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INDUCED VARIABILITY DURING THE TENNIS SERVICE PRACTICE AFFECT THE PERFORMANCE OF EVERY TENNIS PLAYER INDIVIDUALLY AND SPECIFICALLY

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ABSTRACT

The aim of this study was to know if the induced variability during the tennis flat serve has specific and individually effects on the performance achieved. The participants were eight tennis players. Each one performed seven series of twenty flat serves. The shot's situations were modified within each series, by changing implement and mobile instruments and support points. The ball's speed was registered and the bounces on the court filmed. These data were later digitalised to calculate the accuracy through radial error. Intra-subject data were analysed and the significance of the produced change was evaluated after every performance series where the variability was applied, compared to the 1st series where the variability was not applied –the tennis players performed as they usually do. Accuracy results show greater falls in amateur tennis players than in expert players in the series of variable performance. Falls are also registered in the ball's speed in the series of variable performance in both groups, but they are more pronounced in the amateur players' group. Through these results, we can confirm that induced variability as a means of learning or training affects each player in different ways depending on his/her game level. For this reason, it would be convenient to quantify and individualise the variability load based on the different effects it produces in each player's performance.

Keywords: tennis, induced variability, service, performance

LA VARIABILIDAD INDUCIDA DURANTE LA PRÁCTICA DEL SAQUE EN TENIS, AFECTA DE MANERA INDIVIDUAL Y ESPECÍFICA AL RENDIMIENTO DE CADA TENISTA

RESUMEN

El objetivo de este estudio fue conocer los efectos de la variabilidad inducida durante la práctica del servicio plano en tenis sobre el rendimiento logrado. Participaron 8 jugadores de tenis. Cada tenista realizó 7 series de 20 servicios planos. En cada serie se modificaron las situaciones de golpeo, variando implementos, móviles y apoyos. Se registró la velocidad de la pelota y se filmaron los botes de la pelota en la pista, digitalizando posteriormente los mismos para el cálculo de la precisión a través del error-radial. Se analizaron los datos intra-sujeto y se evaluó la significatividad del cambio producido por cada serie de práctica variable respecto a la serie 1 de ejecución habitual -sin aplicar variabilidad-. Los resultados de precisión muestran mayores descensos en los jugadores amateurs que en los jugadores de nivel nacional en las series de práctica variable. Se observan descensos en la velocidad de la bola en las series de práctica variable en ambos grupos, siendo más acusados en los jugadores amateurs. A partir de estos resultados, se confirma que la variabilidad inducida como medio de aprendizaje o entrenamiento afecta diferente en función del jugador y de su nivel de juego. Por tanto, sería conveniente cuantificar e individualizar la carga de variabilidad en función de sus efectos sobre el rendimiento de cada jugador.

Palabras clave: tenis, variabilidad inducida, servicio, rendimiento

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INTRODUCTION

Tennis is a sport played worldwide. The International Tennis Federation (ITF) affirms that, nowadays, tennis is a sport played by over 80 million people. Regarding tennis learning, the traditional way consisted in learning through the reproduction of technical models (concerning the different shots of the ball with the racket) by constant repetition (Nieblas and Molina, 2016; Unierzinski and Crespo, 2007). However, newer approaches of learning and training have introduced concepts of ecological models and of complex dynamics systems. These usually refers to the game and the player as a totality (Crespo, 2009) formed by different elements that interact at the same time.

There are diverse variables that occur during the game that make the characteristics of the practice differ within each match and training (E.g., climate variables; height above sea level; mobile instrument pressure; string tension; the court's surface; speed, effect and direction with which the adversary plays). That is the reason why tennis is a sport in which the practice and shot conditions vary constantly. Those aspects should be considered in the teaching and learning of tennis, creating practice situations that avoid technical repetitions in identical conditions (e.g. Menayo, Moreno, Sabido, Fuentes, & García, 2010).

State-of-the-art perspectives of motor learning lay part of their bases in the theory of dynamic systems. Specifically: i) athletes are considered as a complex system, ii) systems tend to go to balance estates and iii) adaptation is an essential learning element. Tennis is a complex system itself, because neither components nor connections are simple. A tennis player on the court interacts with all the present stimuli and he/she adapts his/her practice to every condition that comes up from this interaction.

Considering this paradigm, the variable practice affects learning, especially in open tasks. An important part of these learning tasks is to acquire the ability to overcome new situations. That is why practicing in the same conditions is not the appropriate method (Schmidt and Lee, 2005). In this respect, various studies have investigated the positive effects of variability in practice or induced variability to improve experts' performance (Davids et al., 2003; García et al., 2011; Hernández-Davó et al., 2014; Menayo et al., 2010; Menayo and Fuentes, 2011; Sanz et al., 2012). Nevertheless, the benefits of induced variability are not as easily seen in inexperienced athletes (Button et al., 2003; Caballero et al., 2012; Davids et al., 2003; Douvis, 2005; García et al., 2013; Hernández-Davo et al., 2014; García-Herrero et al., 2016; Hamidreza et al., 2017).

Regarding tennis service, the kind of training carried out influences the accuracy and the ball's speed. According to Urbán et al. (2014) variable conditions in practice improved accuracy to a larger extent than specific

practice. Regarding the ball's speed, both practice conditions would be beneficial to improve performance in this game action. Some other authors also affirm that it would be interesting to vary mobile instruments and implements in learning tasks of the tennis service, especially in the flat serve, because it does not affect performance (Menayo and Fuentes, 2011). In this sense, the trainer should cause destabilisations of the technic to explore movement possibilities to look for more efficient solutions (Menayo et al., 2010).

Concerning the variation of the practice conditions, there are different sources of variability which can be used to apply loads (spatial, temporal, human and instrumental loads), providing that they suppose a condition strong or optimal enough so that the tennis player is forced to modify his/her performance and execution to solve the suggested task successfully. Besides, the practice conditions can also be modified by induced wind (Mendes, Fuentes, Mendes, Martins, Clemente, & Couceiro, 2013). Expert players tend to stabilise the ball release during the service on the spatial axis. That is why variability must be seen as a part of the training programmes and not something that must be avoided by players and trainers. However, it is difficult to determine the effect of induced variability loads and it is essential to quantify them previously. In this sense, the introduction of disturbances in the execution of the movement should respect the key aspects of the technique (Menayo et al., 2010), because not every variability is beneficial (Urbán et al., 2012).

With respect to the load of variable practice, it is a learning element that must be applied as a strong stimulation in order to cause adaptations. The load magnitude concept is related to the stimulus' intensity of training applied to trainees, which will generate different stress levels in the system (Moreno and Ordoño, 2009). In consonance with Moreno and Ordoño (2015), the practice must be modulated to achieve a proper stimulation in the trainee. Once this is accomplished, an adaptation to a superior performance level and an optimisation of motor learning will be attained. In this sense, the exposition to the stimulus and the adaptive response of the trainee are related to each other in an inverted U curve. Intermediate levels of stimuli allow major adaptations, while upper and lower levels of stress exposition produce negative results. According to the principles of the General Adaptation Syndrome (Selye, 1956), stimuli are the tasks proposed by the trainer to produce changes and adaptations in tennis players. These stimuli must be considered as a practice load. So, if the tasks proposed by the trainer are designed with a suitable magnitude, the tennis player behaviour will undergo fluctuations at the beginning. This situation will make the functional performance decrease and the system will enter in an alarm phase. A not enough strong load magnitude would produce a just few changes in learning. On the contrary, excessively heavy practice loads could produce dysadaptations and the manifestation of

undesirable coordination patterns (Moreno and Ordoño, 2015). In this sense, the analyse of the variability structure can be useful to predict the learning rate (Barbado et al., 2017). However, that analyse is not usually available for trainers, since they do not have the knowledge, nor the statistical tools needed (Harbourne and Stergiou, 2009) to extract this kind of data. Thus, it is necessary to develop protocols and methods which will allow the trainer to quantify the load of induced variability and its effects on his/her players' performance.

Something that must also be considered is that the same task can produce different practice load levels in each trainee. It can even produce different practice load levels in one single trainee depending on the practice situations, due to the singularity of the intra and interindividual motor behaviour in each trainee's service performance (Moreno and Ordoño, 2015).

In consideration of what we have stated above, we suggest that individuals can experience different adaptations in response to different intensities of stimuli. Thus, it is essential to know if the load magnitude variability is fitted to the trainee's personal characteristics. In accordance to the previous approach, our objectives are the following: i) to analyse the effects of different load magnitude variabilities in expert and amateur athletes; ii) to calculate the induced load magnitude variability by the modification of shot conditions in relation to the usual pattern of performance in the service; iii) to offer a protocol which allows to determine the load magnitude variability produced by different shot conditions.

Our hypothesis are: i) the series of induced variability carried out by amateur tennis player will produce greater falls in accuracy than the ones carried out by professional tennis player that play at a national level; ii) the series of induced variability carried out by amateur tennis player will produce greater falls in speed than the ones carried out by tennis player that play at a national level; iii) the performance series of induced variability will produce more load of variability in amateur players than in players who play at a national level; iv) the more different the performance of the service is from the usual motor pattern of it, the more rises will be registered in the load magnitude variability.

METHOD

The participants were 8 tennis players, 4 of them play at a national level and 4 are amateur players. They were selected from quota sampling. Every participant had to be able to perform the flat serve using a continental grip.

The national players' average age was 24.25 ± 2.86 years, and the average of experience in tennis was 13.25±1.48 years. The amateur players' average age was 14.75 ± 0.83, and the average of experience in tennis was 5.50± 1.50 years.

Everyone participated in the investigation voluntarily and through informed consent according to the San Antonio Catholic University's ethical principles and the Declaration of Helsinki.

To register services' accuracy during the tests we used a video camera (Casio EXILIM, High Speed EX-ZR1000). The video camera filmed the bounces of the balls in 240 herzts to its later digitalisation and transformation in real coordinates. In order to do so we used a Kinovea® software (0.8.27 version). We later calculated the radial error (Van den Tillar and Ettema, 2003) of each performance.

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

The video camera was placed on a tripod (2.0 meters high) located on the intersection of the service line and the centre service line (when the players were performing the service on the right side) and on the intersection of the service line and the singles side-line (Figure 1) (when the players were performing the service on the left side).

The ball's speed during the services was registered using a radar (Sport Radar® SR 3600), which measures mobile's speed at ± 1 km/h accuracy. The radar was placed on a tripod located behind the player and on the distance of the impact, specifically 1.5 metres behind the centre line (Figure 1). To avoid mistakes that come from the angle formed by the radar and the ball's trajectory, the radar was orientated from the shot spot to the bullseyes.

At the beginning of the test 5 services were performed to check the proper working of the radar. During the test different mobiles were used according to the International Tennis Federation classification: the yellow ball, the red ball (which is 75% slower than the yellow ball), the orange ball (which is 50% slower than the yellow one), and the green ball (which is 25% slower than the yellow one). A paddle racket (Green Siux Tsunami ®) was also used.

Before starting the test, the tennis players carried out a general 5-minutes warm-up. Then, they carried out 5 flat serves on the right side of the court and 5 on the left side. Later, the players were informed that they should hit the ball as fast as possible in the flat serve and try to keep accuracy on the ball, except from the 5th series, where they had to attain a maximum accuracy as possible without trying to do so at a maximum speed. The tennis players had to direct the ball to the *middle T* on the right side of the service and on the left side ("open area"). The point of maximum accuracy was placed on the intersection of the service line and *T* (right side) and on the intersection of the service line and the singles side-line (left side).

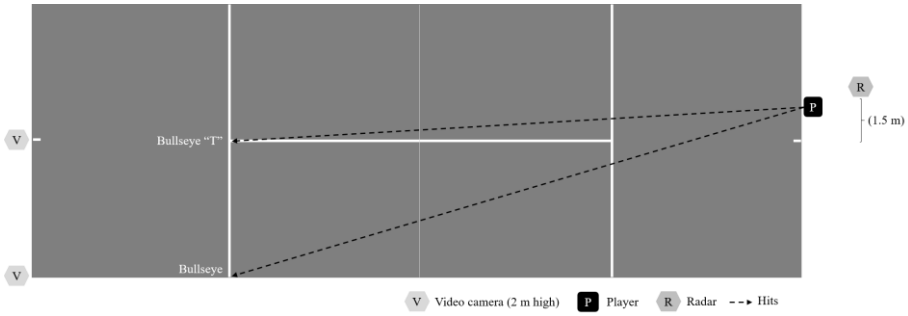

FIGURE 1: Setup of the data collection and location of the measuring instruments.

During the test 20 services were carried out at each series: 10 from one side, 10 from the other side. There was 1-minute break between series. The following series were carried out: i) usual performance; ii) performance using orange balls; iii) performance using the paddle racket; iv) performance aiming a maximal accuracy (it was not necessary to hit the ball at a maximum speed); v) performance using green balls; vi) performance hitting the ball while performing an open stance; vii) performance using red balls.

Statistical analysis

We used for that a technique of data analysis for single-case research designs adapted from investigations in psychological treatments (Jacobson and Truax, 1991) from which we must first establish a cut-off point (C) to determine if there is a significant change. Then, the method requires to determine that the change is not due to a measurement error, but that it shows a reliable change. For that, these authors proposed a Reliable Change Index – Raito determine it, we consider the typical error difference between the results of each test (s_{dif}).

$$\mathrm{RCI} = \frac{\mathrm{X2} - \mathrm{X1}}{\mathrm{Sdif}}$$

$$(\mathrm{Sdif} = \sqrt{2 \times \left(\sigma\mathrm{group} \times \sqrt{(1 - \alpha\ \mathrm{Cronbach})}\right)^2}$$

x_2 Stands for one tennis player's test result and x_1 is the punctuation obtained from the instrument in a previous test. The typical error of the difference between two tests ($_{Sdif}$) would describe the distribution amplitude of the change of the punctuation that would occur if there was not any real change. Hence, it would be rather unlikely (p<.05) to obtain more than 1.96 RCI without a real change. Thus, the change in the tennis players' results should exceed this RCI value to guarantee that this change is not due to measurement mistakes in the test or at random.

$$\mathrm{RCI} > 1.96 \rightarrow \frac{\mathrm{X2} - \mathrm{X1}}{\mathrm{Sdif}} > 1.96 \rightarrow X2 - X1 > \ Sdif\ x\ 1.9$$

RESULTS

We carried out an intrasubject analysis of the data obtained from accuracy and the ball's speed, considering the kind of induced variability in each series. We did so considering the small sample size and keeping in mind that the same task can produce different magnitude variability loads in each trainee and even in one single player (Moreno and Ordoño, 2015). The significance of the produced change in performance was evaluated after each series of variable performance regarding the series performed without variation.

Table 1 shows the accuracy results (radial-error) registered in each series. We can see through it that the effects of the variable practice on the services' accuracy seem to be different based on the kind of induced variability and game level.

TABLE 1
Accuracy (cm) –radial-error– registered in each practice series
(mean ± standard deviation).

Level Player	Serie 1 Without induced variability	Serie 2 Orange ball	Serie 3 Paddle racket	Serie 4 Accuracy	Serie 5 Green ball	Serie 6 Open Stance	Serie 7 Red Ball
1-Am *	207.7±141.8	238.0±161.1	287.8±141.2	149.3±73.6	183.0±72.3	246.8±123.2	219.9±165.6
2-Am.	283.9±209.4	225.1± 66.0	245.5±100.6	263.3±241.7	218.7±45.4±	222.7±161.3	227.0±128.2
3-Am.	249.1±269.4	289.2±196.4	155.8±93.5	255.7±154.5	219.2±119.1	232.5±159.3	232.1±59.7
4-Am.	242.4±96.5	162.8±94.2	285.4±163.0	248.5±105.3	196.5±91.9	161.4±77.3	206.9±49.1
5-Nac**	181.1±52.4	148.5±67.6	206.8± 77.1	160.1±101.3	146.8±43.0	144.0±87.0	121.7±57.3
6-Nac.	200.0±124.8	202.9±122.6	208.6± 52.7	145.6±81.7	141.0±66.9	298.6±203.8	152.0±57.6
7-Nac.	144.3±37.1	238.2±325.4	379.4±176.2	101.1±26.7	176.9±103.2	120.6±78.7	117.2±56.1
8-Nac.	160.8±58.3	133.5±78.0	333.0±136.3	194.0±117.7	110.0±48.4	217.2±95.6	156.5±45.0

* Amateur
** Nacional

Table 2 gathers the ball's speed results (km/h) registered in each series. We can observe that the effects of the variable practice on the ball's speed during the services seem to be different based on the kind of induced variability and game level.

TABLE 2
Speed (km/h) registered in each practice series (mean ± standard deviation).
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Level Player	Serie 1 Without induced variability	Serie 2 Orange ball	Serie 3 Paddle racket	Serie 4 Accuracy	Serie 5 Green ball	Serie 6 Open Stance	Serie 7 Red Ball
1-Am *	117.4±6.1	114.7±6.9	86.2±7.0	103.8±10.8	106.4±8.5	101.1±9.8	101.6±11.9
2-Am.	121.3±10.2	122.0±6.6	93.8±7.3	103.7±14.0	121.1±8.9	107.6±10.0	114.4±6.9
3-Am.	142.5±13.3	137.6±9.9	108.9±7.8	137.9±5.7	140.0±7.7	120.9±12.1	123.1±7.2
4-Am.	118.5±7.8	109.4±7.6	87.8±7.4	78.8±10.8	107.7±8.5	109.1±9.1	107.5±6.6
5-Nac**	162.8±5.5	160.4±8.9	126.7±5.4	147.6±4.0	165.0±7.5	158.3±7.2	147.5±6.1
6-Nac.	163.9±8.8	151.4±10.6	82.5±2.3	157.6±11.2	166.5±4.6	158.1±10.5	142.7±14.3
7-Nac.	155.4±6.9	153.4±8.9	111.1±5.2	154.5±6.2	159.0±4.9	146.7±9.3	141.5±7.1
8-Nac.	151.8±8.1	151.7±6.7	108.4±5.9	135.4±12.2	155.9±5.3	134.4±8.4	140.7±5.8

* Amateur
** Nacional

To calculate the variability load, we considered a 100% value on the performance series without a variation on the usual performance. Then, we calculated the variability load percentage of each series for each player, considering its effect on the attained performance in accuracy and speed. This was carried out in 10% intervals, depending on the rises or the falls of the shots' performance experienced in each series.

Table 3 shows the load magnitude variability percentages of each series performed by each player, with reference to the series of usual performance on the accuracy variable. As we can see, the load percentage of the induced variability in each series is different for each tennis player. We must highlight that there are series where the load of induced variability is inferior than in the series performed without variability.

TABLE 3
Load magnitude variability percentages (%) on the accuracy.

Level Player	Serie 1 Without induced variability	Serie 2 Orange ball	Serie 3 Paddle racket	Serie 4 Accuracy	Serie 5 Green ball	Serie 6 Open Stance	Serie 7 Red Ball
1-Am *	100	110	130	70	80	110	100
2-Am.	100	70	80	90	70	70	70
3-Am.	100	110	60	10	80	90	90
4-Am.	100	60	110	100	80	60	80
5-Nac**	100	80	110	80	80	70	60
6-Nac.	100	100	100	70	70	140	70
7-Nac.	100	160	200	70	120	80	80
8-Nac.	100	80	200	130	60	130	90

* Amateur
** Nacional

Table 4 shows the load magnitude variability percentage in each series performed by each player, with reference to the series of usual performance on the ball's speed variable. As we can observe, it seems that the load percentage of the induced variability in each series is different for each tennis player. We must highlight that there are series where the load of induced variability is inferior than in the series performed without variability.

TABLE 4
Load magnitude variability percentages on the ball's speed.

Level Player	Serie 1 Without induced variability	Serie 2 Orange ball	Serie 3 Paddle racket	Serie 4 Accuracy	Serie 5 Green ball	Serie 6 Open Stance	Serie 7 Red Ball
1-Am *	100	110	130	120	110	120	100
2-Am.	100	100	120	120	90	120	120
3-Am.	100	110	130	110	110	120	120
4-Am.	100	110	130	140	120	110	110
5-Nac**	100	110	120	110	100	110	110
6-Nac.	100	110	150	110	100	110	120
7-Nac.	100	110	130	110	100	110	110
8-Nac.	100	110	130	120	100	120	110

* Amateur
** Nacional

The table 5 show the produced change's significance in amateur tennis players' performance during the induced variability series, regarding the series of usual performance.

TABLE 5
Significant changes (RCI 1.96; p <.05*) produced in the performance after induced variability series regarding the service specific practice series (1st series) in amateur tennis players.

Level Player		Serie 1-2	Serie 1-3	Serie 1-4	Serie 1-5	Serie 1-6	Serie 1-7
1-Amateur	*Sdif*	Accuracy (cm)					
	RCI 1.96	34.16	40.55	35.25	11.65	24.75	7.19
	(p <.05)	0.89	1.97*	1.66	2.12*	1.58	1.69
		Ball speed (km/h)					
		3.59	3.03	7.11	4.58	2.42	2.71
		0.74	10.29*	1.91	2.40*	6.74*	5.82*
2-Amateur	*Sdif*	Accuracy (cm)					
	RCI 1.96	34.16	40.55	35.25	11.65	24.75	7.19
	(p <.05)	1.72	0.95	0.59	5.60*	2.47*	7.93*
		Ball speed (km/h)					
		3.59	3.03	7.11	4.58	2.42	2.71
		0.19	9.09*	2.48*	0.04	5.67*	2.54*
3-Amateur	*Sdif*	Accuracy (cm)					
	RCI 1.96	34.16	40.55	35.25	11.65	24.75	7.19
	(p <.05)	1.17	2.30*	0.19	2.57*	0.67	2.37*
		Ball speed (km/h)					
		3.59	3.03	7.11	4.58	2.42	2.71
		1.37	11.10*	0.66	0.55	8.94*	7.20*
4-Amateur	*Sdif*	Accuracy (cm)					
	RCI 1.96	34.16	40.55	35.25	11.65	24.75	7.19
	(p <.05)	2.33*	1.06	0.17	3.94*	3.28*	4.95*
		Ball speed (km/h)					
		3.59	3.03	7.11	4.58	2.42	2.71
		2.53*	10.11*	5.59*	2.36*	3.86*	4.07*

The table 6 show the produced change's significance in national players' performance during the induced variability series, regarding the series of usual performance.

TABLE 6
Significant changes (RCI 1.96; p <.05*) produced in the performance after induced variability series regarding the specific practice series (1st series) in national tennis players.

Level Player		Serie 1-2	Serie 1-3	Serie 1-4	Serie 1-5	Serie 1-6	Serie 1-7
		Accuracy (cm)					
5-Nacional	*Sdif*	17.96	32.51	14.25	10.15	29.74	7.50
	RCI 1.96 (p <.05)	1.82	0.79	1.48	3.39*	1.25	7.93*
		Ball speed (km/h)					
		3.72	16.23	8.71	4.45	10.05	2.72
		0.65	2.23*	1.75	0.50	0.45	5.61*
		Accuracy (cm)					
6-Nacional	*Sdif*	17.96	32.51	14.25	10.15	29.74	7.50
	RCI 1.96 (p <.05)	0.16	0.26	3.82*	5.82*	3.32*	6.40*
		Ball speed (km/h)					
		3.72	16.23	8.71	4.45	10.05	2.72
		3.36*	5.02*	0.73	0.58	0.58	7.80
		Accuracy (cm)					
7-Nacional	*Sdif*	17.96	32.51	14.25	10.15	29.74	7.50
	RCI 1.96 (p <.05)	5.23*	7.23*	3.03*	3.28*	0.80	3.61*
		Ball speed (km/h)					
		3.72	16.23	8.71	4.45	10.05	2.72
		0.53	2.73*	0.10	0.81	0.87	5.10*
		Accuracy (cm)					
8-Nacional	*Sdif*	17.96	32.51	14.25	10.15	29.74	7.50
	RCI 1.96 (p <.05)	1.52	5.30*	2.33*	5.01*	1.90	0.58
		Ball speed (km/h)					
		3.72	16.23	8.71	4.45	10.05	2.72
		0.03	2.68*	1.88	0.90	1.73	4.10*

DISCUSSION

The aim of this study was to analyse the effect of induced variability during the practice of the tennis service, with a view to quantify its load and individualise it when applying it during training or learning tasks. Each tennis player registered different results, authors obtained similar results in the analyse of intra-subject variability in skills like realising a shooting basketball (Miller, 2005). In this sense, Mendes et al. (2015) affirm that intra and interindividual variability of motor behaviour becomes clear in each player's unique service performance. Therefore, the different shot conditions can produce a wide variety of magnitude load levels during each player's practice. It can even produce different load magnitude levels for the same trainee depending on the situations in which tests are carried out (Moreno and Ordoño, 2015). Each tennis player seems to respond in an individual adaptive way to the variability loads of the proposed tasks.

This result matches with the complex systems' characteristics which show behaviours based in self-organisation, meaning it arranges its components or

modify its organisation state according to the control parameters of its environment (Menayo et al., 2010; David et al., 2008).

As for the effect of induced variability on accuracy, most decreases are registered in amateur players. Thus, variability series have a bigger effect on this group of players.

These results agree with our hypothesis and with previous studies, which found out that variability in practice is usually more effective to improve adults' and expert players' learning than children's or inexpert players' (Douvis, 2005; García-Herrero et al., 2016; Taheri et al., 2017). This suggests that people who have not a stable motor pattern (inexpert players or children) are in an exploration phase (high variability) in which they must find the better motor solution to solve the proposed task when they are learning a new skill by practising it. Therefore, athletes who does not play at high performance could achieve learning only practising the target task, so the variable practice does not provide any additional advantage (García-Herrero et al., 2016).Consequently, the application of variability on motor skills learning (the tennis service in this case) should be at an intermediate perturbance level to allow an improvement in the performance and to avoid perturbances that make the trainee be far from his performance goal (Davids et al., 2003).

Regarding the effect of induced variability on the ball's speed, results also vary depending on the tennis player. However, we can see that induced variability practice seems to reduce the ball's speed. These results may be due, for example, to differences in applied force, as reflected by other authors (e.g. Baiget, Corbi, Fuentes, & Fernandez-Fernandez, 2016). Menayo et al. (2010) also registered similar results. He affirms that variable practice produced a decrease on the ball's speed during the service because of the shot modifications. Specially, when implements and mobiles were modified, the mobile's speed decreased as it was released in the tennis flat serve. Nevertheless, decreases in speed could be originated from the characteristics of the instruments used during the service performance, as well as from the tennis players' precaution to keep accuracy even if it meant to sacrifice the ball's speed. In this sense, we can see that in the 5th series (where shots were carried out using a green ball) the ball's speed has increased, maybe because of the ball's light weight. Still, in Menayo's (2010) work, even if the speed decreased in the service series in which the mobile was modified, the variability load of the ball's speed decreased using a frontennis ball. Therefore, the modification of the mobile could produce a greater consistency in the service performance. In this sense, we agree with some authors when we affirm that it would be interesting to analyse variability loads in practice on the effects of consistency and the ball's speed (Menayo et al., 2010; Davids et al., 2006), as we have approached in this study. Hence, we underscore the interest of calculating the

variability load magnitude to know the effects of the load of each tennis player's practice.

In our study, it seems that induced variability has a different load percentage for each tennis player. Some series of induced variability have less loads than the series performed without variability, meaning that performance increases. Some other series have greater loads than the series of usual performance, which means that performance decreases.

CONCLUSION

We must highlight that the variability load has been greater in the series that differs more from the series of usual performance (using a paddle racket) in speed as well as in accuracy.

In this case, results coincide with the hypothesis of our study, since the series of induced variability have produced bigger differences in speed for amateur tennis players than for national tennis players. Likewise, series which differ more from those of usual performance (paddle racket performance) have produced greater variability load magnitudes and have decreased performance. However, according to the variability load magnitude results do not coincide with our hypothesis. There have not been more variations in the variability loads in amateur tennis player than in national tennis players, but we can see load magnitude variations in both groups.

According to the exposed studies and the obtained results, we can see the importance of realising further investigations about the effects of the practice with induced variability conditions in tennis players of different levels and practising different shots. It is essential to determine the optimal variability load magnitude, as well as select the appropriate learning and training tasks, in which we can introduce variability to improve tennis players' performance.

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REFERENCES

Baiget, E., Corbi, F., Fuentes, J. P., & Fernandez-Fernandez, J. (2016). The Relationship Between Maximum Isometric Strength and Ball Velocity in the Tennis Serve. *Journal of Human Kinetics*, 53(1), 63-71. doi: 10.1515/hukin-2016-0028

Barbado, M., Caballero, C., Moreside, J., Vera-García, F.J., Moreno, F.J. (2017). Can the Structure of Motor Variability Predict Learning Rate? *Journal of Experimental Psychology: Human Perception and Performance, 43(3)*, 596-607. doi: 10.1037/xhp0000303

Caballero, C., Luis, V., Sabido, R. (2012). Efecto de diferentes estrategias de aprendizaje sobre el rendimiento y la cinemática en el lanzamiento del armado clásico balonmano. *European Journal of Human Movement*, *28,* 83-100. Recuperado de http://www.redalyc.org/pdf/2742/274224368005.pdf

Crespo, M. (2009). Tennis Coaching in the Era of Dynamic Systems. *Journal of Medicine and Science in Tennis, 4(2),* 20-25. Recovered from https://www.academia.edu/536983/Tennis_coaching_in_the_Era_of_Dynamic_Systems

Davids, K., Glazier, P., Araujo, D., Bartlet, R. (2003). Movement systems as dynamical systems: the role of functional variability and its implications for sports medicine. *Sports Medicine, 33,* 245–60. doi: 10.2165/00007256-200333040-00001

Douvis, S.J. (2005). Variable practice in learning the forehand drive in tennis. *Perceptual Motor Skills, 101(2)*, 531-545. doi: 10.2466/pms.101.2.531-545

García, J.A., Moreno, F.J., Cabero, M.T. (2011). Efectos del entrenamiento en variabilidad sobre la precisión del lanzamiento de siete metros en balonmano. *E-balonmano.com: Revista de Ciencias del Deporte, 7(2),* 67-77. Recuperado de http://www.e-balonmano.com/ojs/index.php/revista/article/view/85/74

García, J.A., Sabido, R., Barbado, D., Moreno, F.J. (2013). Analysis of the relation between throwing speed and throwing accuracy in team-handball according to instruction. *European Journal of Sport Science, 13(2),* 149-154. doi: 10.1080/17461391.2011.606835

García-Herrero, J.A., Sabido, R., Barbado, D., Martínez, I., Moreno, F.J. (2016). The load of practice variability must be regulated in relation with learner expertise. *International Journal of Sport Psychology, 47(6),* 559-570. Recovered from http://www.ijsp-online.com/abstract/index/47

Hernández-Davó, H., Urbán, T., Sarabia, J.M., Juan-Recio, C., Javier, F. (2014). Variable training: effects on velocity and accuracy in the tennis serve. *Journal of Sports Sciences*, *32*(14), 1383-1388. doi: 10.1080/02640414.2014.891290

Jacobson, N.S., Truax, P. (1991). Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology, 59,* 12-19. doi: 10.1037/0022-006X.59.1.12

Menayo, R., Fuentes, J.P. (2011). Aprendizaje diferencial y práctica variable como medios para optimizar la ejecución del servicio en tenis. *Revista Electrónica Del Técnico De Tenis, 10,* 4-10. Recuperado de http://www.adicodeporte.es/adicode/images/stories/articulos/publicaciones-tenis/revista_ecoach.pdf

Menayo, R., Fuentes, J.P., Moreno, F.J., Reina, R., García, J.A. (2010). Relación entre variabilidad en la práctica y variabilidad en la ejecución del servicio plano en tenis. *European Journal of Human Movement, 25,* 75-92. Recuperado de https://dialnet.unirioja.es/servlet/articulo?codigo=3351062

Menayo, R., Moreno, F. J., Sabido, R., Fuentes, J. P., & Garcia, J. A. (2010). Simultaneous Treatment Effects in Learning Four Tennis Shots in Contextual Interference Conditions. *Perceptual and Motor Skills*, 110(2), 661-673. doi: 10.2466/pms.110.2.661-673.

Mendes, P.C., Couceiro, M.S., Rocha, R., Clemente, F.M., Lourenço, F.M., Mendes, R.M., Fuentes, J.P. (2015). Effects of an Extrinsic Constraint on the Tennis Serve. *International Journal of Sports Science & Coaching, 10(1),* 97-110. doi: 10.1260/1747-9541.10.1.97

Mendes, P. C., Fuentes, J. P., Mendes, R., Martins, F. M. L., Clemente, F. M., & Couceiro, M. S. (2013). The Variability of The Serve Toss in Tennis Under the Influence of Artificial Crosswind. *Journal of Sports Science and Medicine*, 12(2), 309-315.

Moreno, F.J., Ordoño, E.M. (2009). Aprendizaje motor y síndrome general de adaptación. *European Journal of Human Movement, 22,* 1-19. Recuperado de https://dialnet.unirioja.es/servlet/articulo?codigo=3323447

Moreno, F.J., Ordoño, E.M. (2015). Variability and practice load in motor learning. RICYDE. *Revista internacional de ciencias del deporte, 39(11)*, 62-78. doi: 10.5232/ricyde2015.03905

Nieblas, J., Molina, P. (2016). Revisión sistemática de la investigación sobre la enseñanza del tenis. *Cuadernos De Psicología Del Deporte, 16(2),* 111-124. Recuperado de https://revistas.um.es/cpd/article/view/264481

Sanz, D., Fernández, J., Zierof, P., Méndez, A. (2012). Variabilidad en la práctica para desarrollar las cualidades coordinativas de tenistas en formación. *ITF Coaching and Sport Science Review, 58(20)*, 16–18. Recuperado de https://pedrozierof.files.wordpress.com/2013/07/artc3adculo-variabilidad.pdf

Selye, H. (1956). *The stress of life.* New York: Mcgraw-Hill.

Schmidt, R.A., Lee, T.D. (2005). *Motor Control and Learning: a Behavioural Emphasis (4th ed.).* Champaing IL: Human Kinetics.

Taheri, H., Fazeli, D., Poureghbali, S. (2017). The Effect of Variability of Practice at Execution Redundancy Level in Skilled and Novice Basketball Players. *Perceptual & Motor Skills*, *124(2)*, 491-501. doi: 10.1177/00315125 16684078

Unierzyski, P., Crespo, M. (2007). Review of modern teaching methods for tennis. *International Journal of Sport Science, 7(3),* 1-10. doi: 10.5232/ ricyde2007.00701

Urbán, T., Hernández-Davó, H., Moreno, F.J. (2012). Variabilidad cinemática en relación con el rendimiento en el saque en jóvenes tenistas. *European Journal of Human Movement, 29,* 49-60. Recuperado de https://dialnet.unirioja.es/ servlet/ articulo?codigo=4775252.