Massed and Distributed Practice on Learning the Serve in Recreational Tennis Players

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Article

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Abstract: This study examined how practice distribution schedules influenced accuracy and efficacy in the tennis serve. 24 recreational players were randomized into two experimental groups. Both groups carried out 4 series of 10 services per session during 12 sessions. Massed practice group did not rested between services and rested 10 seconds between series. Distributed practice group rested 10 seconds between services and 30 seconds between series. The accuracy and efficacy were registered and computed based on the 2D digitalization. The learning and retention were tested in a post-test and retention test. The learning program increased the efficacy in the post-test in both groups (p =.001 massed group; p =.015 distributed group). On the retest, the group of massed practice decreased efficacy (p =.021). In accuracy, the group of massed practice reduced its performance in the post-test (p =.015). The effects of the program on the accuracy in the retention test were not observed. It is concluded that this type of sports learning programs, applied at a recreational level, can provide a rigorous approach that contributes with guarantees to the learning of tennis.

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Introduction

Tennis is a sport practiced recreationally throughout the world. There are millions of tennis players and we're here to support every one of them. The International Tennis Federation have the aim to increase participation in tennis for all ages, genders, playing standards and physical abilities, anywhere the game is established or developing. Its promotion as a sports practice contributes to the maintenance of healthy lifestyle habits, both physically and psychologically, but it is essential that learning programs are developed from a scientific perspective. This contributes to implementing a structured and rigorous practice, which ensures quality intervention and guarantees the adherence of practitioners. In this sense, authors such as Lundvall & Jakobsson (2021) establish that sport constitutes a cultural and social practice and that a person requires specific dispositions if they are to be comfortable with, and want to continue, their practice in a certain field. Others, such as Carlman & Hörman (2022), emphasize the importance of considering, by young people, the choice of practicing sport according to their personal, political, economic, cultural and geographical contexts. Thus, providing the learning of tennis with scientific support adds to these interests, contributing to obtaining a positive assessment of this sport from young practitioners.

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Under this approach, the distribution of practice is a way of manipulating practice conditions, and managing learning sessions, in order to generate adjustments to the performers and to improved performance. Therefore, it is considered one of the contextual factors that influence performance levels (García et al., 2008). There are two types of practice (Magill, 2011; Schmidt and Lee, 2005): massed or concentrated and distributed. Massed practice schedule can be characterized by a small period of recovery and trials are grouped in the same task. Distributed practice schedule means longer intervals of rest between trials, although the number of these is the same as in the concentrated practice (Dail and Christina, 2004; Lee and Genovese, 1988; Leite et al., 2013).

Most studies on practice distribution effects have been conducted on continuous skills, with only a few studies examining discrete, lab-based tasks (Panchuk, Spittle, Johnston, & Spittle, 2013). This implies a shift away from the actual game situations and hinders the transfer and generalization of findings.

In general, discrete learning tasks using distributed practice have produced a lower acquisition than massed practice, thus experimental results have not supported the benefits of distributed practice (García et al., 2008). In a study in which individuals performed a discrete task, the group of massive practice not only performed best during acquisition, but also in the following retention tests (Lee & Genovese, 1988). Moreover, participants who performed the task in a distributed practice showed significant reductions in retention compared to the group of massed practice. Nevertheless, it was suggested that the type of practice schedule used by Lee and Genovese (1988) carried out with short rest intervals between repetitions in one session should normally be conducted over two or three days (Shea et al., 2000). Notwithstanding this generality, some studies demonstrated that the use of distributed practice for a discrete task reported greater benefit than the use of massed practice (Dail & Christina, 2004).

In a review about massed and distributed practice it was concluded that the distribution of practice has a greater effect on learning simple motor skills such as writing and others (Donovan & Radosevich, 1999). According to Magill (2011), this superior effect of practice distributed over the concentrated is based on that, the reduced rest time in the latter, would result in the learner more fatigue, less cognitive effort, little time for biochemical changes occur and poorer memory consolidation in motor patterns. Only a few experimental studies have included complex skills, and perhaps the effects of distributed practice vary with the type of task completed. Currently continues the dispute and the conflicting results about both practice schedules on discrete skills. A study of handball players (García-Herrero et al., 2011) revealed that massed practice led to less accuracy and velocity in throws as the amount of practice increased. Others researches also revealed a decline in the learning performance of a coincident timing task when massed practice was used (Leite et al., 2013). Specifically, a study by Fuentes et al., (2022) on the effect of practice distribution on learning the forehand in tennis, revealed a significant improvement in the skill acquisition of the forehand shot in the groups of massed and distributed practice.

Despite these findings, there are not researches that have been conducted in tennis, applying massed and distributed practice schedules to testing their effects over the accuracy and efficacy in the tennis serve. The tennis serve is a complex and discrete skill. It presents difficulties for the learner, since it must mobilize both arms at the same time, coordinating the movement with his whole body to hit a ball over the head. Teachers try to apply different strategies for learning (e.g., variability, contextual interference, feedback), but do not know what is the best option to series periods of work and rest in the learning sessions. In recreational contexts of teaching tennis, practitioners have short time to practice, and sessions are usually widely spaced in time (2 sessions per week on non-consecutive days). This means that the practice is already distributed in itself, so that the negative effects of massed practice raised by Magill (2011) would be diluted in time. Therefore, this recreational context, it may be more interesting to raise massed practice within the sessions (Spittle, 2013).

For that reason, the aim of this study was to compare the effects of a 6-week learning program based on massed and distributed practice. It is hypothesized that the massed practice will be more

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beneficial for learning and performance the tennis serve than the distributed practice schedule in recreational players.

Methods

Participants

Twenty-four male (*N* = 18) and female (*N* = 6) children (11.8 ± 1.6 years old; 156.9 ± 14.6 cm; 48.8 ± 12.6 kg) participated in this study. All of them were recreational tennis players. The players and their parents were informed about the objectives and protocol of the study, and subsequently all signed a free informed consent in line with the Declaration of Helsinki. We did not make distinctions by gender for ethical issues to offer the program to all potential participants.

The International Tennis Number (INT) test of International Tennis Federation (ITF) it was carried out for all participants before the research and this one revealed an INT value of 9, thus suggesting a recreational category (1 is the top score and 10 the lowest). The INT test was used to distribute the players in two experimental groups in a balanced way. The procedure applied for validation the throwers of INT test can be found in Appendix 1.

One group (*N* = 12) practiced in massed practice schedule and the other group (*N* = 12) practiced in the distributed practice.

Measures and Instrumental

The accuracy in the serve was measured pre- and post- program. Accuracy was determined based on radial error (Robins et al., 2006) considering as reference system 9 points on the service box -8 corners and 1 centre of target- (Figure 1).

$$Radial\ Error\ (RE) = \sqrt{(x - x')^2 + (y - y')^2} \quad (1)$$

During the test, the service box and target were recorded with a HD Sony® HDR-XR155E digital video camera (50 Hz sampling frequency de-interlace) to establish the bounce's zone. The video camera was placed pointing at to the service box at 3.82-meter height from the floor and 1.18 meter to end line of the court (Figure 1). The bounces of the ball were digitalized to calculate the radial error of each serve regarding the centre of target with Kinovea® 0.95. The digitalization error was 0.005 millimetres. Matlab R2015b® routine was applied for the calculation of real-space Cartesian coordinates of the ball bounces (Hernández-Davó et al., 2014).

The efficacy was measured based on the capacity to hit the ball inside the box serve according to Anguera (1997):

$$Efficacy\ (\%) = \frac{Strokes\ inside\ the\ box\ service}{Strokes\ inside\ the\ box\ service + out\ strokes} \times 100 \quad (2)$$

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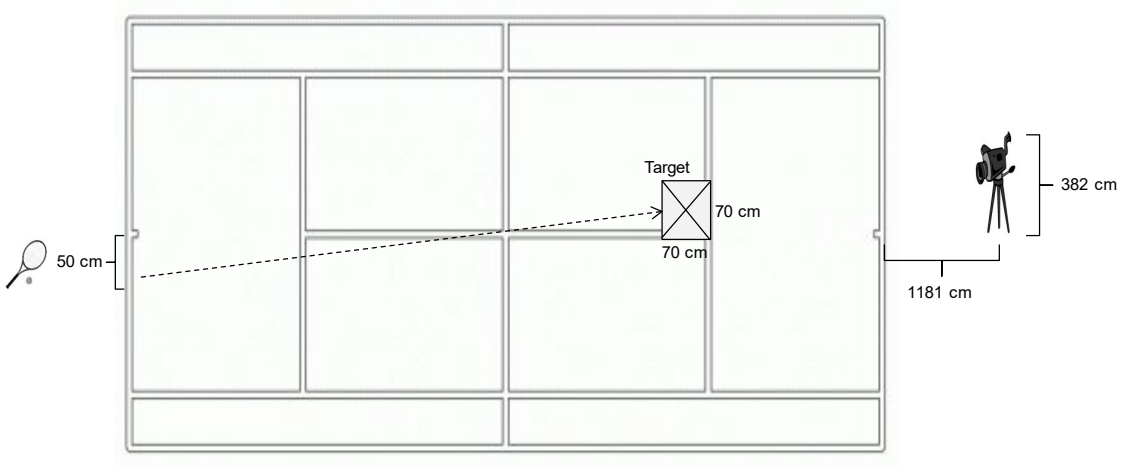

Figure 1. Experimental set-up applied in pre-test, post-test and retention test. *Tasks and procedure*.

A 6-week learning program was carried out with two learning sessions per week, thus a total of 12 sessions were completed by the participants of both groups. The practice organization can be observed in Table 1.

Table 1. Practice schedules per experimental group.

Group	Series	Trials	Rest time between trials (seconds)	Rest time between series (seconds)	Frequency (days per week)
Distributed	4	10	10″	30″	2
Massed	4	10	0″	10″	2

Into the test, accuracy and efficacy were measured through 3 series of 15 serves per series were performed. The post-test was carried out one week after program and re-test was applied at two weeks. The rest time was 5 seconds between trials and 20 seconds between series.

The test required a serve in the direction of a square (0.70 x 0.70 m) placed at the "T" of the court (Figure 1) (Landlinger et al., 2012). An adjustment based on the ITF's Play and Style, Tennis 10*s* was made for the children.

Statistical Analysis

The effect of the learning program (massed and distributed practice) on the radial error and percentage of efficacy was analysed using mixed repeated measures ANOVA after validating the normality and homogeneity assumptions. The assumption of normality for each univariate dependent variable was examined using Kolmogorov-Smirnov test (p>0.05). The assumption of the homogeneity of each group's variance/covariance matrix was examined with Box's M test. The effect size –power analysis– was calculated by Partial Eta Squared (η^2), (Lakens, 2013). All statistical analyses were performed using IBM SPSS Statistics® v. 29, at a significance level of p<0.05.

Results

Efficacy recorded in both groups is around 50% and accuracy is never below 210.3 cm. (Table 2). Analysis of variance shows no significant difference in efficacy between groups in any test. Regarding the accuracy, there are no significant differences in any test depending on the condition of practice.

Table 2. Mean and standard deviation of groups in the efficacy (%) and accuracy (cm) in the seve.

	Massed group	Distributed group

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Efficacy	Pre-test	40.6±14.2	40.4±14.9
	Post-test	51.3±12.7	51.3±16.1
	Re-test	44.3±14.0	49.6±17.3
Accuracy	Pre-test	227.8±63.3	210.3±61.1
	Post-test	217.9±44.8	239.6±76.3
	Re-test	237.5±84.0	251.5±60.2

On the intragroup analysis of efficacy (Figure 2), significant increase can be seen in the massed group efficacy between pre-test and post-test (p = 0.001; η^2= 0.93). Significant decrease were also found between post-test and re-test in the massed group (p = 0.021; η^2= 0.93). In distributed group, significant increase were found between pre-test and post-test (p = 0.015; η^2= 0.92), but no significant differences were found between post-test and re-test.

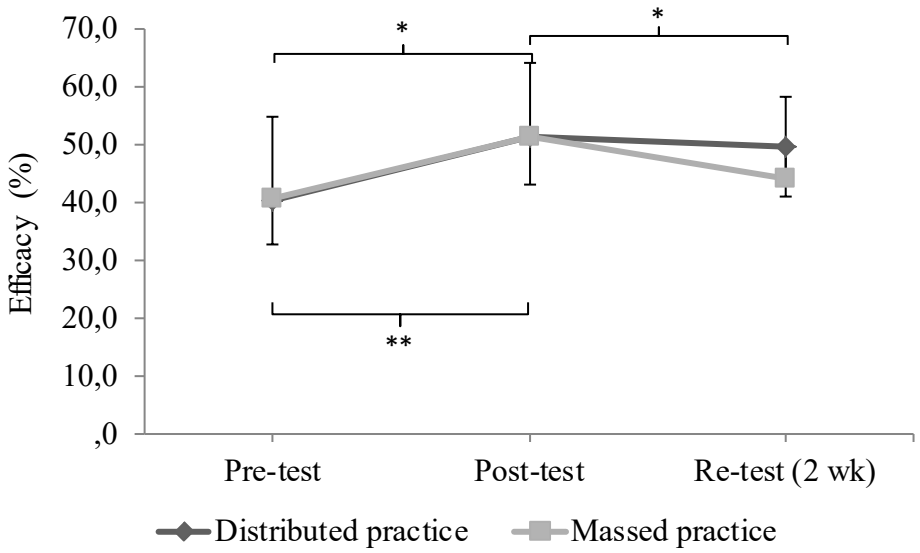

Figure 2. Efficacy in pre-test, post-test and re-test in massed and distributed practice groups. The bar shows standard deviations.On the intragroup analysis of accuracy –radial error–, significant increase can be seen in the massed group between pre-test and post-test (p = 0.015; η^2= 0.92). No more significant differences were found in the remaining comparisons. * Significant differences between test on massed group practice (p≤.05). ** Significant differences between test on distributed group practice (p≤.05).

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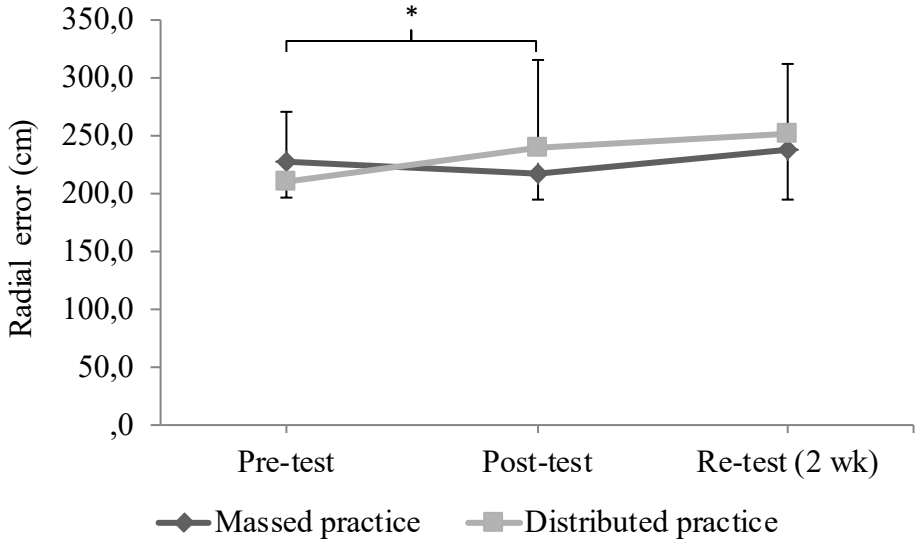

Figure 3. Accuracy in pre-test, post-test and re-test in massed and distributed practice groups. The bars show standard deviations. * Significant differences between pre-test and post-test on massed group practice ($p \leq .05$).

Discussion

Two practice schedules -massed vs. distributed- were applied to compare the effects on the efficacy and accuracy of tennis serve. The main results on efficacy revealed no differences in performance between massed and distributed practice groups in post-test. For the tennis serve, both groups showed improved performance during acquisition. This result coincides with those provided by Fuentes et al. (2022), which leads us to think that, in learning tennis strokes, the practice itself, regardless of whether it is concentrated or distributed, already generates increases in performance in the phase learning.

The main results are not in line with some related studies with discrete skills in which the use of distributed practice, as in our case, reported higher benefits than massed practice (Leite et al., 2013; García et al., 2008; Dail & Christina, 2004; Savion-Lemieux & Penhune, 2005). These studies suggest that in discrete tasks there is a tendency for massed practice to influence the decrease in performance. Nevertheless, there are some authors whose results are similar from our and where the massed practice group in a discrete task performed during the acquisition phase (Lee & Genovese, 1988).

In the efficacy between post-test and re-test worse scores were found in the re-test in the massed group. No differences were found in distributed practice. This may suggest the long-term effects of distributed practice in skill acquisition. In one research, it was noted that the distribution of practice was the most important retention factor studied in relation to discrete tasks (Savion-Lemieux & Penhune, 2005), and similar results were found in our research. Similar results revealed that participants in the distributed practice group performed the task more efficiently than those in the massed practice group during the holding phase (Dail & Christina, 2004). These results contradict those found by Lee and Genovese (1989), in which the concentrated practice group performed a discrete task better during retention testing than the distributed practice group, which showed significant reductions in retention. Moreover, with regard to the efficacy, in contrast to the results of our study, some researchers found a better retention provided by massed practice in a discrete task, although this may be due to differences in age between their research and ours (Ammons, 1988).

Regarding the accuracy calculated by the radial error, no differences were found between groups. Intra-group, only massed practice group performed significantly better in post-test. The absence of decreased performance in the accuracy when compared post-test and re-test can be related to the findings obtained in a study that revealed that the learning process continues driving forward after the stabilization of performance (Fonseca et al., 2012). Furthermore, a similar study suggested

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the possibility that the differences in retention are due to the practice schedules, type of skills and the time elapsed since the learning period (Menayo et al., 2010).

Conclusion

Based on the results, the hypothesis that the massed practice will be more beneficial for learning and performance the tennis serve than the distributed practice schedule in recreational players is not fully. The massed practice is only better than the distributed one in post-test accuracy. However, the learning program developed under both practice schedules can inform recreational tennis practice. The approach to this sport from the initial stages, as well as adherence to it throughout life, cannot be contemplated without there being scientific support that provides rigor and security to learners, making the learning process more comfortable.

Author Contributions: Ruperto Menayo (RM) participated in the conceptualization of the research, in the design of the methodology, in the formal analysis, in the data curation, in the writing, review and editing of the manuscript. Silvia Pulido (SP) and Noemí Morales (NM) participated in the development of methodology, in the investigation, provision of materials and participants. Juan Pedro Fuentes García (JPFG) participated in the project administration, in the conceptualization of the research, in the design of the methodology, in the writing, review and editing of the manuscript.

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Appendix 1

Procedure and Efficacy of Throwers

The INT test required the use of throwers. Three throwers were tested before the study began. The test had three series of 10 repetitions with a rest of 1 minute between series. The throwers were positioned on the "T" of the court and were asked to put the ball in a specific square on the opposite side of the court. The INT was adjusted for the participants, thereby reducing the size of the court and the distance to the net. Each participant performed three trials and all of them were analysed for efficacy.

The throwers' efficacy was tested using one-way ANOVA and the Bonferroni test. No statistical differences were found between the throwers, thereby revealing homogeneity and a small variability among the throws. An efficacy of 92% was also found among the throws, suggesting sufficient reliability to follow in the study. The results can be seen in Table 3.

Table 3. Efficacy of throwers.

Launcher (I)	Throwers (J)	Averages Difference (I-J)	Typical Error	*p*-value	Confidence Interval (95%) Lower Limit	Upper Limit
1	2	-0.967	4.513	1.000	-12.01	10.08
	3	4.836	4.249	0.776	-5.56	15.23
2	1	0.967	4.513	1.000	-10.08	12.01
	3	5.804	4.477	0.596	-5.15	16.76
3	1	-4.836	4.249	0.776	-15.23	5.56
	2	-5.804	4.477	0.596	-16.76	5.15

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