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The effect of differential learning method on the international tennis number level among young tennis player candidates

Yahya Yıldırım[1*], Ali Kızılet[2] and Tuba Bozdoğan[2]

[1]Department of Common Courses, Bursa Technical University, Bursa, Turkey.
[2]Faculty of Sport Sciences, Marmara University, Istanbul, Turkey.

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The objective of the study is to assess the effects of Differential Learning (DL) approach on learning the tennis stroke techniques, retention of skills, and improving the mobility time of young tennis player candidates in comparison with the traditional teaching methods and, accordingly, to present the teaching methods that are suitable for a more effective development in tennis education. It is thought to be one of few studies on tennis education and determining the retention, although there are studies on DL. Twenty-four (12 girls-12 boys) volunteers doing high school-level tennis courses in İstanbul province were involved in this study (15.00±0.00 years, 1.65±0.06 m, 63.46±10.64 kg and body mass index 23.26±2.91 kg/m^2). One of the groups was named DL group, whereas the other group was named control group (6 girls and 6 boys in each). In both groups, 90-min trainings (three days/week) were performed for 10 weeks. In the present study, the International Tennis Number (ITN) test was used in determining the ITN scores and mobility times. The mobility test of ITN was modified using the Fitlight TrainerTM device according to the expert opinion. According to the results of the study, it was determined that, while the DL method is more effective than traditional training methods in learning tennis strokes and retention of learning, no statistically significant difference was observed in mobility time for both groups.

Key words: Differential learning, traditional learning, tennis skill, mobility.

INTRODUCTION

In recent years, various studies were carried out on the learning models that might enhance the classical learning approaches within the sports branches' own skill education for the athletes (Henz and Schöllhorn, 2016). In order to determine how the sports education has been developed, the studies recommended analyzing the education practice (Canadas et al., 2018). Despite that, there still are few studies focusing on the most appropriate training practices and methods aiming to enhance the athletic performance (Rivera and Badillo, 2019).

In the sports branches, in which equipment, racket, and such instruments are used, it might be difficult to maintain the quality in repeating the skills since there may be

*Corresponding author. E-mail: yahya.yildirim@gmail.com. Tel: +90 546 278 20 25.

different requests regarding the implementation of methods incorporating constant variability during the game. Different situations may be observed. For this reason, in order for the learning to be effective and persistent, the teaching methods should also incorporate the variability (Frank et al., 2008).

In different studies carried out on this subject or various sports branches, it was emphasized that the practices incorporating differences improve the motor learning rates more than the repetitive learning programs do. Among these studies, the remarkable ones have reported the efficiency of differential learning in football (Schöllhorn et al., 2004; Hegen and Schöllhorn, 2012), athletics (Jaitner et al., 2003; Beckmann and Gotzes, 2009; Beckmann and Schöllhorn, 2006), handball (Wagner and Müller, 2008), basketball (Schönherr and Schöllhorn, 2003; Lattwein et al., 2014), volleyball (Römer et al., 2009), ice skate (Savelsbergh et al., 2010), hockey (Beckmann et al., 2010), and tennis (Humpert and Schöllhorn, 2006).

Moreover, the retention of learning is also important. In order to achieve the long-term retention, certain physiological changes should be created in the body during the exercise (Saltin and Rowell, 1980; Boström et al., 2013; Alleman et al., 2015). The priority here is to protect the mechanisms that are responsible for the homeostasis. Thus, the retention of long-term adaptation processes in the body will be achieved (Boström et al., 2013). Similarly, the learning process will be accelerated and given retention by increasing the perception level of athlete, who will learn. Nowadays, the rate of participation in the tennis, which is the most popular among the racket sports, rapidly increases and, consequently, the competition also increases (Pluim et al., 2007). It became important to support this increase with the training practices.

The tennis is a multifaceted sports branch, which requires high level of technical, tactical, psychological, and physical skills. Although the technical skills are the dominant factor, the physical fitness, agility, speed, strength, and aerobic and anaerobic capacity of athletes are very important (Fett et al., 2017; Reid and Schneiker, 2008; Fernandez et al., 2006). In tennis, the successful performance depends on the combination of speed, accuracy, and agility. Thanks to the new training approaches implemented in improving these physical characteristics, the technical skill trainings reached a higher speed levels during the game (Fernandez et al., 2013). Especially service strokes at high speed became the key factor for winning the game (Fett et al., 2017; Kovacs, 2007; Reid and Schneiker, 2008). A non-fast stroke would give the opponent an advantage even if it is a technically correct stroke (Landlinger et al., 2012; Carlton et al., 2006).

The fact that the tennis is a dynamic branch of sports requires the athletes to rapidly change their positions in different directions and to accelerate and decelerate. In order to be able to have a good stroke, the athletes must be at the right point of the court. From this aspect, the speed and mobility are very important for reaching the ball (Ferrauti et al., 2002). In order to achieve this fast change of position, the role of mobility, which is one of the important components of physical fitness, in the trainings should be carefully adjusted (Paul et al., 2011). Mobility is defined as the athletes' ability to adapt to changing conditions, to react quickly, to adjust their body positions and to apply skills most efficiently (Ratamess, 2012; Brown and Ferrigno, 2005). Another factor playing role in the sufficiency of mobility is the cognitive functions. The term "mobility", defined as the ability of independently moving in the environment, also requires a complex control mechanism that can adapt to the internal and external changes (Brustio et al., 2018; Azadian et al., 2016; Shumway-Cook and Woollacott, 2012). As can be understood from these definitions, the term "mobility" is one of very important prerequisites of the effective performance of skills.

Within the scope of these factors, meeting the multifaceted demands regarding the physical and skill characteristics of the tennis is the key factor for success. Within this context, it became very important to employ the scientific and innovative methods in achieving the desired level of performance. One of these methods is the differential learning (Schöllhorn, 2000). In this method, the diversity in a method is considered rather than the repetition for multiple times. The Differential Learning Method is based on adapting to the random instruments, ground, and body motions to the skill in order to confuse the mind, avoiding the repetition during the training, and avoiding corrective feedbacks (Schöllhorn et al., 2012). The results obtained by integrating random tools, grounds and movements into the skill in the learning process are at least as successful as the results obtained in traditional teaching methods. Moreover, it was observed that the skill learning gains are at a higher level in the differential learning approach (Müller et al., 2009).

The objective in the present study is to evaluate the effect of differential learning approach on the skill education of tennis player candidates in comparison to the traditional teaching methods. The first hypothesis is that the differential learning method would have positive effect on the tennis stroking techniques and mobility scores. The second hypothesis is that the increases in ITN scores would be more effective than in the traditional teaching methods. The third hypothesis is that the retention effect of differential learning approach would be higher.

MATERIALS AND METHODS

Participants

Twenty four (12 girls and 12 boys) volunteers doing high school-

Table 1. Descriptive statistics by group (mean ± SD).

Group	Age (years)	Body height (m)	Body mass (kg)	BMI (kg/m^2)
DLG (n = 12)	15.00 ± 0.00	1.66 ± 0.06	62.72 ± 11.68	22.60 ± 3.06
CG (n = 12)	15.00 ± 0.00	1.64 ± 0.05	64.20 ± 9.96	23.90 ± 2.72
Total (n = 24)	15.00 ± 0.00	1.65 ± 0.06	63.46 ± 10.64	23.26 ± 2.91

DLG = Differential Learning Group; CG = Control Group; BMI = Body Mass Index.

level tennis courses in Istanbul Province were involved in this study. According to the pre-test results, the participants were divided into 2 homogeneous groups (6 girls and 6 boys in each). One of the groups was Differential Learning Group (DLG), whereas the other group was the control group (CG). The demographic and anthropometric characteristics of the participants are presented in Table 1. The body heights of participants were measured using 0.1cm-sensitive stadiometer (Holtain), whereas the body weight was measured with lightweight clothes and bare feet by using 0.1kg-sensitive digital bascule (Omron) (Sanz et al., 2019).

The families and school principles of the participants were informed about the study protocol and their written consents for the participation were obtained. Moreover, the consents of the children were also obtained and the volunteer consent form prepared in accordance with Helsinki Convention was. All the procedures were approved by the Ethics Council of Marmara University's Faculty of Medical Sciences (09.01.2017-1).

Measurements and procedures

In both groups, 90 min trainings (three days per week) were performed in the sports hall of high school for 10 weeks. Following the warm-up, the tennis training was performed with differential learning method in DLG, whereas the traditional methods were used in CG. In differential teaching practices, the differential principles of Schöllhorn were adopted and the process was constructed on adapting to the random instruments, ground, and body motions to the skill in order to confuse the mind, avoiding the repetition during the training, and avoiding corrective feedbacks (Schöllhorn, 1999). Different balls (crazy ball, crumpled paper, ping-pong ball etc.), different rackets (brush handle, soccer ball, funnel, etc.), different floors (on balance board, on the gymnastic cushion, on the cobblestone ground etc.) and different body movements (arms are extended in different directions, on one leg, bending the body in different directions, etc.) were used. In the traditional teaching group, a standard training incorporating multiple repetitions and corrective feedbacks was performed. At the end of training, the cooling session was performed at the same duration and with the same content in both groups.

The tests were performed on a standard tennis court (firm ground) in the morning hours in the weekends. The athletes performed no tiring physical activity within last 24 h before the tests and consumed no food or beverage other than water in the last 3 h. All the tests and measurements were performed in the same day and 15 min warm-up and stretching were performed before the tests. The pretest was performed before the tests, the posttest was performed at the end of 10-week training process, and the retention test was performed after 2 weeks from the end of study. The athletes were informed about the tests and study protocols and the volunteer consent form prepared in accordance with the Declaration of Helsinki was filled out.

Tennis stroke test

The tennis strokes were measured and scores using the International Tennis Number (ITN) test. ITN is a practice introduced by ITF (International Tennis Federation) in order to determine the levels of tennis players throughout the world. While performing this test, rather than the technical aspects of tennis strokes, the consistency, accuracy, depth, and strength in Service, Ground, and Volley Stokes are analyzed among 5 game situations (International Tennis Federation, 2004). ITN score refers to the score calculated by summing the total points obtained from tennis strokes and the total score of mobility.

Mobility test

In order to measure the tennis-specific mobility, the mobility test of International Tennis Number (ITN) was modified and implemented according to the opinions of experts (Figure 1). In the ITN mobility test, there are racket at 1st light and balls at the other lights and it is aimed to gather the balls on the racket in the shortest minimum time. The time is measured using a chronometer (International Tennis Federation, 2004). Because of the risk of ball falling and because of the use of chronometer, it is thought that this test is not suitable for the scientific studies. For this reason, a Fitlight TrainerTM (Fitlight TrainerTM, 2019) light was placed at the each of ball locations and a new test setup was designed. The locations of lights are as seen in the standard tennis court. The beginning point was the middle of rear line; each of the lights turns on according the order specified and then manually turned off: 1 – 2 – 1 – 3 – 1 – 4 – 1 – 5 – 1 – 6 – 1. The time begins when the light 1 is turned off. The light 1 turns on whenever a light is turned off and the time stops when the light 1 is turned off last time. The time is recorded as second. The total time is recorded as second in the ITN mobility test and there is a score system corresponding to every length of time. In the present study, the results of mobility measurements were expressed as Mobility Time (seconds) in the analyses and the scores corresponding to the seconds were used in calculating the total ITN score (Figure 2).

Statistical analysis

The data analyses were performed using SPSS 16.0 package software (SPSS Inc., Chicago, IL, USA). The OneWay ANOVA test was used in analyzing the intergroup differences, whereas the Repeated Measures test was used for the differences between the pretest, posttest, and retention test scores of groups. In interpreting the statistical analyses, the level of significance was set at $p<0.05$.

RESULTS

As a result of the pretest performed at the beginning of study, it was determined that there was no statistically significant difference between the total stroke scores of the groups ($F=0.07$, $p=0.795>0.05$). However, there were statistically significant differences between the groups in

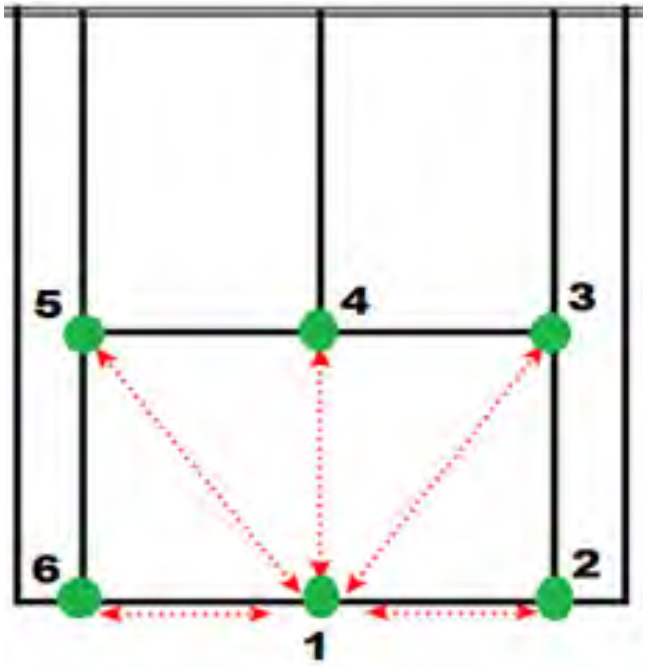

Figure 1. ITN mobility test.

Time (s)	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15
Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	21	26	32	39	45	52	61	76

Figure 2. ITN mobility test's time and score chart (International Tennis Federation, 2004).

terms of posttest and retention test scores (F=5.24, p=0.032<0.05; F=4.99, p=0.036<0.05, respectively). As a result of repetitive tests, it was determined while evaluating the advancements within the groups that there was a statistically significant increase from pretest and posttest in the mean total stroke scores of DLG and CG groups (p=0.000<0.05). Although the increases in both groups were statistically significant, the increase in DLG group doubled the increase in CG (129.3 and 67.9%, respectively). It was determined that there was no statistically significant change between posttest and retention test scores in both groups (p=1.000>0.05) (Table 2).

In the present study, it was determined that there was no statistically significant difference between the groups in terms of mobility time pretest, posttest, and retention test scores (F=0.51, p=0.485>0.05; F=1.08, p=0.309>0.05; F=0.18, p=0.674>0.05, respectively). As a result of the repetitive tests, the advancements in the groups were examined and it was determined that, regarding the mean mobility times of DLG and CG groups, there were irregular increases and decreases from pretest to posttest and from posttest to retention test but the changes were not statistically significant (Table 3).

As a result of the pretest performed at the beginning of study, it was determined that there was no statistically significant difference between the mean ITN scores of the groups (F=0.00, p=0.958>0.05). Given the results of posttest, it was determined that there was a statistically significant difference between the groups (F=4.63, p=0.043<0.05). In the retention test, it was found that

Table 2. The results of ANOVA test of total stroke score pretest, posttest, and retention test and Repeated Measure test of change scores in DLG and CG groups.

Group		Pre-test (1)	Post-test (2)	Retention-test (3)	Repeated measures		
		Mean (Points)	Mean (Points)	Mean (Points)	Test	Mean differences (%)	Sig.[b]
DLG (n = 12)		45.17 ± 20.80	103.59 ± 27.74	103.92 ± 26.67	1 - 2	- 129.31*	0.000
					2 - 3	- 0.33	1.000
					1 - 3	- 130.06*	0.000
CG (n = 12)		47.58 ± 24.13	79.92 ± 22.67	79.33 ± 27.26	1 - 2	- 67.97*	0.000
					2 - 3	0.74	1.000
					1 - 3	- 66.73*	0.000
ANOVA	F	0.07	5.24	4.99			
	P	0.795	0.032*	0.036*			

*Significant difference ($p < 0.05$).

Table 3. The results of ANOVA test of mobility time score pretest, posttest, and retention test and repeated measure test of change scores in DLG and CG groups.

Group		Pre-test (1)	Post-test (2)	Retention-test (3)	Repeated measures		
		Mean (Second)	Mean (Second)	Mean (Second)	Test	Mean differences (%)	Sig.[b]
DLG (n = 12)		20.42 ± 2.02	20.08 ± 1.78	20.84 ± 1.75	1 - 2	1.67	1.000
					2 - 3	- 3.78	0.080
					1 - 3	- 2.06	0.943
CG (n = 12)		21.00 ± 2.00	20.83 ± 1.75	21.15 ± 1.80	1 - 2	0.81	0.997
					2 - 3	- 1.54	1.000
					1 - 3	- 0.71	1.000
ANOVA	F	0.51	1.08	0.18			
	P	0.485	0.309	0.674			

*Significant difference ($p < 0.05$).

there was no statistically significant difference between the groups ($F=3.83$, $p=0.063>0.05$). As a result of the repetitive tests, the advancements in the groups were examined and it was determined that there was a statistically significant increase in mean ITN score of DLG from pretest to posttest (78.28%, $p=0.000<0.05$) but there was no statistically significant change from posttest to retention test (1.70%, $p=1.000>0.05$). Regarding the mean total stroke scores of CG group, it was determined that there was a statistically significant increase from pretest to posttest (42.72%, $p=0.000<0.05$), whereas no statistically significant change from posttest to retention test was observed (0.23%, $p=1.000>0.05$) (Table 4).

DISCUSSION

The importance of new teaching approaches, which influence the duration, effectiveness, and retention of skill education in sports, and the number of studies examining this subject gradually increase (Velička et al., 2016). In various studies, it was reported that the variable practice approaches increased the motor learning rates more than the repetitive learning protocols did (Lage et al., 2015; Henz et al., 2018).

In the studies carried out in last 20 years, the repetition of program-centered exercises has been questioned (Schöllhorn, 1999; Savelsbergh et al., 2010; Lage et al., 2015; Henz and Schöllhorn, 2016). In the present study, it was aimed to examine the effects of differential learning on learning the tennis stroke techniques, retention of skills, and improving the mobility time in comparison to the traditional teaching methods. The first hypothesis of the present study is that the differential learning method would positively affect the tennis stroke techniques and the mobility time. The results obtained supported the first hypotheses. Although significant increases were observed in the mean value of total stroke scores of both groups, it was also determined in the posttest that the increase in DLG was statistically significantly higher than in CG. In a similar study carried out on the shooting skills in football, it was found that the differential learning method was statistically significantly more effective than the traditional method (Hegen and Schöllhorn, 2012). In

Table 4. The results of ANOVA test of ITN score pretest, posttest, and retention test and Repeated Measure test of change scores in DLG and CG groups.

Group		Pre-test (1)	Post-test (2)	Retention-test (3)	Repeated Measures		
		Mean (Points)	Mean (Points)	Mean (Points)	Test	Mean differences (%)	Sig.[b]
DLG (n = 12)		76.75 ± 29.49	136.83 ± 34.30	134.50 ± 33.35	1 - 2	- 78.28*	0.000
					2 - 3	1.70	1.000
					1 - 3	- 75.24*	0.000
CG (n = 12)		76.08 ± 31.43	108.58 ± 29.87	108.33 ± 32.11	1 - 2	- 42.72*	0.000
					2 - 3	0.23	1.000
					1 - 3	- 42.39*	0.000
ANOVA	F	0.00	4.63	3.83			
	P	0.958	0.043*	0.063			

*Significant difference ($p < 0.05$).

the other studies carried out on this subject, it was reported that the differential learning method was more effective on the learning levels and retention when compared to the traditional methods (Henz and Schöllhorn, 2016; Hegen et al., 2016). Moreover, the increase percentage in DLG almost doubled the increase in CG (129.3% and 67.9%, respectively). In another study carried out on the individuals learning speed skating, it was determined that the differential learning method was more effective than the traditional teaching methods (Savelsbergh et al., 2010).

However, no statistically significant difference was observed in the mobility time. It can be stated that the study period was not sufficient because the mobility is a very complex phenomenon. In a study investigating the effects of differential learning on the mobility, it was reported that there was a slight but statistically insignificant change (Poureghali et al., 2019). The second hypothesis was that the differential learning method would be more efficient in terms of the advancement in ITN scores when compared to the traditional teaching method. When testing this hypothesis, it was determined that DLG had statistically significantly higher scores in posttest when compared to CG. According to these results, it can be stated that differential learning method is more effective in improving the ITN score in comparison to the traditional methods but there was no difference in terms of the retention of learning; it can be said that the learning is permanent in both groups. Examining the improvement within the groups, it was determined that there were statistically significant increases in both groups from pretest to posttest but there was no change in the score from posttest to retention test. Given this result, it can be stated that the methods implemented in both groups increased the ITN score but the differential method was more effective than the traditional methods. In a study carried out on the tennis skill education and retention, it was reported that significant improvements from pretest to posttest were achieved both traditional and differential learning groups but a remarkable decrease was observed in traditional group in the period until retention test, whereas the differential learning group maintained their level (Hegen et al., 2016). In another country, in comparison to the traditional group, both of differential learning groups showed superior performance in learning the techniques and maintaining the performance after the test (Schöllhorn et al., 2012).

The third hypothesis was that the differential learning method would be more effective on the retention. The change between posttest and retention test was similar in both groups. In a study examining the retention by making use of different learning methods, it was reported that, to the contrary with our results, the traditional learning group regressed to the initial levels but differential learning group remained stable (Hegen et al., 2016). In another study, the differential learning method and traditional teaching methods were compared among the shot putters; in all the retention tests performed at the end of 4-week training period and 2^{nd} and 4^{th} weeks after the end of training period, it was determined that the improvement in differential learning group was statistically significantly higher than in the other group (Beckmann and Schöllhorn, 2003). In another study, to the contrary with the groups in which the traditional teaching methods were used, it was reported that the differential learning group achieved a remarkable improvement but the retention scores were similar to each other (Schöllhorn et al., 2012). These studies differ from the present study in terms of achieving the learning and the retention of learning.

All the studies achieved in the present study show similarity with many studies in the literature. In these studies, when compared to the traditional teaching methods, it was found that the differential learning method was more useful and the learning was more permanent (Beckmann and Schöllhorn, 2003; Schöllhorn et al., 2006; Henz and Schöllhorn, 2016). According to

the principles of traditional teaching philosophy, repeating for many times is deemed to be compulsory for mastery and it is assumed that the "ideal" movements defined by the athletes at the world standard would be improved by repeating as many times as possible (Schöllhorn, 2000). Considering the results of the present study, it is thought that the principles of traditional education philosophy should be revised.

In conclusion, it was determined in the present study that a higher level of improvement was observed in the skill performances of differential learning group when compared to the control group. Moreover, since there are no multiple repetitions in the differential learning method, it saves from the total time of training. Besides that, the successful results have been achieved in the literature, in which the differential learning method was employed in other studies on the other sports branches, and it was reported that the differential learning method can be used in training programs for both new beginners and advanced level athletes (Savelsbergh et al., 2010; Schöllhorn et al., 2012). The trainings should directly influence the performance of athlete and maximize the performance during the games. In fact, the previous reports revealed that the training programs focusing on the differential learning and physical literacy improved the players' ability to make use of environmental knowledge (Coutinho et al., 2017). The differential learning method may establish a new skill implementation model since it exceeds beyond the nature of movement and it incorporates new trials under different conditions (Torrents et al., 2007).

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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