.1)	15 (34.1)	18 (40.0)	
No	56 (62.9)	29 (65.9)	27 (60.0)	
Weekday practice time				
Before sports restriction		4.0 [3.0–5.0]	4.0 [3.0–5.0]	0.386
After sports restriction		4.0 [3.0–5.0]	4.0 [4.0–4.0]	0.619
Changes before and after sports restriction				0.697
Decreased from before sports restriction		8 (19.0)	8 (19.5)	
No change		22 (52.4)	18 (43.9)	
Increased from before sports restriction		12 (28.6)	15 (36.6)	
Holiday practice time				
Before sports restriction		5.0 [3.0–6.0]	5.0 [4.0–6.0]	0.799
After sports restriction		5.0 [3.0–6.0]	5.0 [4.0–6.0]	0.594
Changes before and after sports restriction				0.053
Decreased from before sports restriction		9 (21.4)	2 (4.9)	
No change		22 (52.4)	30 (73.2)	
Increased from before sports restriction		11 (26.2)	9 (22.0)	

Data are shown as n (%) or medians [interquartile range]. *p*-values represent comparisons between male and female respondents. †: *p* < 0.05.

gistically increased injury risk [20]. Future research should examine how mental health, such as anxiety and nervousness, affects re-injury when athletes with a history of injury return to sports.

Regarding gender differences, males had a higher incidence of injury and a higher proportion of acute trauma after returning to sports from restricted club activities than females (males: 79.5% acute trauma and 20.5% chronic disability; females: 55.6% acute trauma and 44.4% chronic disability). The results partially support a gender-specific sports injury investigation conducted before the COVID-19 pandemic [21]. A study of 1132 Italian athletes showed that males had lower perceived stress than females during the COVID-19 lockdown [10]. Another report of 759 competitive athletes showed that females were more anxious about returning to sports than males [22]. These findings suggest that males are less prone to negative emotions and less cautious about returning to sports than females after a prolonged rest following the COVID-19 pandemic; thus, the risk of traumatic injury is expected to be higher. To bridge the gendered distribution of injuries after returning to sports, efforts to provide for athletes' psychological and physical aspects during long-term rest may be necessary.

On the other hand, there was no significant difference in the body area of sports injuries by gender, and the most common injury was in the lower limb in both male and female. The results showed a similar trend to a previous study of 182 000 injuries among university students before the COVID-19 pandemic [20]. Hence, no need may be found to change the concept of the body area of sports injuries before and during sports restrictions due to COVID-19. What should be noted is that sports restriction due to COVID-19 reduces the training load and consequently the injury rate [7,23], which could not be investigated in this study. Future studies should investigate how sports injury rates in adolescent athletes change before and during the sports restriction.

Notably, re-injury in the same body area was 37.1% (overall). Athletes with a history of injury may be "high-risk athletes", meaning they may have a high risk of injury to any body parts. For example, returning to sports with inadequate rehabilitation or mental anxiety may cause other body areas to unconsciously protect the injured area, resulting in injury to a different body area. The low compliance with injury prevention programs for adolescent athletes is a problem [24]. Thus, coaches and trainers on the sports field need to pay attention to athletes' pre-existing body areas of injury and their subsequent injuries.

This study has several limitations. First, the survey was self-administered; therefore, a biased response is possible. Second, the survey was self-reported, and responses were obtained retrospectively, which may have led to recall bias. Third, we could not experimentally determine the exact duration or amount of practice. Finally, injury information diagnosed by a physician could not be obtained. Future prospective studies are needed to determine what injury

characteristics are present before and after long-term sports withdrawal.

5. Conclusions

A retrospective study was conducted focusing on restrictions on student sports activities among adolescent athletes following the declaration of the first state of emergency for the COVID-19 pandemic in Japan. The results of the study showed that the injured athlete group had increased weekday and holiday practice time after sports restriction, and injury experience before sports restriction due to the COVID-19 pandemic was associated with injury after returning to sports. Injury rates were higher among females, and males had more cases of acute trauma than females. These findings indicate that practice time and previous injury experience prior to club restriction are associated with the risk of injury after returning to sports after long-term club restriction due to COVID-19. Furthermore, we believe that the results, such as different types of injuries by gender, provide gender-specific ideas and suggestions related to injury prevention.

Author Contributions

YS, KF, and YU initiated the idea. NM, YS, KF, MK, and YU designed the research study. YS, KF, and RM performed the research. TT, ST, KF, and HI analyzed the data. NM, MK, and RM interpreted the data. TT, YS, and ST wrote the manuscript. TT, KF, and HI revised the manuscript. NM initiated the idea. NM, YS, KF, MK, and YU designed the research study. YS, KF, and RM performed the research. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

We followed the Declaration of Helsinki and obtained permission from the Epidemiology Ethics Review Committee of Hiroshima University (approval ID: E-2308).

Acknowledgment

We thank all the participants who participated in this study.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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