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Rodrigo Vitasovic Gomes

Ricardo Santos

Ken Nosaka
Edith Cowan University

Alexandre Moreira

Elen Miyabara

See next page for additional authors

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Authors

Rodrigo Vitasovic Gomes, Ricardo Santos, Ken Nosaka, Alexandre Moreira, Elen Miyabara, and Marcelo Saldanha Aoki

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MUSCLE DAMAGE AFTER A TENNIS MATCH IN YOUNG PLAYERS

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AUTHORS: Gomes R.V.[1], Santos R.C.O.[4], Nosaka K.[2], Moreira A.[1], Miyabara E.H.[3], Aoki M.S.[4]

[1] School of Physical Education and Sport, University of Sao Paulo, Sao Paulo, Brazil
[2] School of Exercise and Health Sciences, Edith Cowan University, Western Australia, Australia
[3] Department of Anatomy, Institute of Biomedical Sciences, University of Sao Paulo, Sao Paulo, Brazil
[4] School of Arts, Sciences and Humanities, University of Sao Paulo, Sao Paulo, Brazil

Reprint request to:
Marcelo S. Aoki
University of São Paulo
Av. Arlindo Bettio, 1000
Sao Paulo, Brazil - 03828000
Email: aoki.ms@usp.br

ABSTRACT: The present study investigated changes in indirect markers of muscle damage following a simulated tennis match play using nationally ranked young (17.6 ± 1.4 years) male tennis players. Ten young athletes played a 3-hour simulated match play on outdoor red clay courts following the International Tennis Federation rules. Muscle soreness, plasma creatine kinase activity (CK), serum myoglobin concentration (Mb), one repetition maximum (1RM) squat strength, and squat jump (SJ) and counter movement jump (CMJ) heights were assessed before, immediately after, and 24 and 48 h after the simulated match play. All parameters were also evaluated in a non-exercised group (control group). A small increase in the indirect markers of muscle damage (muscle soreness, CK and Mb) was detected at 24-48 hours post-match ($p<0.05$). A marked acute decrement in neuromuscular performance (1RM squat strength: -35.2 ± 10.4%, SJ: -7.0 ± 6.0%, CMJ: -10.0 ± 6.3%) was observed immediately post-match ($p<0.05$). At 24 h post-match, the 1RM strength and jump heights were not significantly different from the baseline values. However, several players showed a decrease of these measures at 24 h after the match play. The simulated tennis match play induced mild muscle damage in young players. Coaches could monitor changes in the indirect markers of muscle damage to assess athletes' recovery status during training and competition.

KEY WORDS: DOMS, creatine kinase, myoglobin, muscle soreness, strength

INTRODUCTION

Tennis attracts millions of players and fans worldwide. There are many tournaments during a year, providing many opportunities for young tennis players to compete in any given week of a year. For example, "Future Tournaments" are the entry-level professional tournaments, consisting of more than 400 events each year [13]. Most tournaments are played over a 7-day period and each player generally has a match play a day. Participation in numerous tournaments imposes significant challenges on young tennis players and their coaches, since it leads to a decrease in time available for training and recovery.

Tennis is characterised by quick starts and stops, several directional changes, repetitive overhead motions, and the involvement of several muscle groups during the different strokes, which alternate from brief periods of maximal intensity to longer periods of moderate and low intensity activities [6,18,19]. The duration of a tennis match play is often more than one hour and in some cases more than five hours [6,14,15], but actual playing time is ~20–40% of total match time on clay courts and ~20% on fast court surfaces [7,14]. A player runs an average of 3 m per stroke and 8–12 m for a point that is decided in an average of 2–3 strokes [6,14,15]. The number of directional changes in an average point is 4, and a rally lasts 5–7 seconds per point [6,7,14]. As a result of tennis match play demands, players are exposed to repetitive eccentric contractions.

Exercise-induced muscle damage is characterized by delayed onset muscle soreness [DOMS], increased muscle proteins (such as creatine kinase [CK] and myoglobin [Mb]) in the blood, and decreased muscle function, especially for untrained individuals [4]. A negative effect of exercise-induced muscle damage for tennis players is the reduction of the ability to generate force, which could impair performance during a match play. The progressive reduction in maximal force and the increase in muscle soreness have been previously observed throughout 3 hours of tennis match play [9].

However, skeletal muscle adapts rapidly to eccentric actions to attenuate muscle damage in the subsequent bouts of the same or similar exercise, known as the repeated bout effect [17,21]. Although many studies have investigated muscle damage and the repeated bout effect [17,21], no information is available concerning the effect of tennis match play on muscle damage in young tennis players.

Sports medicine practitioners, trainers, coaches and players need to understand the magnitude of muscle damage induced by a match play and the recovery period required by junior tennis players after a match.

The aim of the present study was to investigate the effect of a simulated 3-hour tennis match play on indirect markers of muscle damage using nationally ranked young male tennis players. Due to their highly trained nature, the authors hypothesized that the magnitude of muscle damage would be minor.

MATERIALS AND METHODS

Subjects. Ten young male tennis players (mean ± SD age, height and body mass: 17.6±1.4 y, 179.0±3.6 cm, 70.2±7.1 kg, respectively) were recruited from a tennis academy in Brazil to participate in the study and six recreational tennis players (mean ± SD age, height and body mass: 19.3 ± 1.3 y, 171.0 ± 5.2 cm, 68.4 ± 5.7 kg, respectively) were recruited to compose the control group. All players had a national junior ranking between 10th-45th, and had trained for 20-30 h per week in the last 5 years at least. The amateur tennis players were involved in at least two tennis practices per week (5 h per week) at least for one year. Members of the control group were instructed to avoid all exercise practice during the study. Written informed consent was obtained before their participation in the study, and the Institutional Human Ethics Committee approved the study (CAAE: 09860412.6.0000.5391). For participants under 18 years of age, a legal guardian provided parental permission for study participation. Players with any preexisting medical conditions that might put them at any risk of injury or influence the outcome measures were excluded from the study.

Experimental Approach to the Problem

To test the initial hypothesis, the dependent variables including muscle soreness, plasma CK activity, serum Mb concentration, one repetition maximum (1RM) squat strength, and squat jump (SJ) and counter movement jump (CMJ) height, were taken before, within 30 min after (immediately after), and 24 and 48 hours after the match. One day before the simulated tennis match play, all players had a controlled diet (isoenergetic diet: 3660 ± 435 kcal) prescribed by a sports dietician. On the match day, they received a carbohydrate solution (10%, 1 $g \cdot kg^{-1}$) 1 hour before the start of the match (8:00 a.m.). Before the match, players had a standardized warm-up for 5 min consisting of ground strokes, volleys, and serves. The simulated match was played on outdoor red clay courts, and the ambient temperature ranged between 23.0 and 25.5°C, and the relative humidity was 70-74% during the matches. The match followed the rules for official matches [13], and the tennis balls (Fort Clay Court Dunlop©, Philippines) were replaced with new balls every seven games of each match. The 3-hour match play was divided into three 1-hour matches, which were played against three different opponents. Officially qualified umpires kept the score. The players had a carbohydrate solution (500mL, 6%) each hour, and took water ad libitum. Match intensity was assessed using the rating of perceived exertion (RPE) scale (CR-10) at the end of each hour. Session RPE was also used as an indicator of exercise intensity.

Procedures

Ratings of Perceived Exertion (RPE)

Match intensity was assessed using the CR-10 RPE scale at the end of each hour. Session RPE was also used as a global indicator of exercise intensity. The session RPE assessment was conducted as previously described by Foster [8]. These data were collected 30 minutes after each match to ensure that the perceived exertion was based on the entire match rather than the last match effort. To assess the match intensity, the athletes were asked individually a simple question: “How was your workout?” and a chart was shown that outlined the full RPE scale with the appropriate explanations. The data were recorded by the same investigator on both occasions. The study group was familiarized with the use of the session RPE before the beginning of the experiment.

Muscle Soreness

Muscle soreness was assessed on the right side for extension of the vastus lateralis muscles. The visual analogue scale (VAS) was selected because it is commonly used in DOMS research [24]. The VAS, which has been shown to be valid and reliable in previous research [22], consists of a line 100 mm long, anchored at the left by the words “no pain” and at the right by the words “unbearable pain” [24]. The players were asked to mark the level of pain after the extension assessment. The players stood up and held a wall for balance, and stretched the quadriceps for 3 seconds, after which soreness was assessed.

Jumping Ability

After 10 min of jogging, three SJ and three CMJ were performed on a jumping mat connected to an electronic timer (Jump System Pro, Cefise©, Brazil). A 2-minute rest between attempts and a 3-minute interval between SJ and CMJ measures were employed. The highest jump height among the three attempts was used for further analysis described by Lara et al. [16]. The intra-class correlation coefficient (ICC) and the coefficient of variation (CV) values for the SJ and CMJ tests were 0.97 and 3.6%, and 0.95 and 4.3%, respectively.

1RM Squat

All subjects were tested for 1RM half-squat according to the NSCA guidelines [1] on four different occasions (pre-match, immediately post-match, 24 h, and 48 h), after warm-up exercise consisting of 10 reps with 40% 1RM, 5 reps with 70% 1RM and 2 reps with 85% 1RM. The intra-class correlation coefficient (ICC, R) and the coefficient of variation (CV) for this test were 0.96 and 3.8%, respectively.

Blood Samples and Analysis

Blood samples (a total of ~10 mL) were obtained from an antecu-

bital vein using 5-mL Vacutainer tubes (Becton Dickinson©, USA) – one containing EDTA for plasma and another for serum. The blood samples were centrifuged at 2500 rpm for 15 min at 4°C, and plasma and serum samples were stored at -80°C until analysis. Plasma CK activity was determined by a spectrophotometric assay using a test kit (CK, Labtest©, Brazil), and serum Mb concentration was assessed by an enzyme-linked immunosorbent assay using a test kit (Myoglobin, MP Biomedicals©, USA). The normal reference ranges were 25-140 $IU \cdot L^{-1}$ for CK and 12-100 $ng \cdot mL^{-1}$ for Mb according to the manufacturer's guidelines.

Statistical Analyses

A two-way analysis of variance (ANOVA) with repeated measures (moments: pre-, post-, 24 h and 48 h) was used to compare the changes in the selected variables between the experimental group and the control group (conditions). The Tukey HSD test was used as the post hoc procedure. Significance level was set at 0.05. The results are reported as mean ± SD.

RESULTS

RPE progressively increased across each hour of match play (1st hour: 3.2±1.4, 2nd hour: 4.4±1.6 and 3rd hour: 6.8±1.8) ($p<0.05$). The match session RPE was 6.0±1.9, but varied between 3 and 8 amongst the players (Table 1).

Figure 1A shows changes in VAS for the stretch assessment. Muscle soreness increased and peaked at 24 h post-match (18 mm) but subsided by 48 h when compared to the pre-match value ($p<0.05$). As shown in Table 1, some variability among players was evident, but none of the players indicated severe muscle soreness (e.g. >50 mm). A similar pattern was observed for the palpation assessment, and peak soreness (15 mm) occurred at 24 h post-match (data not shown). No significant change in muscle soreness was observed for the control group.

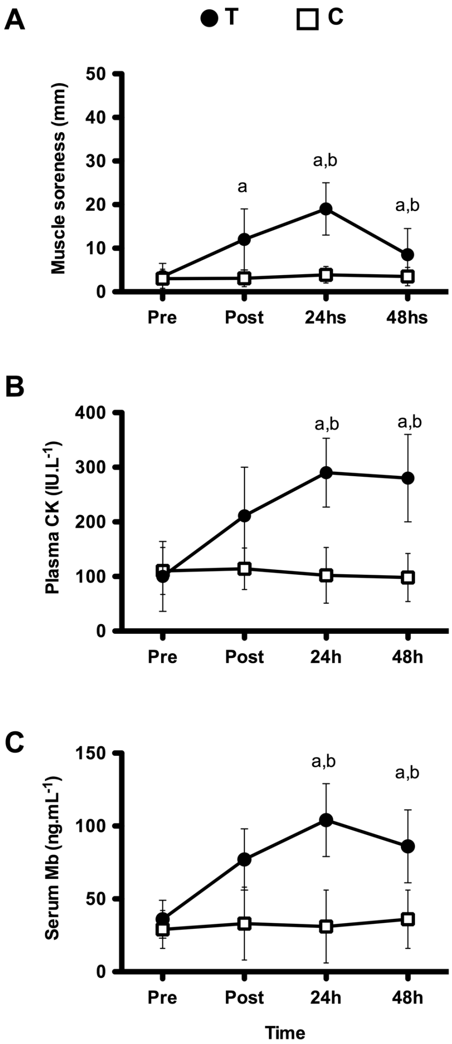

FIG. 1. CHANGES IN MUSCLE SORENESS ON VAS (A), PLASMA CK ACTIVITY (B) AND SERUM MYOGLOBIN CONCENTRATION (C) BEFORE (PRE), IMMEDIATELY AFTER (POST) AND 24 AND 48 H AFTER A SIMULATED TENNIS MATCH.

Note: a – indicates significant difference from the control group. b – indicates significant difference from the pre-match value. (●T) Tennis Players, (□C) Control Group.

TABLE 1. SESSION RPE (RPE), PEAK MUSCLE SORENESS (DOMS) UPON MUSCLE STRETCHING, PEAK PLASMA CREATINE KINASE ACTIVITY (CK) AND SERUM MYOGLOBIN CONCENTRATION (MB), AND RELATIVE CHANGES IN COUNTERMOVEMENT JUMP HEIGHT (CMJ), SQUAT JUMP HEIGHT (SJ) AND 1RM SQUAT (1RM) FROM PRE- TO IMMEDIATELY (POST) AND TO 24 H POST-MATCH FOR 10 PLAYERS

Players	Session RPE (0-10)	Peak DOMS (mm)	Peak CK ($IU \cdot L^{-1}$)	Peak Mb ($ng \cdot mL^{-1}$)	1RM (%)		SJ (%)		CMJ (%)	
					post	24h	post	24h	post	24h
1	8	20	498	150	-47.6	-13.3	-7.8	-4.1	-12.9	-5.3
2	8	21	367	121	-33.3	-18.6	-7.0	-5.5	-8.5	-7.1
3	4	18	336	112	-33.3	-14.3	-14.5	0.7	-11.7	-0.5
4	3	10	105	81	-18.2	0.0	0.0	0.0	-2.6	1.6
5	7	9	157	106	-26.7	0.0	-2.9	1.6	-5.9	2.9
6	4	18	149	101	-27.3	-9.0	-0.6	-3.4	-3.6	1.6
7	8	29	299	139	-50.0	-14.0	-12.1	-8.0	-15.4	-0.3
8	5	15	490	100	-38.8	-8.3	-4.2	-7.1	-9.7	-1.5
9	6	20	290	115	-30.0	-15.0	-3.2	-4.0	-6.0	-2.7
10	7	20	409	175	-46.7	-15.1	-17.5	-5.6	-23.5	-9.5
Mean	6.0	18.0	310.0	120.0	-35.2	-10.8	-7.0	-3.5	-10.0	-2.1
SD	1.9	5.7	138.8	27.6	10.4	6.4	6.0	3.3	6.3	4.1

As shown in Figure 1B, a significant increase in plasma CK activity from the baseline was evident at 24 and 48 h post-match as compared to the pre-match value ($p<0.05$) (Figure 1B). Mb concentration also increased at 24 and 48 h after the match when compared to the pre-match value ($p<0.05$) (Figure 1C). As shown in Table 1, peak values of each player ranged from 105 to 498 $IU \cdot L^{-1}$ for CK activity and 81 to 175 $ng \cdot mL^{-1}$ for Mb concentration. No changes in CK activity and Mb concentration were observed for the control group.

As shown in Figure 2A, the average 1RM squat strength decreased immediately post-match ($p<0.05$) when compared to the pre-match value, but returned to the baseline by 24 h post-match. As shown in Table 1, seven players still showed a decrease in the 1RM strength 24 hours after the match; however, none of them showed a decrease at 48 h post-match.

A significant decrease in SJ ($-7.0 \pm 6.0\%$) and CMJ ($-10.0 \pm 6.3\%$) performance was observed immediately post-match ($p<0.05$) when compared to the pre-match value, but returned to the baseline by 24 h post-match (Figure 2B and 2C). However, for the individual responses, seven players achieved lower SJ and CMJ values than baseline at 24 h post-match (Table 1). A full recovery of jump ability was seen at 48 h post-match for all players. No changes in 1RM, SJ and CMJ were observed for the control group.

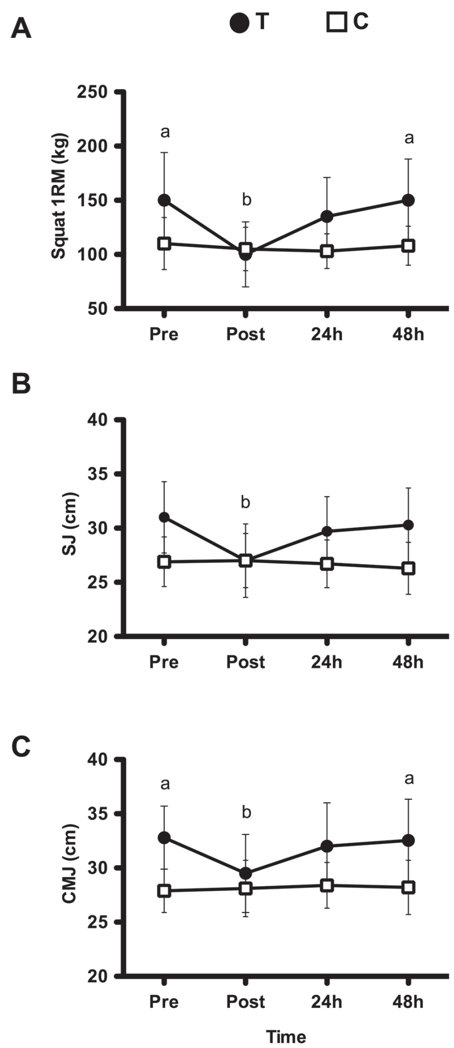

FIG. 2. CHANGES IN 1RM SQUAT STRENGTH (A), SQUAT JUMP HEIGHT (B) AND COUNTERMOVEMENT JUMP HEIGHT (C) BEFORE (PRE), IMMEDIATELY AFTER (POST) AND 24 AND 48 H AFTER A SIMULATED TENNIS MATCH.

Note: a – indicates significant difference from the control group. b – indicates significant difference from the pre-match value. (●T) Tennis Players, (□C) Control Group.

DISCUSSION

The simulated tennis match play induced mild muscle soreness, small increase in blood markers of muscle damage, and acute decrease in muscle strength and jump ability in the young tennis players. None of the players reported severe muscle soreness; however, the 1RM squat strength and jump ability did not recover to the baseline values at 24 h post-match for several players. These results suggest that the magnitude of muscle damage induced by the simulated tennis match play was mild, but full recovery from the match could take more than one day.

The RPE response in the present study is in line with previous tennis studies using professional players during official [18] or simulated matches [9,11]. A gradual increase in RPE was observed as the match progressed, indicating increase in fatigue towards the end. Mendez-Villanueva et al. [18] reported that official matches were rated as "somewhat hard" (13 ± 2) by professional players, ranging from 9 to 17 (6-20 on Borg's scale). The session RPE assessed 30 minutes after the match (6.0 ± 1.9, range: 3-8 on the CR10 scale) suggested that the simulated match was hard. The RPE score at the end of the match was accompanied with the magnitude of decrease in 1RM strength and jump ability in the young male tennis players. The players who had greater RPE scores (e.g. players 1, 7 and 10) showed greater decrements in the performance measures immediately after the tennis match play (Table 1). Girard et al. [9] also reported a significant decrease in isometric maximal voluntary contraction strength of knee extensor and jump ability (SJ and CMJ) 30 minutes after a 3-hour simulated tennis match performed by national level players. The acute decrease in 1RM strength and vertical jump height immediately post-match may reflect a combination of neuromuscular fatigue and muscle damage [9,10,19].

The magnitude of muscle damage observed in the present study appeared minimal based on the mild muscle soreness, small increase in muscle proteins in the blood and fast recovery of 1RM strength and jump ability after the tennis match play (Figures 1 and 2, Table 1). Since no previous studies have focused on muscle damage in tennis, comparison of the present study results could only be made to studies on other sports or exercises. Fatouros et al. [5] reported greater changes in muscle damage markers (e.g. muscle soreness: ~80 mm on a 100 mm scale; CK: ~900 $IU \cdot L^{-1}$) and decrement in performance assessed by 20 m sprint test (-2%) and a maximal jump test (-10%) at 24 h after a soccer match played by elite youth soccer players. Takarada [23] reported a significant increase in peak CK activity (~1000 $IU \cdot L^{-1}$) and peak Mb concentration (~1000 $\mu g \cdot L^{-1}$) after a rugby match played by elite amateur rugby players. Howatson &

Milak [12] also observed a significant increase in muscle soreness (~120 mm on a 200-mm scale) and CK activity (~800 $IU \cdot L^{-1}$) and a marked decrease in knee extensor isometric maximal voluntary contraction strength (-28%) at 24 h after 15 sprints of 30 m performed by young team sports athletes.

The increase in the muscle damage markers in these studies [5, 12,23] is greater than those observed in the present study. A 3-hour simulated tennis match induced minimal muscle damage compared to other sports such as soccer and rugby. The mild level of muscle damage induced by the tennis match play might be explained by the specific patterns of the activities performed in tennis matches. Approximately 80% of all strokes are played within 2.5 m of the player's initial position and the mean distance covered in one point is approximately 10 m [7,14]. On the other hand, the mean sprint in soccer is longer, reaching 10 to 20 m [2,20]. The deceleration phase of longer sprints might impose greater eccentric loads, resulting in greater muscle damage [12]. Takarada [23] stated that physical contacts were attributed to the large increase in CK and Mb after a rugby match, but such contacts are not included in tennis match play. Although the match lasted 3 hours, the playing time on a clay court is reported to be 20% of the total time [7,14,15]. It is possible that the intermittent nature of tennis with relatively long rests between play does not result in severe muscle damage.

The training sessions and matches that these well-trained players had experienced may confer protective effects against muscle damage, since the tennis players recruited in the present study had been constantly performing repeated sprinting drills and plyometric exercises during training, and playing tennis for a long time. This adaptation (protective effect) is relevant in all types of activity when exploring exercise-induced muscle damage. The players frequently experienced official matches lasting for more than 3 hrs. Thus, the simulated match used in the present study was not an unaccustomed exercise for the players. It has been well documented that repeated bouts of the same or similar exercises attenuate the magnitude of muscle damage and enhance recovery of muscle function [3].

Several players still demonstrated a decrement of 1RM strength and jump ability at 24 h post-match, as shown in Table 1. Based on the test-retest reliability of these tests (1RM strength: 3.8%, SJ: 3.6%, CMJ: 4.3% in the present study), some of the changes may be within the measurement error. Even after considering the measurement error, the decrease in the 1RM strength at 24 h post-match exceeded 5% for 7 players, and 3-4 players showed greater than 5% decrease in SJ and CMJ heights at 24 h post-match. These findings suggest that a full recovery from muscle damage was not achieved for several players. However, at 48 h post-match, in all players their lower limbs strength and power were restored to the pre-match levels. Thus, a full recovery from a previous match could take two days even for highly trained young tennis players.

Muscle function measurements were limited to the 1RM squat strength, SJ and CMJ, and muscle soreness was assessed only for the vastus lateralis. However, some of the players reported that other leg muscles (e.g. knee flexors, plantar flexors) also became sore. Further studies are necessary to investigate other muscles in order to understand the muscle damage profile in tennis.

Official matches played in real tournaments may result in greater magnitude of muscle damage than the simulated match used in the present study. Furthermore, fatigue accumulates in repeated matches in a tournament, and players may be predisposed to more muscle damage. In a tournament, young tennis players often have consecutive matches within 48 hours or less after a previous match, so interventions to enhance muscle recovery could be required.

CONCLUSIONS

The present data suggest that muscle damage induced by tennis match play was mild for trained young tennis players. In addition, muscle strength and power were restored within 48 hours after a tennis match play. Daily training and past tennis playing experience make the athletes less susceptible to severe muscle damage as a result of the repeated bout effect. Nevertheless, coaches should consider monitoring changes in the indirect markers of muscle damage in order to establish proper recovery periods between training sessions, especially at the beginning of the season when these players might not be able to experience the protective effect of repeated muscle actions.

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