INFLUENCE OF THE PERFORMANCE LEVEL OF BADMINTON PLAYERS IN NEUROMOTOR ASPECTS DURING A TARGET-POINTING TASK

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

Luiz de França Bahia Loureiro Jr.
Paulo Barbosa de Freitas

Graduate Program in Human Movement Science and Institute of Physical Activity and Sports Sciences, Cruzeiro do Sul University, São Paulo, SP, Brazil

Mailing address:
Paulo Barbosa de Freitas
Universidade Cruzeiro do Sul
Rua Galvão Bueno, 868 – Bloco B, 13º andar, Sala 1.301 - Liberdade
01506-000 – São Paulo, SP, Brasil.
E-mail: deFreitasPB@gmail.com

ABSTRACT

Badminton is a racket sport where athletes have to accurately react to powerful and rapid strokes from their opponents. Therefore, the aim of the study was to investigate whether expert badminton players (members of the national team) would present better indices of neuromuscular performance than intermediate level badminton players in a target-pointing task. Twelve expert badminton players (EPG), who currently play or have already played for the Brazilian national team, and 12 intermediate-level players (IPG) participated in the study. The standing participant was instructed to press a switch placed in front of him and at his midline with the tip of the index finger and touch a target displayed in a touchscreen located in front of him as soon as this target was lighted. The target was shown either ipsi- or contralateral to the dominant upper limb and either in blocks (simple reaction time – SRT) or randomly (choice reaction time – CRT). The dependent variables reaction time (RT), movement time (MT), and radial error (RE) were calculated. The results revealed no effect of group on MT and RE, but revealed that RT was shorter for EPG than for IPG. Moreover, RT was lower in SRT than in CRT condition and RT and MT was lower when the target was ipsilaterally presented and during STR condition. The shorter RT presented by expert badminton players when compared to intermediate level players could indicate that RT could be a key neuromuscular variable to distinguish expert from non-expert badminton players. Finally, although the experimental protocol does not integrally represent the actions performed during the game, it is a progress when compared to the tests commonly used to investigate the response time (RT and MT) in athletes, and should be used to assess those neuromuscular variables in athletes of sports that use the upper extremity.

Keywords: reaction time, movement time, accuracy, racket, upper extremity

INTRODUCTION

Badminton is considered the fastest racket sport in the world, and hence, it demands from the players quickness in planning and performing movements and temporal and spatial accuracy in the racket position for interception of the projectile (shuttlecock). Previous studies have shown that the high level badminton players (e.g. who play for national teams or are well positioned in the world ranking) present better capacity to use visual hints obtained from the opponents' movements when compared to players of lower levels and, consequently, are able to achieve higher index of success in predicting the correct trajectory and landing site of the shuttlecock in court[1-4]. Such skill allows these athletes to plan and start their movements before the end of the opponent's stroke, and consequently, have higher chances to be successful in their moves.

However, it is known by badminton coaches and players that expert players use deceptive movements during some strokes that make the shuttlecocks' trajectory and the approximate final position unknown by the opponents until after it has touched the racket, which avoid the opponents from planning his/her movement in anticipation (e.g. before the shuttle contact the racket). Thus, the badminton players should be able to quickly react in the situations in which he/she is not able to anticipate the shuttle trajectory and final destination in order to be successful in this sport and reach high performance levels. This fact makes us hypothesize that the expert badminton players have better reactive ability than lower-level athletes.

Two neuromotor variables have been commonly used for evaluation of the reactive ability of athletes of different sports modalities [5-8], including badminton[9,10]: reaction time (RT) and movement time (MT). RT is defined as the interval between the sudden presentation of a imperative stimulus and the beginning of the motor action, while MT is defined as the interval between the beginning and the end of the motor action. The RT and MT variables represent, respectively, the time needed for the information processing (e.g. detection and identification of the stimulus, response selection and movement planning) in the central nervous system and the capacity of the musculoskeletal system in dislocating one or more body segments or the body as a whole from an initial to a final and desirable position[11,12], in most cases, as fast as possible.

Besides reacting and moving quickly, another variable which could differentiate the performance level of the players is the movement accuracy. In this case, the badminton player should be able to rapidly take the upper limb that holds the racket to a given position in space, reaching the exact contact point between it and the shuttle. Incorrect or inappropriate reach of the contact point negatively interferes in the result of the strike action. Therefore, the badminton players performance can also be characterized by how accurate they are in reaching the target (e.g. shuttle)[13].

Thus, the aim of the present study was to investigate whether expert badminton players present higher indices of neuromuscular performance during the execution of a task when compared to lower-levels badminton athletes.

METHODS

Participants

Twenty-four male badminton athletes, aged between 18 and 32 years were evaluated. They were divided in two groups, where 12 badminton players were considered expert players (EPG) and 12 were considered intermediate-level players (IPG). EPG was formed by athletes with more than five years of experience in official competitions, who play or played in the badminton national team and who are still playing in national or international competitions [age: 24.2 ± 4.8 years (mean± standard deviation); body mass: 74.5 ± 14.8kg; stature: 1.8 ± 0.07m]. The athletes from IPG had between two and five years of practice in badminton and competed in state and national championships [22.8 ± 4.4 years; 70.8 ± 10kg; 1.74 ± 0.05m]. All signed a Informed Consent Form approved by the Ethics Committee of the Cruzeiro do Sul University before the beginning of the study.

Experimental procedure

In order to simultaneously evaluate the three neuromotor aspects (RT, MT and accuracy) it was necessary to develop an experimental protocol which was closer to the badminton practice and game situation and different from the commonly used tests for evaluation of RT and MT, where the sitting participants are asked to press a button on a board or a key in a computer keyboard as quick as possible after presentation of a visual and/or auditory stimulus [5-9].

During the experiment, the participant remained standing with the dominant upper limb (e.g. used for moving the racket) positioned in front of and the non-dominant one relaxed along the body (figure 1, C and D). This position was chosen for being similar to the initial position taken by badminton athletes in game situations (e.g., standing, feet medio-laterally aligned and racket positioned in front of the trunk). The feet position of the participant was marked with adhesive tape on the ground to assure that the positions were kept during all trials.

A touchscreen monitor (figure 1A) was positioned in front of the participant, at a distance equivalent to 85% of the total length of his arm (scapula acromion until the tip of the pointing finger) and at a height which enabled comfortable performance of the target-pointing movement (e.g., screen lower limit to the height of the elbow joint). Two targets with 2.5cm of diameter were shown on the right and left lateral extremities of the monitor, to the height of the mean point (50%) of the distance between the scapula acromion and the humerus lateral epicondyle. The targets were initially presented in dark green and this color represented that the targets were "off". Besides the touchscreen monitor, a tension switch was used (figure 1B). It was positioned in front of the participant, with distance equivalent to 50% of the total distance between the monitor and the center of the shoulder joint of the participant, at the height of the navel and aligned with the body's midline.

At the beginning of each trial, the participant was told to take the position described while pressing the tension switch with the tip of his pointing finger from the dominant hand. At that time a beep sound was given indicating that in up to four seconds (between 0.5 and 4s) one of the targets would light on next, the participant was asked to reach and touch the center of the target using the index finger of the dominant upper limb, as fast and as accurate as possible, as soon as the target lit (e.g., when the target changed from dark green to light green).

In addition to evaluate the different groups, we manipulated the site of the target presentation (e.g., contralateral and ipsilateral to the dominant upper limb) and the previous information about which target should be reached (blocked or random conditions). In the blocked condition, the participants previously knew what target would light on and performed all the pointing trials toward that specific target (ipsilateral ou contralateral), which characterized this condition as simple reaction time (SRT). In the random condition, the participants had no previous information about which of the two targets would light on, which characterized it as a choice reaction time condition (CRT).

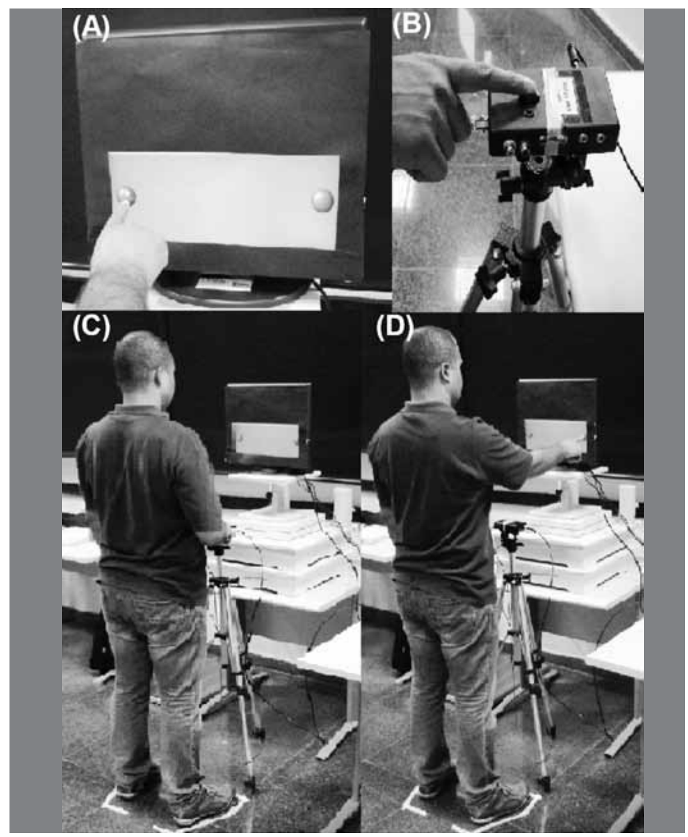

Figure 1. (A) Touchscreen monitor and the contralateral and ipsilateral targets, (B) tension switch and (C) participant positioned while waiting for the alert beep sound that indicated the trial beginning, and (D) responding to the visual sign, reaching the target positioned ipsilaterally with the dominant upper limb.

Three blocks of trials were performed. In two blocks, the participants performed 10 trials, either for the ipsilateral target or for the contraleteral target (blocked condition, SRT). In another block of trials, the participants had no previous knowledge on which of the two targets (contralateral or ipsilateral) would light on (random condition, CRT). In that block, the participants performed 30 trials, with 10 reaching towards the ipsilateral target, 10 towards the contralateral target, and in 10 trials neither of the targets lit. Trial order within that block was randomly defined. The 10 trials with no target light ing on were performed to minimize the ocurrence of an anticipatory response. The performance order of the three blocks occurred in a balanced way among the participants of each group. The three first trials for each condition were not used for the analysis for being considered necessary for familiarization to the task. Thus, only the five trials with the lowest RT out of the seven remaining in each block were analyzed, since they (e.g., trials with the lowest RT) would indicate more attention and commitment with the task by the participant.

Data analysis

The data were recorded and immediately processed and the calculated dependent variables were saved for subsequent analyses. All these procedures were performed with a computer routine written in *LabView* language (Version 7.1, National Instruments, Austin, TX, USA). The voltage signal generated by the switch and the position of the pointing finger during contact with the monitor, provided by the touchscreen sensors, were used for the calculation of the dependent variables. Three dependent variables were calculated and analyzed: reaction time (RT), movement time (MT) and radial error (RE). The RT was calculated as the interval between the moment of the stimulus presentation (target became light green) until the moment of the response beginning, determined by the moment in which the participant removed the finger from the switch positioned in front him [voltage surpassed 10V (closed circuit) to 0V (with the circuit opening) after finger removal]. During the experiment, trials in which the RT was below 100ms or above 500ms were not considered and were repeated at the end of the block, since these events could be characterized as an anticipatory behavior or lack of attention, respectively. The MT was calculated as the time between the moment of finger removal from the switch and the end of the response, determined by the moment of the first touch of the pointing finger on the monitor.

Finally, the radial error (RE) was calculated concerning the distance between the point touched by the participant and the center of the target. The RE was calculated as the resultant vector of the contant errors measured on the horizontal and vertical axes, providing the direct distance between the position touched and the center of the target ($RE = \sqrt{P_h^2 + P_v^2}$, where P_h is the distance between the touch position corresponding to the horizontal axis and the center of the target, and P_v is the same measurement for the vertical axis).

Statistical analysis

Three three-way analyses of variance (ANOVAs) were performed to test the effects of the group (EPG and IPG), the side of the target presentation (ipsilateral and contralateral) and, condition (target presentation in group and randomly) and the interaction between these factors for the dependent variables RT, MT and RE. The two last factors were treated as repeated measures. The alpha value was set at 0.05.

RESULTS

Figure 2 presents the mean values of the RT (upper chart), MT (middle chart) and RE (lower chart) variables for each group in each condition and side on which the target was presented. The ANOVA for the RT did not reveal main effect or any interaction between the evaluated factors. However, ANOVA revealed that the RT was lower for the group of expert players (EPG) than for the intermediate players (IPG) [$F_{(1.22)} = 9.25$, $p < 0.01$, $\eta^2 = 0.3$] and that the RT was lower for the blocked than for the random condition [$F_{(1.22)} = 76.5$, $p < 0.001$, $\eta^2 = 0.78$].

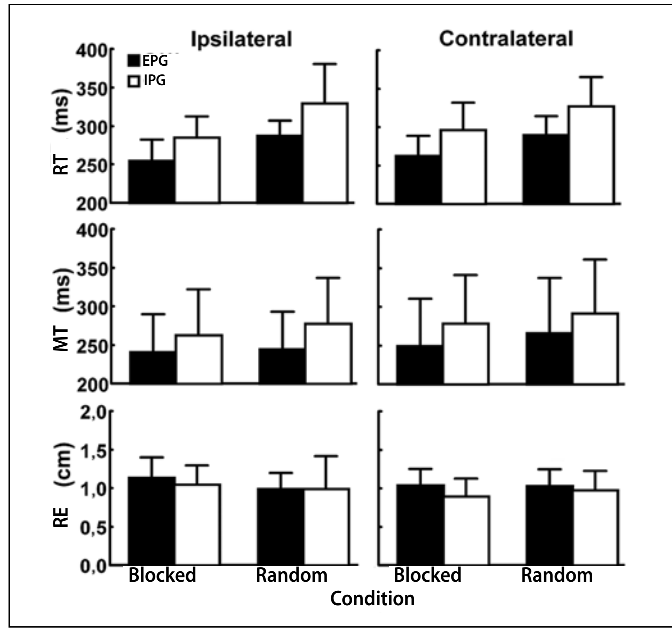

Figure 2. Means and respective standard deviations of the variables reaction time (RT – upper chart), movement time (MT – middle chart) and radial error (RE – lower chart) for the two groups (EPG – expert players group and IPG – intermediate-level players group) at the blocked and random conditions for the targets ipsilaterally positioned (left side) and contralaterally positioned (right side).

Concerning the MT variable, ANOVA did not reveal main effect of group, but revealed that MT was lower for the blocked condition than for the random condition [$F_{(1.22)} = 5.78$, $p < 0.05$, $\eta^2 = 0.21$] and that the MT was lower when the target was ipsilaterally presented than when it was contralaterally presented [$F_{(1.22)} = 9.34$, $p < 0.01$, $\eta^2 = 0.29$]. Finally, ANOVA for the RE did not reveal any main effect or interaction between and among factors.

DISCUSSION

The aim of the study was to investigate whether badminton expert players (EPG) present neuromuscular alterations which differentiate them from intermediate badminton players (IPG) during a target-pointing task. The only difference found between groups was in RT (e.g., the athletes from EPG presented lower RT when compared to the athletes from IPG). Since the interactions between groups and condition and group and side of target presentation were not significant, such RT result suggests that the athletes with higher performance level react more rapidly to the visual stimulus regardless of the side of the target presentation (ipsilateral and contralateral) or the number of stimuli and responses (blocked and random). Nevertheless, both groups of athletes move the hand and reach the target more rapidly at the blocked condition; that is, in the situation in which the touched target is known in advance (e.g., SRT). Moreover, the results evidenced that the participants take longer (e.g., longer MT) when they have to touch the contralateral target. The results of the RE variable suggest that the level of performance of the athletes, the target site and the target presentation condition did not have effect on the accuracy in the target-pointing task. Since the main effects of side and condition have been widely discussed in the motor control literature and the main aim here was to investigate the differences between groups, we will only discuss the results which involved comparisons between the groups.

Badminton is a modality in which the athlete, in many situations, needs to respond as fast as possible to a visual stimulus. Tests have recorded high shuttle flying velocities during the games, challenging the athletes to perform movements in fractions of a second[14,15]. Since the badminton expert players started their movement in the direction of the target sooner than the players from the intermediate group (approximately 30ms earlier), we could suggest that expert players have better reactive ability than the intermediate-level players and this difference could be crucial to determine the success or lack of it in an action during the game.

The results of some studies have shown that experienced athletes and with better performance levels present lower RT than less experienced athletes with lower performance levels. However, such differences are found, in most cases, in tasks which involve more than one stimulus (e.g., choice reaction time – CRT and discriminated reaction time – DRT). Barcelos *et al.*[6] compared the RT of highly and poorly experienced female volleyball players in two tasks: to press a computer key after the presentation of a stimulus (SRT) and after the presentation of a specific stimulus which was shown inserted in the middle of others (DRT). While difference between groups was not verified for the SRT task, for the task which involved discrimination the more experienced group presented lower RT than the little experienced players. Furthermore, the results of a study with karate athletes revealed that athletes with higher performance and with more competition experience did not react faster than the athletes less experienced and with lower performance in a SRT task, but they were faster CRT in task[16]. In addition to that, the results showed that the difference between groups was even more remarkable when the task involved stimuli specific of the sport (e.g., videos showing karate strokes) than when a new stimulus was given by light points on the monitor. The authors of that study concluded that the familiarity with the stimulus would directly influence the high level and more experienced karate athletes.

Finally, an experiment with Chinese badminton players aged between 15 to 17 years did not present difference between groups classified as with "excellent performance" and of "general performance" for the RT when a stimulus and an option of response were given (SRT) or two stimuli and two options of response were given (CRT). However, when the number of stimuli and options of response was increased to four, which the authors named "high-complexity reaction time task", the group with excellent performance presented lower RTs[10]. Such findings would indicate that the players with "excellent performance" reacted more rapidly than badminton players with "general performance", but this could only be evident when the task complexity (e.g., the number of options for response) was high. Conversely, the results of the present study have already indicated differences between groups for the SRT. The main difference of our study in comparison to the study by Young-min *et al.* was the task performed. In the study by Young-min *et al.*[10], the players remained seated and responded to light stimuli presented on a board pressing keys. In the present study, the badminton players performed a target-pointing task from a standing position, similar to the neutral waiting position adopted by the badminton players. Thus, it is clear that the use of a test which involves more complex motor demands, closer to the ones found in the sports practice, could offer more reliable results than the results obtained in tests which involve only the action of pressing computer keys. Moreover, athletes with different performance levels may be distinguished due to their reactive abilities with the use of this new test, which could make it a promising instrument for detection of talents in many sports that use the upper limb.

Although we have found differences between the groups for the RT, this difference was not extendet to the MT variable. Despite the increase in complexity in the task used in this test (e.g., reaching for and touching a target) compared to the tasks performed in traditional RT tests (pressing a key with a finger), the same was not as complex in motor terms as compare it to the movements performed by the athletes during the badminton games. In this study the participants were asked to move their hands until a certain position in space in order to reach as fast as possible with the pointing finger the center of a static presented target. These movements mainly involved the shoulder and elbow joints. In the game situation it is also necessary that the player takes his/her hand to certain position in space with time limitation. However, the player, during the games, uses an implement (racket), and has to move the body as a whole to increase his/her possibility. These actions require control of a larger number of joint degrees freedom, besides the control involved in the maintenance of body balance. Consequently, the motor task performed in the study, despite its complexity, cannot be compared in complexity level with the motor actions involved in the badminton shuttlecock strokes.

Corroborating this result, a study with fencing athletes did not evidence significant difference between groups of higher and lower performance for the MT in tasks involving reaction to auditory, tactile and visual stimuli and short movements towards to a target (push button) placed 35mm away from the initial position[17]. Another study showed that elderly tennis players, even using more the hands in fast game actions, did not present MT lower than elderly street runners in reaching with the dominant hand a target placed 20cm away from the initial position[18]. However, in a test where karate athletes were asked to perform strokes; that is, movements specific to the sport, the experienced karate athletes group presented lower MT than the less experienced group[19]. In sum, the MT measurement as a determinant factor in performance seems not to be directly related to the results of tests involving unspecific movements, but rather in measurements of movements directly related to the techniques specific to the sport.

Concerning accuracy (RE), our hypothesis thatexpert players would be more accurate in the experiment due to the fact they are generally more successful in reaching the desired places on court with the shuttlecock than the non-experienced players[13,20] was rejected. The rejection of this hypothesis takes us back to the task complexity. Besides the movement of the upper limb of a badminton player in direction to the shuttle being more complex than pointing movement used in this study, the target to be reached (shuttle) is always in movement, contrary to the target presented in this study. It is possible that differences in accuracy between groups would be evident if the targets unexpectedly changed the direction (double-step would be). It is also necessary to stress that the measurement of accuracy of the strokes in a game situation[20] is done at competition demands which require high physical and psychological conditions. Conversely, our test require much lower physical stress and psychological barriers than those found in competitive situations.

CONCLUSION

Based on the results of the present study, it can be concluded that the expert badminton players evaluated react more rapidly to a visual stimulus than intermediate-level players during a target-pointing task, which could be an indication that the ability to react to a visual stimulus could act as a restriction to the athletes with lower performance to reach higher performance levels in this sport. Moreover, we can conclude that intermediate-level players are able to perform movements as fast and accurate as the expert athletes. Nevertheless, they need a longer time to plan these movements.

Furthermore, we can conclude that the test used, despite not fully representing the game actions, can be considered as an advance when compared to the commonly used tests in the response time (RT and MT) investigation in athletes, and hence, should be used to evaluate athletes, especially of those who practice sports with great participation the upper limbs.

All authors have declared there is not any potential conflict of interests concerning this article.

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