Effects of training in the preparatory phase on amateur badminton players' performance

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Abstract

The main aim of the present study was to verify the effect of eight weeks of training during the preparatory phase on performance variables for amateur Badminton players. A second aim was to monitor the internal training load (ITL) during the training period. Seven state-level amateur badminton players performed a battery of tests at pre and post eight training weeks. The following performance tests were performed: vertical jump, badminton-specific movement agility test, 5m-Multiple shuttle test (5m-MST) and Yo-Yo intermittent recovery test level 1 (Yo-Yo test). After each training session, ITLs were monitored by session rating of perceived exertion (sRPE). Although there were no statistically significant differences between pre- and post-training, it was found an increase of 5.4 ± 9.3%, 4.7 ± 10.4%, and 4.7 ± 16.7%, respectively, in the 5m-MST, vertical jump performance, and Yo-Yo test after the training period. The ITL demonstrated that the preparatory phase presented a variation (e.g., low to high) during general preparatory phase (GP) and high ITL during specific preparatory phase (SP). Therefore, eight training weeks during the preparatory phase promoted important improvements in individuals' analysis and percent change values on vertical jump, the 5m-MST, and the Yo-Yo test, although there were no statistically significant differences. Furthermore, the ITLs varied throughout the training period.

Keywords: Racquet sports; Physical assessment; Training loads; Longitudinal monitoring.

Introduction

Badminton has developed significantly in recent years and is known as the fastest racquet sport in the world[1]. Badminton matches include a combination of long, moderate, and short high-intensity rallies and require both aerobic (≈60-70%) and anaerobic (≈30%) energy systems[1-5]. Badminton players must possess a high level of agility combined with accurate technical execution when performing specific strokes, allowing rapid changes of direction followed by specific postural positions that assist them in hitting the shuttlecock[6,7].

To verify the effects of training on players' performance, it is necessary to carry out physical evaluations or tests to identify changes in their physiology and performance during different training phases (e.g., preparatory), and consequently demonstrate the improvements in their performance that can be attributed to badminton training[4,8,9]. Thus, specific tests should be performed to evaluate badminton players' physical fitness. Past studies have used a variety of physical tests to assess the most important capacities related to the badminton performance, such as aerobic and anaerobic performances, muscular power and agility[10-12].

Few studies have attempted to identify the effects of badminton training on physiological and performance variables[8,9,13]. In a study with elite badminton athletes, Walklate et al.[9] examined whether supplementing a training program with sessions of badminton-specific agility-sprint training led to any changes in players' performance. The authors found that the group with complementary training had a higher repeated-agility sprint performance compared to the control group. Wee et al.[13] examined the effects of a four-week period of high intensity intermittent badminton multi-shuttle training on performance variables and found significant improvements in maximal oxygen uptake ($\dot{V}O_{2max}$) and agility in eighteen university college badminton players. It is important to note that in these studies[9,13], participants performed their normal badminton training routines with supplementary high- intensity training. However, no study thus far has evaluated the effect of a specific training phase (e.g., preparatory) on performance variables, especially for amateur badminton players.

Positive adaptations of physical fitness must be achieved through systematic and specific training prescribed with consideration of appropriate loads[14,15]. In addition to performance tests, an important tool used in sports is training load monitoring, which is crucial for achieving training outcomes, improving performance, and avoiding overtraining[16,17]. Training loads may vary according to training phases respecting progress and adaptations to different physical aspects[17,18]; for example, in the preparatory phase, the objective is to develop general and specific physical capabilities that will support the players' best performance during the competitive period[18,19].

In badminton in particular, some studies have sought to monitor the internal training load (ITL) using methods based on physiological variables such as heart rate (HR)[13,20-22], blood lactate concentrations, urea, uric acid and creatine phosphokinase[14,23]. However, none of these studies aimed to show the ITL during the preparatory phase. Furthermore, concerning the session rating of perceived exertion (sRPE)[24], although some studies of tennis have used this method to quantify ITL at different training phases[25-27], no badminton research has used this method to monitor ITL, as far as our knowledge. Therefore, the main aim of the present study was to verify the effect of eight weeks of training during the preparatory phase on performance variables for amateur badminton players. A second aim was to monitor the ITL during this training period. Our hypothesis is that players' performance will improve after the training period and ITL will vary from low to high loads.

Methods

Participants

Seven (four men and three women), young, amateur badminton players with 20.1 ± 5.3 years participated in this study. The body composition measures (mean ± SD) were: body mass 61.9 ± 13.2 kg; height 167.0 ± 11.8 cm; body mass index (BMI) 22.1 ± 3.4 $kg{\cdot}m^{-2}$; body fat: 15.5 ± 8.1%. Prior to testing, all participants signed the Physical Activity Readiness Questionnaire (PAR-Q)[28] and written informed consent was obtained from all participants. Procedures and test protocols were explained individually for each participant. The experimental protocol was approved by the local Human Research Ethics Committee (#3.091.191/2018). The research was conducted in accordance with international ethical standards.

Experimental design

Participants performed a battery of physical tests pre and post the preparatory phase of eight training weeks. The training sessions were prescribed by coaches, and researchers did not alter or ask coaches to alter training sessions in any way. All assessments were performed at the same place as the players training and at the same time of the day, on three alternate visits and with an interval of 48 hours between each visit. On the first day, body composition measures were taken and the players completed the vertical jump test and the 5-m multiple shuttle test (5m-MST)[29] to determine sprint performance; between each test there was an interval of 20 min with passive recovery.

On the second day, the badminton-specific movement agility test[11] was performed. In the last day, the Yo-Yo intermittent recovery test level I (Yo-Yo test)[30,31] was applied to determine aerobic performance. The tests were performed individually and all participants were familiar with the testing protocols and procedures. For all physical tests the participants were instructed to avoid strenuous exercise 24 hours before the assessments and to perform maximally throughout the test. Furthermore, during the eight weeks, internal training load (ITL), monotony and strain were monitored by the session rating of perceived exertion (sRPE) after each training session. FIGURE 1 shows the experimental design of the study.

Body composition measures

The variables used to characterize the participants were body mass and height for calculating BMI, and the percentage (%) of fat. A stadiometer attached to the wall was used to measure height, and to measure body mass a Wiso® digital scale was used. BMI was calculated from: body mass / height^2. The % of fat was obtained using the bipolar digital bioimpedance device with tactile poles (Omron, model HBF-306BL, Omron Healthcare Corporation, Japan), in which the participants were instructed to fast (without eating and consuming water) two hours before collection and to abstain from exercise 24h before the evaluation[32].

Vertical jump

Participants performed three attempts of countermovement jump (CMJ), with 20 s of recovery between them, and the best performance was used for the analysis. Firstly, the wingspan of the players was measured, in which the appraised should position the graduated surface laterally with the soles of the feet fully resting on the ground and the arm extended above the head. The measurement from the floor to the tip of the middle finger was considered the wingspan. Before testing, the players performed self-administered submaximal CMJ. To test CMJ, each participant performed the vertical jump with the arms help and started from the erect standing position (180° knee angle). For the execution of the movement, the arms moved back and forth synchronously to the leg flexion and extension. The test consists of jumping as high as possible, with the participants having to make a mark with their fingers at the highest distance they could reach33. The jump score (cm) was calculated from the difference between the wingspan and the total height of the vertical jump.

5-m Multiple shuttle test (5m-MST)

The 5m-MST was performed according to the methods described by Boddington et al.[29] to determine sprint performance. Each participant had 10 min to complete own specific warm-up and two submaximal efforts of the 5m-MST. For this test, six cones were placed 5 m apart from each other in a straight line to cover a total distance of 25m. The test consisted of six sprints with a change of direction, with run time of 30s sprint and 35s recovery time between sprints. To start the test the players positions themselves in the first cone and upon an auditory signal they sprinted 5m to a second cone, touched the ground with one hand

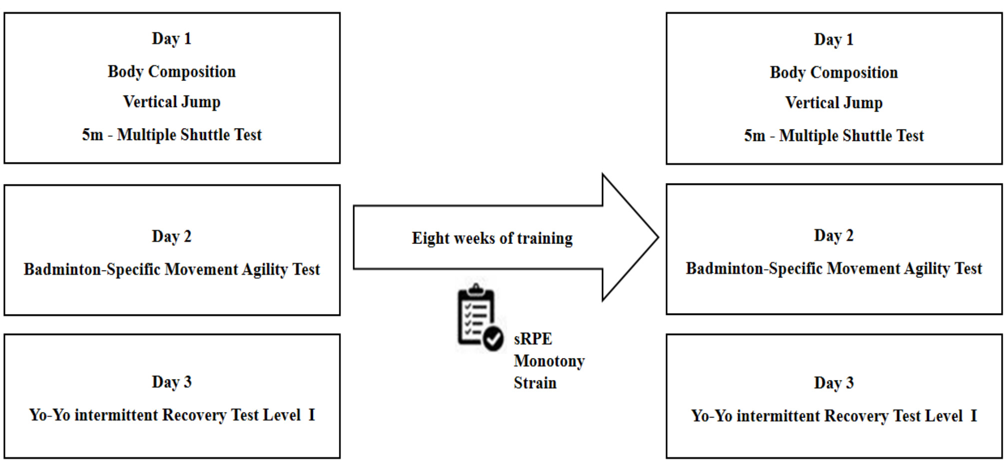


FIGURE 1 - Schematic representation of the study experimental design.

and returned to the first cone. Then, they sprinted 10m to a third cone and back to the first cone, etc., until 30s (e.g., shuttle) of exercise had been completed. The distance covered by each participant was recorded to the nearest 2.5 m during each 30-s shuttle. The participants were then allowed 35s recovery, during which they walked back to the first cone. To complete one test session the participants performed this 30 s shuttle and 35 s recovery six times. The players were instructed to touch all the cones using the hand that handles the racket and also when approaching the cones, they should perform displacement similar to that used in badminton. The players should remain in the test until voluntary exhaustion and accumulate the greatest possible distance within the execution time. The performance was determined by the total distance (m) (the total distance covered during the 6×30-s shuttles). Is was also calculated the fatigue index from the equation: 5m-MST fatigue index = [(sprint 1 + sprint 2) / 2 - (sprint 5 + sprint 6) / 2] / (sprint 1 + sprint 2) / 2 * 100)[29].

Badminton-specific movement agility test

The test to determine agility was performed with specifics badminton movements using the protocol described by Ooi et al.[11]. Each participant had 10 min to complete own specific warm-up and two submaximal efforts on the badminton-specific movement agility test. The test was performed on a single Badminton court with standardized measures and required players to perform rapid sideways and diagonal movements with abrupt changes in direction to touch the shuttlecocks with their hands. The test had two phases (a sideways agility phase and a four-corner agility phase), in which the players should position themselves in the central base of the court to start and return with at least one foot to the center of the court to validate their execution during and at the end of the test. The total duration time of the two phases was considered the results and between the phases the players had five minutes for recovery.

The first phase was performed with sideways agility movements, in which the players had to move laterally across the width of the court for a total of 10 repetitions in order to strike each up-turned shuttlecock placed at each corner. There were five shuttlecocks on each side of the court on the lateral line at a distance of 30 cm between them. In the second phase of the test, there were four shuttlecocks positioned diagonally in the four corners of the court within the service zones with a distance of 30cm between them. In this phase, the players moved diagonally in a sequence of four different directions for a total of 16 repetitions. For the data analysis the duration times of phase 1 and phase 2 were added and it was used as the test duration.

Yo-Yo Intermittent recovery test level I (Yo-Yo test)

The Yo-Yo test was conducted according to established methods[30,31]. The test consisted of repeated 2 x 20 m runs at a progressively increased speed, which was controlled by audio beeps located immediately adjacent to the 20m long running lanes indicated by markers. Between each running bout, the participants had a 10s rest period in which they were required to move to a cone 5 m away before returning to the start line. The first stage of the test started with a speed of 10 $km \cdot h^{-1}$; between stages 1 and 2 the speed increment was 2 $km \cdot h^{-1}$ and between stages 2 and 3 the increment was 1 $km \cdot h^{-1}$. From the third stage onwards, the speed increment between the stages was 0.5 $km \cdot h^{-1}$. The participants should remain in the test until voluntary exhaustion. The parameters analyzed were the total distance covered (m) and the maximal oxygen uptake ($\dot{V}O_{2max}$) was predicted from the formula: $\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$) = Distance (m) x 0.0084 + 36.416.17.

Training program during the preparatory phase

The training program consisted of eight weeks of traditional badminton training during the preparatory phase, with a frequency of three sessions per week, lasting 120 minutes each session. During the study, there was no interference of the researchers in the training prescription, which was divided into a general preparatory phase (GP) (weeks 1, 2, 3 and 4) and a specific preparatory phase (SP) (weeks 5,6,7 and 8) with three training types (e.g., physical, technical and tactical). The physical training program included sessions focused on different physical capacities: motor coordination, agility, flexibility, aerobic capacity, anaerobic power, muscle strength and endurance. In technical training, the improvement of specific and fundamental technical strokes was the focus and as well as the specific badminton movements. During tactical training exercises were performed on tactical perception, space perception, and identification of the opponent's position, reaction time and problem solving. TABLE 1 brings the training distribution during the GP and SP periods.

Internal training load (ITL)

During the eight-week period, ITLs were monitored through the session rating of perceived exertion (sRPE) proposed by Foster et al.[24]. This method was used to determine the ITL, monotony and strain of each week. The players responded to the CR-10 scale, considering the training session performed; the response was collected 30 minutes after the end of the session to ensure that the perceived effort was based on the entire session and not on the final intensity of the exercise. To quantify the ITL, the duration of the session (minutes) was multiplied by the RPE score (CR10) classified by the player. From the training load data, strain and monotony were calculated weekly. Monotony was calculated by dividing the average load of the week by the standard deviation, while the strain was calculated by multiplying the monotony by the weekly sum of training loads[24].

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) (Version 15.0 for Windows; SPSS, Inc, Chicago, IL, USA) was used to perform the analysis. The normality of the data was verified by the Shapiro-Wilk test and the data are presented as mean ± standard deviation (SD). For comparisons between pre- and post-training, the dependent t test was used. Additionally, the percentage change value (%) was calculated for each variable. For the comparisons between ITL, monotony and strain during the weeks, Anova for Repeated Measures was used followed by Bonferroni post hoc for multiple comparisons. The level of significance adopted was $P < 0.05$.

TABLE 1 - Percentage distribution of training types across the 8-week preparatory phase (PP).

	General Preparation (GP) (1440 min)					Specific Preparation (SP) (1440 min)					Preparatory Phase (PP)
	Wk 1	Wk 2	Wk 3	Wk 4	Mean ± SD	Wk 5	Wk 6	Wk 7	Wk 8	Mean ± SD	Mean ± SD
Physical (%)	55	60	50	45	52.5 ± 6.5	43	40	30	30	35.8 ± 6.8	44.1 ± 10.8
Technical (%)	35	30	30	40	33.8 ± 4.8	50	40	40	45	43.8 ± 4.8	38.8 ± 6.9
Tactical (%)	10	10	20	15	13.9 ± 4.8	7	20	30	25	20.5 ± 9.9	17.1 ± 8.0

Notes:
Wk: week;
SD: Standard deviation.

Results

Participants performed 22.9 ± 2.0 sessions and had a frequency of 87.9 ± 7.8% during the eight-week training period. TABLE 2 present the results obtained during the physical tests performed before and after the preparatory phase. No significant differences were found between the pre- and post-training ($P > 0.05$). However, from the analysis of the % change values, it was found an increase of 4.7 ± 10.4% in the vertical jump, an improvement of 5.4 ± 9.3% of the distance covered in the 5m-MST and stands out and the reduction of the fatigue index of -14 ± 36.6%. Additionally, for the Yo-Yo test a positive change of 4.7 ± 16.7% was found concerning the distance covered.

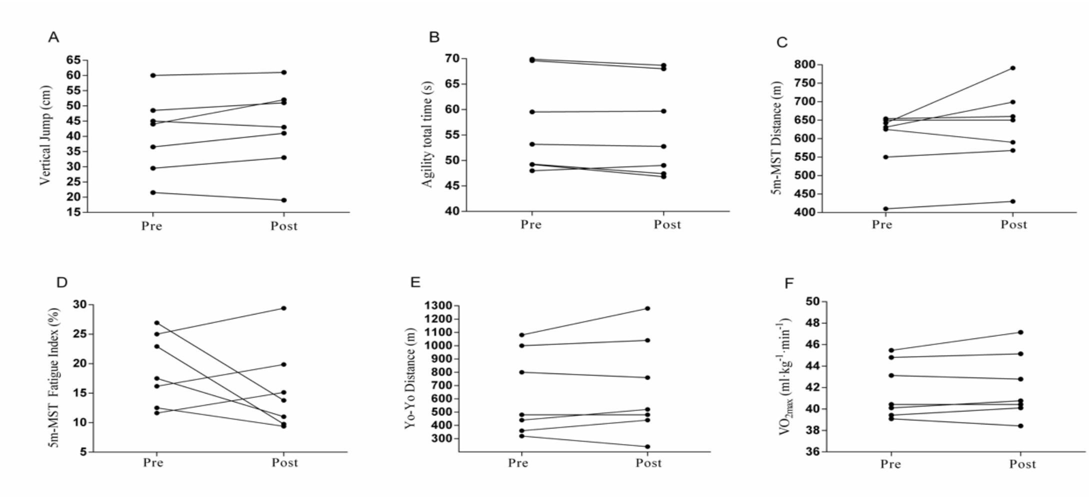
FIGURE 2 shows the individual results obtained from the physical tests performed pre- and post-training. For the vertical jump, it was observed that only two players did not obtain an improvement in performance. For the specific agility test, five players decreased the total execution time. Concerning the 5m-MST distance, five players increased the distance covered. The Yo-Yo distance values revealed that four players increased the total distance covered.

TABLE 3 shows the individual sRPE score (CR10) for weekly averages and training phases. In the general preparatory phase, the average of the players varied between 2.8 ± 0.9 and 4.5 ± 1.6. In the specific preparatory phase, the average of the players varied between 5.4 ± 1.3 and 7.0 ± 2.0.

TABLE 2 - Variables obtained from the performance tests of amateur badminton players at pre- and post-training (mean ± SD).

Variables	Pre-training	Post-training	% change
Vertical jump (cm)	40.7 ± 12.7	42.9 ± 13.8	4.7 ± 10.4
Agility total time (s)	56.9 ± 3.6	56.0 ± 3.6	-1.6 ± 2.4
5m-MST distance (m)	594.6 ± 88.7	626.9 ± 113.5	5.4 ± 9.3
5m-MST fatigue index (%)	19.0 ± 6.1	15.5 ± 7.1	-14.0 ± 36.6
Yo-Yo distance (m)	640.0 ± 315.0	680.0 ± 368.1	4.7 ± 16.7
$\dot{V}O_{2max}$ (ml·kg^{-1}·min^{-1})	41.8 ± 2.6	42.1 ± 3.1	0.8 ± 1.8

Notes:
n = 7;
5m-MST: 5m multiple shuttle test;
Yo-Yo test: Yo-Yo intermittent recovery test level 1;
$\dot{V}O_{2max}$: maximum oxygen uptake;
SD: standard deviation.



Notes:
n = 7;
5m-MST: multiple shuttle test;
Yo-Yo: Yo-Yo intermittent recovery test level 1;
$\dot{V}O_{2max}$: maximum oxygen uptake.

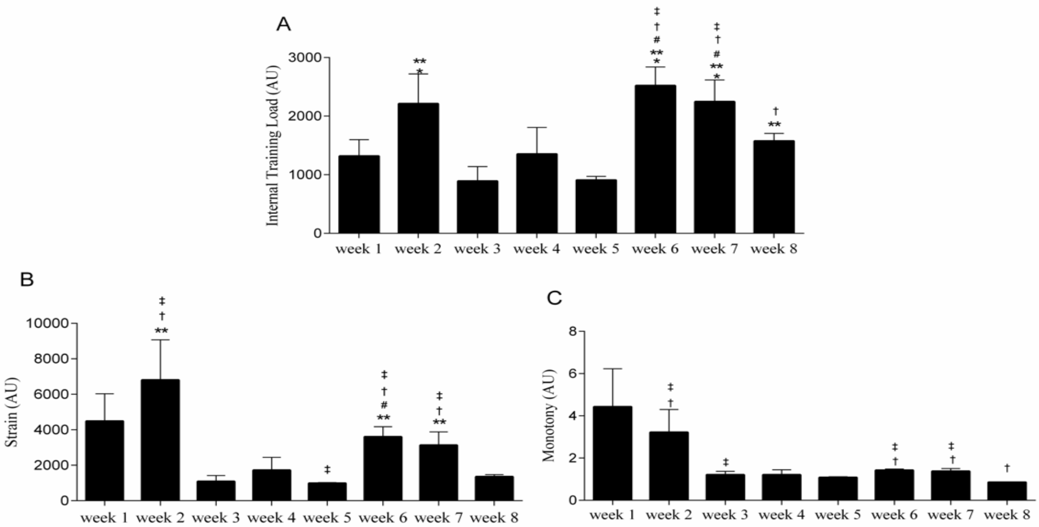
FIGURE 2 - Individual results for vertical jump (A), agility total time (B), 5m-MST distance (C), 5m-MST fatigue index (D), Yo-Yo distance (E) and $\dot{V}O_{2max}$ (F) obtained from the performance tests of amateur badminton players at pre- and post-training.

TABLE 3 - Individual and group mean ± standard deviation (SD) for sRPE score (CR10) across the 8-week preparatory phase.

	General Preparation (GP)					Specific Preparation (SP)					Preparatory phase (PP)
	Wk 1	Wk 2	Wk3	Wk 4	Mean ± SD	Wk 5	Wk 6	Wk 7	Wk 8	Mean ± SD	Mean ± SD
P1	2.7 ± 0.6	4.0 ± 1.0	3.0 ± 1.0	4.5 ± 0.7	3.5 ± 0.9	3.5 ± 0.7	6.3 ± 1.5	5.7 ± 2.1	6.0 ± 1.4	5.4 ± 1.3	4.5 ± 1.4
P2	2.3 ± 0.6	4.0 ± 1.0	3.0 ± 0.0	2.0 ± 2.8	2.8 ± 0.9	4.0 ± 1.4	6.3 ± 2.1	6.0 ± 1.0	6.5 ± 0.7	5.7 ± 1.2	4.3 ± 1.8
P3	2.3 ± 0.6	3.7 ± 0.6	2.0 ± 0.0	3.7 ± 1.4	2.9 ± 0.9	3.5 ± 0.7	6.3 ± 1.5	6.0 ± 1.7	6.0 ± 1.4	5.5 ± 1.3	4.2 ± 1.7
P4	3.5 ± 0.7	5.0 ± 2.6	3.5 ± 0.7	4.3 ± 1.4	4.1 ± 0.7	4.0 ± 1.4	6.3 ± 0.6	7.0 ± 0.0	6.5 ± 0.7	6.0 ± 1.3	5.0 ± 1.4
P5	3.0 ± 2.6	6.7 ± 1.5	4.0 ± 1.4	4.3 ± 1.4	4.5 ± 1.6	3.5 ± 0.7	7.3 ± 1.5	6.7 ± 1.5	6.5 ± 0.7	6.0 ± 1.7	5.3 ± 1.7
P6	2.7 ± 1.2	5.7 ± 2.1	2.5 ± 0.7	4.7 ± 1.4	3.9 ± 1.5	4.0 ± 1.4	8.0 ± 1.0	6.7 ± 0.6	7.0 ± 0.0	6.4 ± 1.7	5.1 ± 2.0
P7	2.5 ± 0.7	5.5 ± 0.7	3.7 ± 1.5	5.0 ± 2.1	4.2 ± 1.4	4.0 ± 1.4	8.3 ± 0.6	8.0 ± 0.0	7.5 ± 0.7	7.0 ± 2.0	5.6 ± 2.2

Notes:
P: Player;
Wk: week.

FIGURE 3 shows the results regarding weekly ITL, monotony and strain. Concerning the comparisons between ITL during eight weeks, the following significant differences between weeks were observed: 1 *vs* 2, 6 and 7; 2 *vs* 3; 3 *vs* 6, 7 and 8; 4 *vs* 6 and 7; 5 *vs* 6, 7 and 8; 6 *vs* 8 and 7 *vs* 8. For monotony, the following significant differences were found: 2 *vs* 5 and 8; 3 *vs* 8; 5 *vs* 6, 7 and 8; 6 *vs* 8 and 7 *vs* 8. Finally, the significant differences found for training strain were: 2 *vs* 3, 5 and 8; 3 *vs* 6 and 7; 4 *vs* 6; 5 *vs* 6, 7 and 8; 6 *vs* 8; 7 *vs* 8.



Notes:
n = 7;
AU: arbitrary unit.
* $p < 0.05$ in relation to week 1;
** $p < 0.05$ in relation to week 3;
# $p < 0.05$ in relation to week 4;
† $p < 0.05$ in relation to week 5;
‡ $p < 0.05$ in relation to week 8.

FIGURE 3 - Average weekly training load (A), strain (B) and monotony (C) of the amateur badminton players across the 8-week preparatory phase.

Discussion

The main aim of this study was to verify the effect of eight weeks of training during the preparatory phase on performance variables for amateur badminton players. A second aim was to monitor the ITL during this training period. The main findings of this study were that, although there were no statistically significant differences between pre- and post-training, important improvements were observed based on percent change values and individual analysis on vertical jump performance, 5m-MST distance and the Yo-Yo test after the training period. Furthermore, the preparatory phase presented a variation (e.g., low to high) in ITL during GP and high loads during SP. Furthermore, we observed that during the 8-week preparatory phase the sRPE score, assessed individually, varied between 4.2 ± 1.7 and 5.6 ± 2.2.

Performance variables assessed using physical tests are important for badminton players because they reflect the specific physical capacities necessary for good performance during competitions. Thus, badminton training programs need to focus on the improvement of agility, sprint capacity, muscle power, and aerobic performance, which reflect positive physiological adaptations[5,34].

Our findings showed that, although there were no significant differences between the pre- and post-training for vertical jump performance, there was an increase of 4.7 ± 10.4% for jump height. The results of our study are similar to those of Wee et al.[13], who evaluated 18 college badminton athletes and identified that after a four-week period of complementary high-intensity-intermittent badminton multi-shuttle training, there was no significant difference between pre- and post-training for leg power assessed with jumping platforms. It is important to mention that players' agility influences the power and strength of the lower limbs (e.g., legs), suggesting that specific agility training involving rapid displacements leads to improvements in the reaction strength of athletes' legs[3,7,35].

Concerning the agility test, we found no significant differences between pre- and post-training and a small percentage change of 1.6 ± 2.4%. In contrast to our findings, studies that evaluated the effect of a training period on badminton agility performance identified better improvements[9,13,36]. For example, Wee et al.[13] showed a significant improvement of 3.2% in the agility test in male university badminton players who participated in complementary training involving high-intensity intermittent-agility actions. Walklate et al.[9] also identified improvements in the performance of repeated-agility-sprint in national elite level badminton athletes; the control group (i.e., traditional badminton training) increased 1.4 ± 1.2% the agility test and the experimental group with supplementary repeated sprints training change 5.0 ± 3.1 % after the training period. It is important to note that our results were similar to those of the group with traditional badminton training.

The results of these studies[9,13,36], indicate that complementary training strategies (e.g., high intensity intermittent agility actions, plyometric or sprint training) are important in promoting improvements badminton players' agility and reactive strength. In addition, technical training with specific displacements are essential for positive adaptations in coordination and consequently in agility[13,21,37].

Furthermore, our findings identified individual improvements for five players (FIGURE 2C) in the 5m-MST and an increase of 5.4 ± 9.3% in the total distance covered after the training period, although the data showed no statistical difference. Ooi et al.[11] evaluated elite and sub-elite athletes in one moment only and identified an average value of 752.8 ± 21.2m in the total distance covered in the 5m-MST. As expected, a comparison of this finding with our results highlights the differences in the performances of elite and amateur players (626.9 ± 113.5m at post-training).

To date, no study has demonstrated the effect of training on badminton players' 5m-MST performance. However, other studies have verified the effect of training on sprint performance using other tests with fixed sprint distances[9,37]. Walklate et al.[9] found that four weeks of repeated sprint training modified sprint performance less than 1% for the 10 and 20-m tests in national elite level badminton athletes; it is important to mention that the test involved one sprint, while our study used multiple sprints. The high-intensity, short-duration actions performed in modalities such as tennis and badminton place significant demands on the anaerobic system and great demand for glycolytic metabolism[1,4,5], and improvements in multiple sprint tests demonstrate an important contribution to badminton match performance.

The results obtained from the Yo-Yo test in the present study showed an increase of 5.4 ± 9.3% in the distance covered after the training period. Four players were able to improve their performance in this variable (FIGURE 2E), although no statistically significant difference was identified between pre- and post-training. As aerobic performance and fast recovery between rallies is essential for performance in badminton and players reach maximum and sub-maximal $\dot{V}O_{2max}$ during badminton matches, a high distance in the Yo-Yo test is reflected positively in badminton players' performance[4,12].

No study thus far has reported the effect of a training period on badminton players' performance in Yo-Yo test. Nevertheless, some studies have measured aerobic performance (e.g., $\dot{V}O_{2max}$) using other physical tests[9,10,13]. For example, Walklate et al.[9] found that traditional badminton training changes badminton athletes' performance in the 20 meter-multistage shuttle run test by 1.2%, a lower percentage compared to the results of our study. Wee et al.[13] observed that only the group with additional training improved the $\dot{V}O_{2max}$ (i.e., 10.1%) determined by an incremental treadmill test; however, the performance of the control group did not change for this variable.

Concerning the individual sRPE score across the 8-week, the present results showed a variation between 4.2 ± 1.7 to 5.6 ± 2.2 (TABLE 3); these values when multiplied by the duration of the session (min) generate the magnitude of the ITL[38]. The sRPE assessed individually allows coaches to monitor the internal responses arising from the training according to the performance of each athlete, so that they can define new training stimuli[39-41]. Murphy et al.[25] when monitoring fourteen elite-level junior tennis athletes over a 16-week hard-court training (21 ± 3 sessions, with a mean on-court duration of 71.8 ± 10.9 min.), found a variation in sRPE score between 4.6 ± 1.9 and 6.5 ± 1.8 A.U. Unlike Murphy et al.[25], the present study identified small average sRPE values.

In addition, it is important to assess the magnitude of the ITL and performance changes that are promoted. Figueiredo et al.[39] when individually monitoring the ITL of sixteen elite male under-19 soccer players during a preseason, identified high ITL values during the first weeks of training. (1770 ± 127; 3656 ± 423; 3866 ± 406 A.U.), followed by a reduction in the last week (1486 ± 131 A.U.), and identify significant improvements in intermittent running performance. Different from Figueiredo et al.[39], our results show that during the GP the individual sRPE scores were lower compared (2.8 ± 0.9 to 4.5 ± 1.6) to the SP (5.4 ± 1.3 to 7.0 ± 2.0), that is, ITL were higher in the last weeks of training, which can be detrimental to performance.

It is important to note that our results demonstrated sRPE values below that what is expected to generate performance adaptations during the pre-season[27,39,41]. However, this can be explained by the performance level of the players (amateurs) and the non-competitive higher-level objective of the participants, which can limit comparisons with elite athletes.

Another important result was the ITL response during the preparatory phase, which demonstrated a constant volume with high intensities in the weeks 1 and 2, low and stable intensities in weeks 3, 4 and 5; as the training advanced, the intensities increased (weeks 6, 7 and 8). Thus, we identified a variation of ITL during GP and a high intensification on EP. Gomes et al.[27] investigated the effects of the periodized preparatory phase on ITL for well-trained young tennis players evaluated by sRPE; in contrast to ours findings, the authors showed that ITL increased significantly during weeks 3 and 4 compared do week 1, and reduced in the last training week (i.e., week 5). It is important to mention that although some studies monitored training loads in badminton using physiological variables[13,14,23], no study demonstrated ITL, monotony and strain obtained by sRPE.

During the period evaluated in the present study, monotony was high in weeks 1 and 2, but it remained low and stable throughout the other weeks. This result was similar to that of Gomes et al.[27], who found similar monotony responses during the preparatory training phase, in which the values remained relatively stable and near to 2AU from weeks 2 to 4. These values presented in both studies are important because monotony index greater than 2AU indicates a risk factor for illness and overtraining in athletes[40]. Despite this similarity in relation to monotony values, it is important to highlight that the intensification of ITL was different comparing our study to Gomes et al.[27], especially due to the load reduction strategy adopted (i.e., tapering period) in end phase of the preparatory period used by Gomes et al.[27].

The intensification and gradual reduction of training loads during the preparatory phase have been reported as an adequate approach for training periodization[39,41,42]. For example, Bosquet et al.[41] found that the ideal strategy to optimize pre-competitive performance is a two-week training load reduction intervention, in which the training volume decreases exponentially without any change in training intensity and frequency. However, in the present study, we found high loads in the last training weeks of the preparatory phase, suggesting that these responses may have been detrimental to performance improvements in amateur players, given that these last weeks precede the pre-competitive period.

Although the present study provides important results for badminton training in amateur players, some limitations must be must be acknowledged, for example the vertical jump evaluation was conducted without a jumping platform to calculate the muscle power. Another limitation is the lack of a control group; however, this is justified because the study was conducted with badminton players under a real preparation program, making it difficulty to recruit a control group with similar characteristics.

In conclusion, eight weeks of training during the preparatory phase promoted important improvements in individuals' analysis and percent change values on vertical jump, the 5m-MST, and the Yo-Yo test, although there were no statistically significant changes in the performance variables. Furthermore, we observed that during the 8-week preparatory phase the sRPE assessed individually shows a small variation (4.2 ± 1.7 and 5.6 ± 2.2 A.U.). The ITL varied throughout the training period, with low to high loads during GP and high loads during SP. Future studies should investigate other training phases to evaluate longitudinal changes during a longer training period and examine high-level badminton athletes.

The present study highlights the importance of analyzing individual performance changes during a training period in badminton through specific tests that evaluate the capacities of badminton players. In practical applications, the evaluations carried out in the present study are validated and do not require technological resources; thus, coaches may use them to evaluate their athletes to obtain feedback with scientific rigor. It is important to emphasize that performance tests make it possible to determine physical preparation in different training phases to test the effectiveness of the applied training method, to establish training control standards, and to appreciate the progress that athletes achieve.

Furthermore, ITLs were reported during the preparatory phase based on the sRPE method, a simple method that allows the quantification of individuals' sRPE after training sessions, thus helping to monitor the acute effect generated by each session. Finally, the results of the present study provide new information about performance tests and the distribution of training loads in amateur badminton players during a preparatory phase, which can help coaches prescribe more successful badminton training programs.

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Declaration

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Resumo

Efeitos do treinamento na fase preparatória no desempenho de jogadores amadores de badminton.

O objetivo principal do presente estudo foi verificar o efeito de oito semanas de treinamento durante a fase preparatória nas variáveis de desempenho de jogadores amadores de badminton. Um segundo objetivo foi monitorar a carga interna de treinamento (CIT) durante este período de treinamento. Sete jogadores amadores de badminton em nível estadual realizaram uma bateria de testes antes e depois de oito semanas de treinamento. Foram realizados os seguintes testes de desempenho: salto vertical, Badminton-specific movement agility test, 5m-Multiple shuttle test (5m-MST) e o teste Yo-Yo intermittent recovery test level 1 (Yo-Yo teste). Após cada sessão de treinamento, as CITs foram monitoradas pela percepção subjetiva de esforço da sessão (sPSE). Embora não tenha havido diferença estatisticamente significante entre o pré e o pós-treinamento, verificou-se um aumento de 5,4 ± 9,3%, 4,7 ± 10,4% e 4,7 ± 16,7%, respectivamente, no 5m-MST, desempenho do salto vertical e Yo-Yo teste após o período de treinamento. A CIT demonstrou que a fase preparatória apresentou uma variação (por exemplo, baixa à alta) durante a fase preparatória geral e alta CIT durante a fase preparatória específica. Portanto, oito semanas de treinamento durante a fase preparatória promoveram melhorias importantes na análise dos indivíduos e nos valores percentuais de alteração no salto vertical, no teste de 5m-MST e no Yo-Yo test, embora sem diferenças estatisticamente significantes. Além disso, as CITs variaram ao longo do período de treinamento.

Palavras-chave: Esportes de raquete; Avaliação física; Cargas de treinamento; Monitoramento longitudinal.

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