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Impact of Fatigue on the Balance and Reaction Time of Amateur Padel Athletes

Alaeddine Bourara [1,*], Zsolt Nemeth [1], Jabeur Methnani [2] and Marta Wilhelm [1]

[1] Institute of Sport Sciences and Physical Education, University of Pécs, Pécs, Hungary
[2] Higher institute of Sport and Physical Education Ksar Said, University of Manouba, Tunis, Tunisia

[*] *Corresponding author*: University of Pécs, P. O. Box: 7624, Pécs, Hungary. Tel: +36204853724, Email: ala.bourara@gmail.com

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Abstract

Background: Physical features, such as body balance and reaction time, can significantly influence the overall performance of Padel's professional athletes.
Objectives: In this paper, we aimed to compare motor performance abilities before and after exhaustion in amateur padel athletes.
Methods: A total of 32 padel amateur athletes participated in our study and performed Y balance test trials and a complex sensometric examination to measure their capabilities before and after exhaustion by the Bruce test.
Results: Our results showed a significant change in both balance and reaction time before and after exhaustion ($P < 0.05$ for both parameters), indicating that fatigue had a negative effect on the motor performance of padel players. Cohen's d was considered moderate ($0.2 < d < 0.5$) both for balance ($d = 0.44$) and reaction time ($d = 0.41$). Data suggested that amateur padel athletes struggled to maintain or improve their balance quality after long-term physical activity, showing the importance of high-intensity training for adapting the central nervous system. Reaction time is negatively affected by fatigue compared to resting reaction time due to the exhaustion effect of the muscle reception of central nervous system stimuli.
Conclusions: Based on our results, focusing on body balance and reaction time training would help reduce the negative impact of fatigue, improve the effectiveness of technical abilities, increase the possibility of scoring during a competitive game, and prevent injuries. Coaches of amateur players should focus on improving the physical abilities of players and give more importance to fitness training in addition to padel training.

Keywords: Postural Balance, Reaction Time, Fatigue, Racquet Sports

1. Background

Invented in Acapulco, Mexico, in 1969, padel is considered an irregular doubles racquet sport that follows the same regulations and scoring system as tennis. However, it is played inside an enclosed court made of manufactured glass and metal (10×20 m dimension), allowing the ball to bounce off the walls during the game (1). Regardless of its worldwide spread, the extant literature about tactical or physical requirements in padel is yet scant (2). Once the physical performance is analyzed, relevant strategies emerge that enable padel coaches to design appropriate training programs and efficient assessment systems, consequently improving the level of the game (3). This approach was used mainly in sports other than padel (4). In racquet sports, coaches evaluate the performance of players by fitness testing to investigate their strengths and weaknesses (5). Tennis and squash requirements are similar to padel, such as strength and conditioning (6), meaning evaluating agility, short-distance sprints, overall body strength, endurance, and body balance might be intriguing (7).

Fatigue was described as reducing the force or power of muscle cells or motor units that oblige the athlete to slow down, affecting the overall performance (8). In tennis, it was found that the accuracy and speed of the tennis serve among college tennis players decreased with exhaustion (9). The same results were found in hitting accuracy (10). Due to its fast-paced character, a regular padel match elevates heart rate and engenders fatigue (11, 12), affecting

the overall performance of players. In the World Padel Tour, an international padel circuit that gathers the best players in the world, it is advised to avoid successive matches since they highly influence the explosivity, balance, and reaction time of players (13).

Balance is considered of prominent importance in researching physical performance in daily sporting activities (14) particularly in padel where the players switch directions and move rapidly (15, 16). Balance refers to the ability to maintain the line of gravity and the symmetry between the left and right sides of the body by using both sides evenly (17).

Reaction time is a measure of the response to a stimulus. Age, gender, left or right hand, level of practice, fatigue, fasting, and exercise affect the average human reaction time (12). Sports training improves reaction time; for instance, elite and amateur racquet sports athletes have lower reaction time than sedentary healthy adults (18), potentially affecting sports performance. Previous research showed an increase in the reaction time of Taekwondo players after exhaustion (19).

2. Objectives

So far, no scientific research has examined the effect of exhaustion on the balance and reaction time of amateur padel players. Therefore, we aimed to assess the motor performance abilities of padel players after exhaustion and study the effect of fatigue on these factors. Our results postulated that exhausting padel training might engender injuries. These findings could be of ultimate value for coaches improving the physical qualities of padel athletes.

3. Methods

3.1. Participants

This study was conducted on 32 male amateur padel players playing in the second- and third-division local competitions. Participants provided their consent to participate in the experiment. Subjects were 18 - 50 years old, never reached the top 25 in the national ranking, and did not play in the first-division local tournaments.

3.2. Procedures

First, the anthropometric data of participants were collected. Standing height and body weight were measured simultaneously with a 1 mm graduation tape measure (D03184 Duratool 5 m Tape Measure) and a 100 g precision electronic scale (WC-321 precision balance, USA). Our study consisted of three major parts. First, the Y Balance Test (YBT) tool was used for a dynamic balance test, and a complex sensometric examination was performed to measure the reaction time of subjects. In the second phase, a Bruce test was administered until it reached volitional exhaustion. Subsequently, their dynamic balance and reaction time were retested. Participants were also asked to wear comfortable clothes and eat their last meal 3 h before the start of the measurements.

3.3. Dynamic Balance Measurement

The YBT was used in this study. This dynamic stability test has proven useful in evaluating the neuromuscular control of the lower limbs (20). In addition, YBT has demonstrated predictive validity for the injury risks of athletes (21). The Functional Movement Systems Professional YBT kit was employed. The kit consists of a central grid on which subjects would perch their dominant leg with a steady heel and need to extend their contralateral legs to the utmost in the posterolateral, posteromedial, and anterior directions. Three practice trials were conducted for reliability, and the highest count was selected. Furthermore, participants were asked to avoid any substances affecting their overall balance, including alcohol, drugs, and sedatives, 2 days prior to testing.

The distance from the far-end tip of the toe to the farthest extent of the reaching foot in the aforementioned directions was measured. The YBT was scored according to Coughlan et al. (2012) using the following formula (22):

Score = [(maximum anterior distance + maximum posteromedial distance + maximum posterolateral distance) / (leg length $\times$ 3) $\times$ 100]

3.4. Reaction Time Measurement

The reaction time of the participants was measured with a complex sensometric examination. The athlete sat on a chair in front of the equipment containing five square buttons in bright colors, four rectangular grey buttons (2 on the right and 2 on the left), 2 buttons for the feet, and a small screen. Sixty stimuli were generated one after the other. The athlete had to react as fast as possible according to the nature of the stimulus (visual, audio, hand, or foot).

If a color was seen on the screen, the athlete had to click on the button of the same color. The grey buttons are used in case of sound (high- or low-pitched) stimuli. White arrows on the screen are indicators of buttons for the feet. Data were collected during the experiment and analyzed immediately. The data included the number of stimuli per nature, number of skipped answers, number of mistakes, number of late answers, average reaction time in minutes, and time of reaction for each stimulus generated. Two trials were given for each athlete, and the best was chosen

for statistical analysis. Prior to starting, participants were asked to stay focused even in case of mistakes during the test, as any reaction might affect the next stimulus.

3.5. Bruce Treadmill Inclined Exercise Test

Subjects completed a Bruce treadmill-graded exercise test, which started at a 2.7 km/h speed and an incline of 10. Speed (from 2.7 km/h in stage 1 to 12 km/h in stage 10) and incline (2% at each stage) were gradually increased every 2 min until subjects reached volitional exhaustion (23).

Athletes must continue the test until they reach their maximum capacity. Therefore, they were requested to continue the exercise until they reached or got close to their expected maximum heart rate, which was calculated with the following formula: 220 - age (24). The test was considered accurate when at least 85% of the predicted maximum heart rate was reached (25). However, athletes were asked to stop the test immediately if they witnessed severe symptoms, including pain, extreme fatigue, or dyspnea. In all cases, exhaustion was reached as all participants had more than 85% of the predicted maximum heart rate.

3.6. Blood Lactate Concentration

Blood lactate concentration was measured to verify that the exhausting exercise was efficient. A portable Lactate Scout+ (LSP, SensLab GmbH, Germany) analyzer was used, which required 0.5 μL of blood from each athlete. The blood sample was collected via finger prick of the index finger before and after the exercise. The second sampling was conducted instantly after the exercise, providing the most accurate results since cooling down alters blood lactate levels.

3.7. Analysis

Data were analyzed using SPSS version 20.0 for Windows (SPSS, Inc., Chicago, IL, USA). All data are presented as mean and standard deviation. All statistical tests are considered significant for a probability threshold of less than 0.05 ($P \leq 0.05$). Normality was analyzed with the Shapiro-Wilk test. Paired samples t-test was used to compare the means and analyze the effect of exhaustion on balance. The Shapiro-Wilk test is the preferred normality test for good power properties (26). A parametric test is used when normal distribution is confirmed. In this study, a repeated measures t-test was applied to compare the means of a single sample at two particular moments (27). In order to analyze the effect size of the measured variables, Cohen's d was calculated. Cohen's d test can be used in a single group with two repeated measure designs to assess the change in the population mean between two measurements (28). The effect is considered small if Cohen's d is less than 0.2, moderate between 0.2 and 0.5, and large if between 0.5 and 0.8.

4. Results

All 32 amateur padel players (age: 35.2 ± 9.1 years, height: 183.2 ± 6.02 cm; body mass: 83.1 ± 8.66 kg) completed the measurements.

Fatigue indicators (blood lactate concentration and heart rate) rose with volitional exhaustion. In all instances, the Bruce protocol test constantly conveyed exhaustion for all athletes (Table 1).

The means and standard deviations were calculated for the pretest and post-test results of the YBT and reaction time test. Significance values were also calculated for the normality test and the means comparison test, similar to Cohen's d value, to evaluate effect size. The data analysis in Table 2 revealed a significant difference between dynamic balance and reaction time values before and after exhaustion ($P < 0.001$). The population was normally distributed ($P > 0.05$) according to the Shapiro-Wilk test.

Results showed a significant difference (Table 3) between resting and exhaustion in terms of the balance test and the reaction time test ($P < 0.05$), showing that exhaustion had a negative effect on balance and reaction time. To analyze the size effect of exhaustion on balance, Cohen's d was calculated ($d = 0.44$), showing that the effect was moderate ($0.2 < d < 0.5$). Cohen's d for the exhaustion effect on reaction time was $d = 0.41$, considered moderate.

5. Discussion

Our study argues that there is a negative effect on the balance and reaction time of amateur padel players following persistent physical exercise. The latter causes a decrease in the quality of motor performance. Some athletes cannot reach the predicted maximum heart rate due to various modifying factors. The blood lactate concentration was measured to ensure that subjects reached exhaustion at the end of the exercise. High lactate concentration reduces the strength of muscle contraction and downgrades the ability of athletes to perform well, resulting in exhaustion (29). Our findings demonstrated a rise in the blood lactate concentrations of all subjects by the end of the exercise.

Existing studies about balance also confirm our findings. A 15-rated Borg-scaled heavy exercise lasting for 20 minutes was performed with young male athletes, showing higher body error scores after exertion and conveying lower balance quality (30). Padel players

Table 1. Heart Rate and Blood Lactate Concentration of Padel Players Before and After Exercise

	Pre-test	Post-test
Heart rate (bpm)	71 ± 6.27	185 ± 12.61
Lactate concentration (mmol/1)	1.01 ± 0.23	10.92 ± 3.55

Table 2. Results of Dynamic Balance Test Performance and Reaction Time of Padel Players Before and After Exhaustion [a]

Variables	Mean PreEx	Std Dev PreEx	Mean PostEx	Std Dev PostEx	P-Value	Normality P-Value
Dynamic balance	101.44	7.59	98.34	7.09	0.000	0.73
Reaction time	0.48	0.06	0.40	0.09	0.000	0.30

[a] Significance levels at 0.001 and 0.005.

Table 3. Analysis of the Effect of Fatigue on Performance and Effects Size in Padel Players [a]

	SEM	Paired *t*-Test P-Value	T	Cohen's d
Dynamic balance	0.20	0.01	2.71	0.44
Reaction time	0.06	0.01	-2.46	0.41

Abbreviation: SEM, standard error mean
[a] Significance level equal to 0.05.

usually perform rapid motions in different directions during the game (2), placing balance at the forefront of overall performance. Even at rest, padel players score low in balance, especially in terms of anterior direction distance, due to the lack of lower limb strengthening and balance exercises in padel training routines. When muscles are less efficient than usual due to exhaustion, the balance capacity becomes lower (31). Kinaesthetic senses and motor activity control are also impacted by exhausting exercises (32). Scholars argue that intensive exercises help considerably adapt the central nervous system since motor-neuron activities to muscles are the fundamental reason behind diminishing the balance capacity. Continuous training would help strengthen body balance despite exhaustion (33). Research also indicated that exhaustion hampers the spinal lower motor neurons by minimizing the motor signal (34), which, in turn, reduces the muscle fiber conduction velocity. The latter induces the downgrading of the dynamic postural control (35).

Reaction time, one of the main parameters of racquet sports performance, is affected negatively by exhaustion (36). In another research, tennis and table tennis amateur players showed higher reaction time performances as the exercise intensity increased with the loadings of 40%, 60%, and 80% of their maximal aerobic power (37). Reaction time also rose for elite fencers of both genders compared to pre-exhaustion (38). It was also shown that the overall performance and reaction time gradually decreased in trained middle-distance runners, who were tested while pedaling on a cycloergometer at 20%, 40%, 60%, and 80% of their maximal aerobic power (39).

5.1. Conclusions

A moderate effect of fatigue was found after exercises in both parameters, leading us to focus on body balance and reaction ability training to reduce the negative impact of fatigue, improve technique effectiveness, boost the possibilities of scoring during a competitive situation, and prevent injuries. This is the reason that the coaches of amateur players should focus on improving the physical abilities of players and give more importance to fitness training in addition to padel.

5.2. Limitations

A set of limitations should be addressed in this study. First, only 32 amateur padel players were recruited and measured, leading to a relatively small sample size. As a result, our findings might not be generalized to a broader population of padel athletes. Furthermore, the study was cross-sectional, so one cannot establish a causal relationship between fatigue and future research might consider a longitudinal design for lance or reaction time for a better insight into the effects of fatigue on padel persider a longitudinal design. Consequently, further research on the influence of padel training requirements on padel players is needed.

Footnotes

Authors' Contribution: A.B., M.W., and J.M. conceived and designed the paper. A.B. collected the data. A.B. and J.M. analyzed and interpreted the data. A.B. drafted the manuscript. Z.N. and M.W. provided a critical revision of the manuscript. A.B. conducted the statistical analysis. Z.N. provided administrative, technical, and material support. M.W. and Z.N. supervised the study. All authors read and approved the final manuscript.

Conflict of Interests: The authors declare no conflict of interest.

Data Reproducibility: The dataset presented in the study is available on request from the corresponding author during submission or after publication. The data are not publicly available due to ethical reasons.

Ethical Approval: This study was conducted under the ethical approval of Decree 23/2002 (V. 9.) of the Minister of Health on Biomedical Research on Human Beings.

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Informed Consent: All participants in this study presented their consent to participate in the experiment.

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