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RESEARCH ARTICLE

Effects of a Tennis Match on Perceived Fatigue, Jump and Sprint Performances on Recreational Players

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Abstract:

Background:

Tennis is an intermittent sport, characterized by hundreds of repetitive explosive efforts, including accelerations, and jumps. A single match can last up to 5 hours and players are called to play several matches often separated by less than 48h of recovery.

Objective:

The study aimed to investigate the effects of a standardized tennis match on perceived fatigue and jump and sprint performances on a group of recreational tennis players and to observe if such variables were affected by residual effects of fatigue 24 hours after the match.

Methods:

Twelve recreational tennis players performed a 120 min match. Before, immediately after and 24h after the match, players completed a set of three countermovement jumps, three 10m sprints, and reported their perception of general fatigue.

Results:

Significant differences between the three conditions have been found for the perceived fatigue: indeed fatigue was higher both in the immediate post ($F_{(1,10)}$= 54.422, η^2 = 0.845, p<0.001) and 24h post-match ($F_{(1,10)}$= 10.947, η^2 = 0.523, p=0.08), with respect to the pre-match condition. No significant differences were detected in the other variables.

Conclusion:

During a tournament, the performance of tennis players may be weakened and the recovery prejudiced. To identify fluctuations of and factors linked to fatigue may help tennis practitioners to apply adequate recovery strategies with athletes, limiting performance decrements within a tournament, and indirectly preventing injuries.

Keywords: Fatigue, Fitlight, Performance, Post-match, Recovery, Sprint, Tennis.

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1. INTRODUCTION

Tennis can be defined as an intermittent sport, with repetitive anaerobic efforts interspersed by aerobic pauses between the rallies. A single tennis match commonly lasts around 2 hours, but it can exceed over 5 hours. During the match, on average, a tennis player runs 3 m per shot and a total of 8 to 15 m for each point, mainly covered with sliding-type movements and running-type movements [1]. Typically, every action lasts between 5 and 10 seconds, and after each point, there is a 20 seconds break. Longer breaks are present during the match: 90 seconds between changeovers and 120 seconds between each set [1]. It has been reported that a tennis player performs between 300 and 500 high-intensity efforts in a single match. Moreover, tennis is a tournament sport, during which players have to play several matches [2]. Professional tennis players must be prepared to tolerate high volumes within tournaments (*e.g.* six matches lasting 2 to 4 hours), often separated by less than 48 hours of recovery; in this scenario,

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acute (within-match) and residual (between-matches) effects of fatigue are produced [3].

The performance model includes both eccentric and concentric explosive muscle actions, such as accelerations, decelerations, strokes, stretches and jumps; tennis demands a mix of power, speed, agility, aerobic and muscular endurance. In addition, players must have anticipatory and decision-making capacities to cope with the onset of fatigue. Fatigue during exercise is linked to several factors, among which the accumulation of metabolites, hypoglycaemia, and dehydration [4]. Some studies in the literature [5, 6] have tried to investigate the effects of exercise-induced fatigue on performance, but very few decrements have been observed if the fatiguing protocol was equivalent to match conditions. Interestingly, tennis skills were instead impaired when players were subjected to other forms of physiological stress, such as exhaustive cardiovascular strain, hyperthermia or dehydration [4]. Most of the studies focused the attention only on motor-skills proficiency as performance measures; however, since the tennis performance is multifaceted, other performance variables should be included in research studies [4]. Indeed, it is still unclear whether fatigue in tennis manifested in changes of locomotion, reduced cognitive performance or technical proficiency. Moreover, the fatigue effects produced by a tennis match may differ between court surfaces and game styles [3]. A game style with repeated changes of directions - and consequent high-intensity eccentric muscle contractions - may lead to higher muscle damage and suboptimal movement patterns.

Only a few studies in the literature [2, 7] examined the effects of a tennis tournament, while most of the paper focused on acute post-single-match effects. During a tournament, several matches may be played across 1 or 2 weeks. Recent studies have investigated the physical performance response of tennis players competing in multiple singles matches in a day [8, 9] or over a 36h period [10]. Despite the noted impaired physical capacities and increased fatigue in same-day tennis matches, it is unclear whether similar changes are univocal. To understand if the fatigue developed during a match may last even in the day after could help athletes to adapt recovery strategies in order to be better prepared for the subsequent matches within the tournament. The aim of this preliminary study was to investigate the effects of a standardized tennis match on perceived fatigue and jump and sprint performances on a group of recreational tennis players and to observe if such variables were affected by residual effects of fatigue 24 hours after the match.

2. MATERIALS AND METHODS

2.1. Experimental Design

All measurements of the present study were performed during two consecutive days. On the first day, players played one single tennis match in the afternoon, and the day after, they had a recovery phase. The measurements were performed before (pre), immediately after (post), and 24 hours after the match (24h-post). The 24h post-tests were performed at the same time as the day of the pre-test, and measured were undertaken in the same order (fatigue perception, countermovement jump - 10-min rest - 10m sprint). Before the pre and the 24h-post evaluations, players warmed up with a 15-min standard protocol including light running, mobility for upper and lower limbs.

Matches were played at the indoor hard court (Greenset® comfort) using the normal ITF (International Tennis Federation) rules except the playing time that was standardized to 120 minutes [11]. The air temperature ranged from 18 to 20 °C, with a humidity level of 50–60%. The week before and during the 2-day test session, players were recommended to keep their usual food and fluid intake, and to continue their normal social and sleep rhythm. Participants were only allowed to drink water to hydrate during the match.

2.2. Participants

A total of 12 recreational tennis players (M=8; F=4; Age: 23.0 ± 5.9 years; Height: 175 ± 8 cm; Weight: 66.9 ± 8.1 kg; BMI: 21.8 ± 1.9 kg/m^2) participated in this study. Inclusion criteria were: age between 18 and 35 years old, a tennis experience of at least two years at a competitive level, to usually complete 3-6 training sessions per week, and to not participate in any competitive tournament for the duration of the study. Exclusion criteria were: being a professional athlete and/or to have had musculoskeletal injuries in the last six months. Participants were informed of the aims of the study that participation was completely voluntary, and there were no consequences for not participating. The study was conducted according to the Declaration of Helsinki, and participants completed a signed consent form prior to their enrollment in the measurement sections.

2.3. Measures

2.3.1. Anthropometric Measures

Participant's weight (accurate to 0.1 Kg) and height (accurate to 0.1 cm) were measured in light clothes, without shoes, using a digital scale and a wall stadiometer (Seca 702, Seca GmbH & Co. KG, Hamburg, Germany). Body Mass Index (BMI) was calculated as weight (kg)/height^2 (m^2).

2.3.2. Perceived General Fatigue

To measure the subjective sensation of general fatigue, the Rating-of-Fatigue scale (ROF) has been used [12, 13]. The ROF scale is an instrument that can track perceptions of fatigue across any range of living, physical activity or recovery contexts. High convergence between the ROF and various physiological measures, such as heart rate, blood lactate concentration, oxygen uptake, carbon dioxide production, respiratory exchange ratio and ventilation, were found during exercise and recovery [13]. It is an 11-point numerical scale (from 0 "*Not fatigued at all*" to 10 "*Total fatigue and exhaustion*") with empirically derived accompanying descriptor and diagrammatic components. All players were familiarized with this scale before the beginning of the study.

2.3.3. Counter Movement Jump

Maximal vertical jumping ability was measured using a Counter Movement Jump (CMJ), registering the height of the jump in real-time. CMJ is considered a good, and it is amongst the most widely used measure of functional power of the lower limbs [14, 15], and it is considered reliable and suitable for neuromuscular fatigue monitoring [16]. This test showed a high test-retest stability coefficient (range 0.80–0.98) [17] on an optical acquisition system (Optojump, Microgate, Udine, Italy) which is triggered by the feet of the subject at the instant of taking-off and the contact upon landing (10^{-3} s of resolution). From the standing position, tennis players were asked to quickly bend their knees to a 90° angle and, immediately after, to perform a maximal vertical jump (stretch-shortening cycle). During the jump, subjects had to keep the hands on the hips to avoid any effect of arm-swing and trying to avoid any knee or trunk countermovement. During the phase of flight, subjects had to keep their body vertical, and land with knees fully extended. The best of three correct jumps (if players failed to adhere to the rigorous protocol, the trial was repeated) was used for the analysis.

2.3.4. 10-meter Sprint

The 10m sprint test is a simple and popular test used to measure an athlete's ability to accelerate. Numerous researches have confirmed the validity and reliability of the 10m sprint test using electronic timing gates [18, 19]. Using the Fitlight training system (a disc system with LED lights and a central wireless controller), the player was standing 0.5 m from the first light and then accelerated maximally over 10 m to the second light. The proximity sensor of the lights registered the total duration of the sprint. The best performance of three trials (recovery from 2 to 5 minutes between the trials) was selected for the final analysis.

2.4. Statistical Analyses

Descriptive statistics were performed using means and standard deviations. In order to verify CMJ, best 10m and ROF changes among pre-game, post-game and 24 h post-game measures, a multivariate ANOVA for repeated measures has been performed. Time was within-subjects 3 levels factor (Pre, Post, 24-h Post). Simple contrasts have been used to compare the mean of each level (Post, 24h) to the mean of "Pre" level. Mauchly's Test of Sphericity was performed; Wilks' lambda (Λ) was considered as an appropriate multivariate test statistic, and partial Eta squared (η^2) was used as effect size estimation [20]. All elaborations were conducted with α=0.05. Elaborations and graphics were obtained using SPSS version 20.0 (SPSS Inc., Chicago, IL) and Prism 6 (Graphpad, La Jolla California).

3. RESULTS

An overall time effect (within-subjects factor) was found to be significant (Wilks' Λ = 0.155, $F_{(6,36)}$= 9.225, η^2 = 0.606, $p<0.001$); Mauchly's Sphericity was confirmed for all the measured variables ($p>0.05$). Since the time × sex interactions were not significant for none of the variables, data are reported for the whole group, without gender stratification.

Neither for CMJ nor for 10-meter sprint performance, significant differences have been found between pre-, post- and 24h post-match values ($p>0.05$). On the contrary, a significant time effect has been found regarding fatigue values ($F_{(2,20)}$=16.108, η^2 = 0.617, $p<0.001$). Simple contrast analysis showed that fatigue values were significantly different both in post- (4.83 ± 1.85, $F_{(1,10)}$= 54.422, η^2 = 0.845, $p<0.001$) and 24h post-match (3.42 ± 1.73, $F_{(1,10)}$= 10.947, η^2 = 0.523, p=0.08), respect to pre-match condition (1.75 ± 1.60). Data are presented in (Fig. **1**).

4. DISCUSSION

In this preliminary study, the effects of a tennis match on perceived fatigue, jump and sprint performance have been investigated; data have been collected on a sample of recreational players before, immediately after and 24h post a simulated time-standardized tennis match. The main finding is the difference in perceived fatigue between the 24h-post and the pre-match condition. Indeed, one day after the match, the general fatigue perceived by the players was still higher than in the pre-match; this included in the context of a tournament, could lead to a progressive increase in accumulated fatigue, and a consequent reduction in performance. Gandevia [21] considered fatigue as the exercise-induced reduction in the force-generating capacity of muscle and defined its key terms (*i.e*., central and peripheral fatigue, maximal voluntary contraction, muscle fatigue). Gescheit *et al*. [7] investigated technical performance changes over 4 consecutive days of competitive 4-h tennis match play, and they found impaired hitting accuracy, stroke positioning and emotional responses among days, while Ojala and Häkkinen [2] showed that tennis tournament led to significant changes in player's physical performance, considerable hormonal responses, and increases in variables indicating muscle soreness. Differently, from our results, these latter studies [2, 7] reported increased self-reported fatigue and muscle soreness only after playing 3 or 4 matches over 3 to 4 consecutive days, but not after a single match.

The mechanical overload produced by successive concentric and eccentric actions match damages contractile proteins, intermediate filaments, and connective tissue surrounding the muscle fibers [22] with consequential reductions in maximum voluntary contraction force [23], explosive force [24], and power [25]. In this study, CMJ, which reflect the functional power of the lower limbs, have demonstrated lower values to those previously reported by studies of Ojala and Häkkinen [2] in all the time conditions analyzed. By the way, CMJ values were not affected by the match: indeed, no significant difference has been found in none of the three testing conditions. This is in accordance with the results of Brink-Elfegoun and colleagues [10], who reported no significant reductions in CMJ performance after 3 tennis matches over 36h (2h per match), and with Maraga and colleagues [9] observing no change in CMJ height after 3 single matches on the same day (90 min per match). Differently, CMJ height was reduced post 2 tennis matches (to the best of 3 sets) played on the same day among young tennis players [8], and a reduction of about 10% on CMJ height was reported by Gomes *et al*. [26] immediately after a 3h match, thus indicating non-univocal changes of power performance of the lower limbs in tournament contexts.

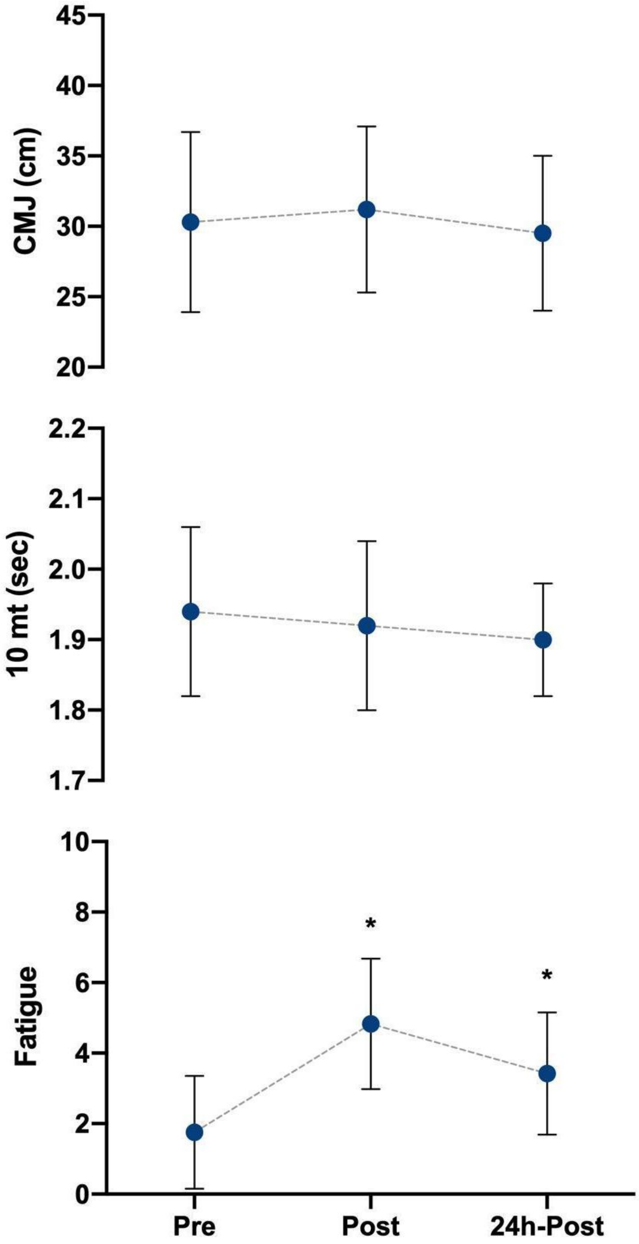

Fig. (1). Variations in Counter Movement Jump (CMJ), 10-meter sprint time and fatigue, in pre-, post- and 24h post a tennis match. Values are represented as means ± standard deviations. * Simple Contrasts Time Effect respect to pre-match condition ($p < 0.05$).

Within a match, a tennis player runs an average of 3 m per shot and a total of 8 to 15 m in the pursuit of one point with 4 changes of direction [1, 27]. The ability to accelerate, decelerate and to change of direction efficiently is imperative to successful tennis performance. The 10m sprint test is a simple and popular test used to measure an athlete's ability to accelerate. Numerous researches have confirmed the validity and reliability of the 10m sprint test using electronic timing gates [18, 28]. Studies [19, 29] highlighted acute reductions in post-match lower-body force production and sprint times following < 3h simulated match-play. In contrast with these results, our study did not show a significant reduction in 10-m sprint time, neither immediately post-match nor 24h post-match. These results are in contrast with those reported by Gescheit *et al*. [7] and Gallo-Salazar *et al*. [8], both reported a ~5% decrease in 10-m sprint performance, in the day after a 4h match or two ~80 min matches, respectively.

The results of our study indicate that disparities exist among physical and psychological recovery trends and optimal and adequate recovery strategies may be needed to return tennis players to a state of readiness following an arduous tennis match. Considering that tennis players could play a match every day during a weeks' tournament, to find out the fatigue severity produced by a tennis match, its effects and/or the athlete's recovery speed, it is big gain value for practitioners (tennis coaches, strength and conditioning coaches, *etc*.) who work for tennis. Infact, being aware of the changes in neuromuscular and sport-specific performance can give the possibility to organize future training and/or recovery sessions to increase performance and possibly reducing injury risk. As a practical application, tennis players should be trained to sustain intensive tournaments, including 2 to 3 consecutive matches on the same day. Training should be focused on the overall dimensions of tennis performance (including speed, strength, plyometric, and flexibility), and the recovery should be carefully programmed in order to maximize the performance, avoiding a progressive reduction in force production during multiple competitions and allow players to keep up playing with high performances.

The main limitation of this study was a low sample size to statistically analyze and compare the recovery phase of perceived fatigue and physical responses between genders. For this reason, further large-scale studies are recommended to investigate the effects of a tennis match on perceived fatigue and jump and sprint performances on tennis players and to observe if there are differences between males and females. Moreover, the match duration in our study was standardized at 2 hours for all the matches played; this could have been a limiting factor in evidencing performance decrements after the match. The magnitude of the effects on fatigue and performance induced by longer matches (*e.g*. 3 to 5 hours) is yet to be investigated.

CONCLUSION

During a tournament, the physical performance of tennis players is weakened, and the recovery is prejudiced. Tennis players' post-exercise recovery is a growing multifaceted area that involves many different techniques to help speed recovery from fatigue. Identifying derived fatigue from different types of stress cannot be overlooked by both the coach and the athlete. Coaches have to suit the individual needs of athletes by a) identifying specific fatigue, and b) using adequate recovery strategies. Be unaware of the physical and psychological responses to a tennis match may cause athletes to be more vulnerable to high risk of injuries.

LIST OF ABBREVIATIONS

10m	=	10 m Sprint Test
BMI	=	Body Mass Index
CMJ	=	Countermovement Jump
ROF	=	Rating-of-Fatigue scale

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All research procedures in this study were performed in accordance with the ethical standards of the responsible committee of University of Urbino Carlo Bo, Italy on human experimentation.

HUMAN AND ANIMAL RIGHTS

No Animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Written informed consent was obtained from each participant.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

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None.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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