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Investigation of the Effect of Badminton-Specific 8 Week Reaction Training on Visual-Motor Reaction Time and Visual Cognitive Dual Task

Badmintona Özgü 8 Haftalık Reaksiyon Antrenmanının Görsel-Motor Reaksiyon Zamanı Üzerine Etkisinin İncelenmesi

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This study was presented as an orally in 16th International Sport Sciences Congress, 31 October-3 November 2018, Antalya, Turkey.

ABSTRACT Objective: Badminton is a sport that includes intervals with high density in short intervals and where coordinative skills such as reaction are very important. Rapid reaction is important for badminton skills. The purpose of the study was to determine the effect of visual reaction training on the visual-motor reaction time of the badminton players after the 8-week training given with Fitlight Trainer™ system. **Material and Methods:** The fifteen elite badminton players, who have participated in international badminton championships, are randomly divided into two groups. (Training Group: n=8; Control Group: n=7). The reaction training was measured by the wireless system FitLight Trainer™ consisted off 8 RGB Laser Led and hand control unit. In preliminary and final measurements applied to the experimental and control group, reaction test specific to badminton and 10 series of simple motor reaction task including 22 reactions were applied. The total duration of the response to the visual stimuli on each plot and the average reaction time were calculated. Paired sample t-test was used to test the mean difference in subjects with before and after the training. Independent samples t-test was used to test the mean difference of the groups. **Results:** There is no difference between the pretest parameters of the groups. According to the main findings of this study a statistically significant decrease was observed between the training group and the control group for the following parameters (1) total test duration and (2) average reaction duration ($p<0.05$). **Conclusion:** As a result of this research conducted to determine the effect of visual reaction training on the visual-motor reaction time of badminton players, the visual reaction training was effective in improving the visual-motor reaction time of the badminton players.

Keywords: Badminton; reaction; motor; training

ÖZET Amaç: Badminton, kısa süreli yüksek yoğunluklu ve kısa intervaller içeren ve reaksiyon gibi koordinatif yeteneklerin çok önemli olduğu bir spordur. Hızlı reaksiyon, badminton branşına özgü becerilerde önem taşımaktadır. Gerçekleştirilen çalışmanın amacı, 8 haftalık Fitlight Trainer™ (FitLight Sports Corp., Kanada) sistemi ile verilen 8 haftalık görsel reaksiyon antrenmanının, badminton oyuncularının görsel-motor reaksiyon zamanı üzerine etkisini belirlemektir. **Gereç ve Yöntemler:** Uluslararası badminton şampiyonalarına katılmış 15 elit badminton oyuncusu rastgele 2 gruba ayrılmıştır (Antrenman Grubu: n=8; Kontrol Grubu: n=7). Reaksiyon antrenmanı, 8 adet RGB Lazer Ledli [(Fitlight Trainer™ (FitLight Sports Corp., Kanada)] ışık vericisinden ve merkezi el kontrol ünitesinden oluşan kablosuz (wireless) reaksiyon geliştirme ve antrenman sistemi olan FitLight Trainer™ ile verilmiştir. Deney ve kontrol grubuna uygulanan ön ölçüm ve son ölçümlerde ölçüm protokolü olarak, badmintona özgü reaksiyon testi ve 22 reaksiyonu içeren 10 seriden oluşan görsel basit-motor reaksiyon testi uygulanmıştır. Uygulanan test protokollerine göre her serideki görsel uyaranlara verilen yanıtın toplam süresi ve ortalama reaksiyon süresi hesaplanmıştır. Bağımlı örneklem t-testi, katılımcıların antrenman öncesi ve sonrası ortalamalarının farklarının test edilmesi için kullanılmıştır. Bağımsız örneklem t-testi grupların ortalamalarının farklarının test edilmesi için kullanılmıştır. **Bulgular:** Grupların ön-test parametreleri arasında fark yoktur. Bu araştırmadaki ana bulgulara göre antrenman grubunda kontrol grubuna göre (1) toplam test süresinde ve (2) ortalama reaksiyon süresinde istatistiki anlamda önemli derecede azalma gözlenmiştir ($p<0,05$). **Sonuç:** Görsel reaksiyon antrenmanlarının badminton oyuncularının görsel-motor reaksiyon zamanı üzerine etkisini belirlemek amaçlı yapılan araştırma ile badminton oyuncularının görsel algı becerilerinin geliştirmesinde görsel reaksiyon antrenmanlarının etkili olduğu sonucuna ulaşılmıştır.

Anahtar Kelimeler: Badminton; reaksiyon; motor; antrenman

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Sports that include a dynamic surrounding require high perceptual competence for athletes to be able to perform motor skills with high competence.[1] Motor skills like fast reaction and good inhibitory control are important for elite sports performance.[2] In the evaluation of reactive skills of athletes in different branches, reaction time (RT) and time of action (TA) are two neuromotor variables. RT indicates to the duration of the start of reaction to present stimuli. TA refers to the duration between the start and end of motor-action. RT is the most reliable indicator of the individual properties of the rate of processing the sensory stimuli by central nervous system and muscle systems.[3,4]

Visual RT and visual prediction time are high perceptual skills that are known to have an important effect on athletes. Visual RT of athletes is related to how fast an athlete reacts to a visual stimulus which involves cerebral processing and coordinated peripheral response. In the studies, visual RT is determined as the time period between a visual stimulus and a motor reaction to a given visual stimuli.[5,6] As it is important for many other sports branches, the RT in badminton is an important motor skill for success.[1] It was stated that racquet sports developed neurocognitive brain functions according to the visual and auditory RT data of racquet athletes.[7] RT is one of the variables assessed in psychomotor skills and is the main determinant of psychomotor performance evaluation for racket sports.[7]

Badminton, which is rapidly spreading worldwide, is a racket sport that includes bounces, sudden swings, and fast movement of arms. This sport is played without any physical contact by 2 or 4 players on a rectangle court divided equally by a net.[1] Players shoot the ball against their opponents and at the same time continuously return their opponents' shots, stepping forward.[5] The speed of ball in badminton was measured as 421 km/h, and this is the highest ball speed in the world as Guinness World Record. It is highly important to react to the high speed of shuttlecock in a very short time and adjust their body position rapidly and continuously throughout the game.[3-8] The rapid return of shuttlecock takes less than 1 second, therefore requires quick thinking and reacting quickly against the stimulus throughout the game.[3] Shuttlecock speed increases linearly as badminton players increase their skill level.[9] Badminton requires constant movement, making decisions in a short time, and following the decision made, it requires responding to the ball making motor programming in the central nervous system.[4] Elite badminton players were found to have better physical properties like height, weight, strength than sub-elite players, but shuttle run tests and on-court badminton-specific movement agility tests were found to be similar between elite and sub-elite badminton players.[10] Elite badminton players change their positions in a short time, analyzing the match quickly, predicting the opponents' movements, the direction of the ball and the place the ball is going to hit in the court.[3] Badminton players have shorter RTs because of their regular training, and better muscle coordination, better concentration, and wakefulness to their bodies. Human brain's rate processing and coordinated peripheral response can be evaluated by measuring the RT.[6]

Eye-hand coordination is a very important visual motor function that enables the targeted use of the arm, hand, and fingers during sport activities, especially badminton, to produce controlled, accurate and fast movements.[11] It has been reported that athletes (soccer players, basketball players, volleyball players, runners, skiers) had a shorter (faster) eye-hand visual RT than the control group and athletes had a higher visual spatial intelligence. Athletic background and RT have correlated negatively. Visual spatial intelligence and athletic background have correlated positively. Thus, exercise has been shown to be beneficial for eye-hand reaction performance and visual perceptual brain functions.[12] In another study investigating visual RT and auditory reaction performance for dominant and non-dominant hand, male badminton players under 15 are proven to have a better RT when compared to the females.[1] In studies, badminton players were shown to have a better simple visual RT than non-players as a consequence of badminton training.[4-6] Reaction time was also analyzed using motion analyzing software for simulation of a real situation in the match. It is found that the RT increases as deception increases.[3] Simple visual-motor RTs of high-level badminton players were determined by a neuro-physical process. They stated that, rather than being related to a process in the motor, visual-motor RT is related to visual process. They found that badminton players indicated higher visual and visuomotor performance in response to visual motion signals than non-athletes.[13] Forehand and backhand coincidence anticipation time was examined in badminton players and anticipation time of badminton players was found better during forehand stroke than backhand stroke.[14] The badminton reaction inhibition test including the field-to-general RT, RT evaluation for badminton players, site-general inhibitor control, and badminton-specific inhibitor control parameters were applied to the elite and non-elite badminton players. They found that elite and non-elite badminton players are able to react at similar rates. But elite badminton players are faster than non-elite badminton players in badminton-specific RT of the go condition and go backhand tests. It has been suggested that badminton specific reaction testing can be used to improve the performance of badminton players in training programs.[2] It is emphasized the necessity to include RT exercises such as shuttlecock and visual stimulus because RT is an important factor for success.[1] However, no study has been carried out that investigates the effect of badminton-specific visual-reaction training on visual reaction.

The present study was aimed to determine the effect of an 8-week badminton-specific reaction training which is conducted using Fitlight Trainer™ (FitLight Sports Corp., Canada) on the visual-motor reaction performance of elite badminton players. Because suitable visual-motor reaction trainings are crucial to be able to improve the badminton-specific RT, the hypothesis of the study was that elite badminton players are expected to have a better nerve-muscle performance at the end of 8-week reaction training.

MATERIAL AND METHODS

DESIGN OF THE STUDY

Patients

In total 15 elite badminton players who have competed in international badminton championships [age=20.55±2.74 years, (range 17-23) height= 169.7±13.08 cm, weight=64.43±13.14 kg, training age=10.53±1.50 years] participated in this study. Those elite badminton players competed within their own age groups in the season, and participated in professional international tournaments and/or in national tournaments. The players were randomly divided into two groups as the training group (n=8) and the control group (n=7).

Participants were given the experiment protocol and their written consents were asked. On conditions when the participants were under the international age limit, consent forms were signed by their parents. The study was approved by the ethics committee in accordance with Helsinki Declaration (Osmangazi University: 56742).

DATA COLLECTION TOOL

This investigation took 8 weeks and contained two time points of measurements pre-test-post-tests. Longitudinal effects of reaction training were measured by FitLight Trainer™ which is a reaction enhancement and training system that consists of a central hand control unit and 8 RGB Laser LED light transmitters. In the pre-test and post-test, as a part of measurement protocol, a visual simple motor reaction test which includes 10 series and 22 reactions (Protocol I) and a badminton-specific reaction test (Water et al. 2017) (Protocol II) were applied.[2,15] Schematic view of the badminton specific RT test protocol (Protocol II) front view of three lights of FitLight Trainer™ on a wall was shown in Figure 1.

The total and average time of response to each visual stimuli were calculated in accordance with the test protocols. Badminton-specific RT training was applied for 8-weeks [(Total training time/week (12 hours: 4 days* 3 hours per week)].

DATA COLLECTION PROCEDURE

Visual Simple-Motor Reaction Test

The light-disk plate was fixed on a 110 cm high table. Participants kept their dominant hand up at the determined start point as in Figure 1. They were told to keep their hands up after the deactivation of each light and this was watched. In the test, maximum time for disk's light stimuli was set as 3 seconds. In the study, a yellow light was used which was seen as 10 cm in diameter in the middle of the disk. Each of 10

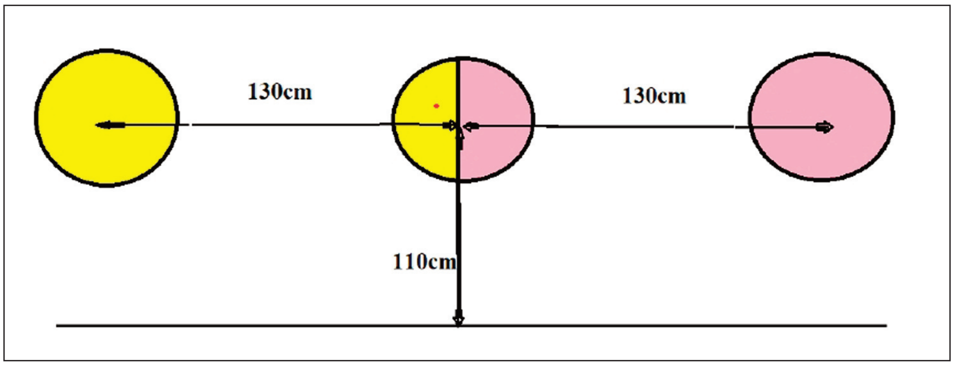

FIGURE 1: Badminton specific reaction time test protocol (Protocol II): Front view of three lights of FitLight TrainerTM on a wall.

series included 22 reactions which at intervals of 1.0-3.0 seconds. Participants were given 5 seconds of break for each plot. In total, each participant who randomly reacted to stimuli completed 220 tasks. Before the test, all participants took a pre-test which included 5 reactions to light stimuli. Participants were instructed to deactivate the light as soon as possible by placing their hands somewhere near the active lights. In the analysis, total amount of 22 RTs in each of 10 plots and average time of response to the stimuli were examined.

Badminton-specific Reaction Time Evaluation Protocol

In the badminton-specific RT test, FitLight Trainer™ system was used. FitLight Trainer™ is a wireless reaction training system which consists of LED-supported lights controlled by a tablet. Lights can be turned off manually. Participant took the test in front of a wall where three lights are positioned. The basic task of the test is to turn off the correct light as soon as the light turns on. So as to make the test protocol more badminton-like, the following directives were applied in the test: (1) lights should be switched off with the hand the players prefer (the hand with which the players hold the racket) (2) the horizontal distance between the central light and the two other lights were set as 130 cm, thus, in order to reach the forehand side (of the preferred hand) or in order to reach the backhand side (the opposite side of the preferred hand) the players needed to make a little forward move forward (3) lights were placed at a height of 110 cm, enabling the players to easily turn off the lights by knee bending and this position reflected the central position in badminton.[16,17] During the test, the participants move towards the lights to turn them off and stop when they turn off. In one plot, central light (which signals yellow or pink) needs to be deactivated, directly the related outer light should be deactivated; yellow light is linked to left outer light and the pink light is linked to the right outer light. After deactivating the outer light, the participants turned back to central position and another plot started. After the deactivation of the central light, all three signals turned red after a certain duration which is called stop signal delay. As to conclude, when the lights signal pink, the players moved from the deactivated central light towards the related outer lights. Red lights means stop signal, showing that motor reaction should be stopped and the outer light should not be deactivated. After inhibiting his/her motor reaction correctly or after (wrongly) deactivating the outer light, the participant returned back to central position. Each block consisted of 12 plots. The duration between the deactivation of central light and the start of the next plot was set as 2150 seconds for all plots and before each plot, the central light turned blue for 500 seconds as a stabilizing stimulus. Badminton players completed the dual task with two cognitive assessments, deactivating appropriate light and using clues at the same time. Dual task paradigm was designed to closely reflect the nature of badminton players.

STATISTICAL ANALYSIS

In the statistical analysis of the data, SPSS Statistics 22.0 (SPSS Inc, Chicago, IL) programme was applied and statistical significance level was set as $p<0.05$. Appropriateness of qualitative variables to the normal distribution was obtained by Kolmogorov-Smirnov test. Levene's test was applied to test the homogeneity of variance. There was homogeneity of variance by Levene's test (p>0.05). Paired samples t-test was applied for the statistics of the difference between the pre-test and post-test variables within the group; and independent samples t-test was applied for the difference in the post-test variables between groups.

RESULTS

THE RESULTS OF TOTAL AND AVERAGE REACTION TIME OF TRAINING GROUP

Total RT (Protocol I) increased from Pre to Post (p=0.967).

Average RT (Protocol I) decreased from Pre to Post (p=0.205).

Total RT (Protocol II) decreased from Pre to Post (p=0.001).

Average RT (Protocol II) decreased from Pre to Post (p=0.001).

All outcome variables are presented in Table 1 show total RT and average RT of training group for Protocol I and II.

THE RESULTS OF TOTAL AND AVERAGE REACTION TIME OF CONTROL GROUP

In the control group, no statistically significant change was observed before and after the training in terms of average and total RT (Protocol II) (p=0.261). A statistically significant increase was observed in total time (Protocol I) (p=0.013) and average RT (in the 8 lighted 220-repetition test) (p=0.020).

THE RESULTS OF PRE-POST TOTAL AND AVERAGE REACTION TIME BETWEEN GROUPS

In the final tests of the groups, no statistically significant change was observed in terms of average and total RT (Protocol I). A statistically significant change was observed in terms of average RT (p=0.001) and total RT (p=0.000) (Protocol II) (Table 2).

TABLE 1: Paired sample statistics of reaction time of pre- and post-tests for training and control groups (mean±SD).

Parameters		TG	p value	CG	p value
Total reaction time (Protocol I)	Pre-test	458.6±20.30	0.967	456.91±17.63	0.666
	Post-test	459.0±10.20		454.76±11.87	
Average reaction time (Protocol I)	Pre-test	0.46±0.05	0.205	0.42±0.04	0.200
	Post-test	0.43±0.05		0.46±0.05	
Total reaction time (Protocol II)	Pre-test	18.82±0.17	0.001	18.04±1.74	0.013
	Post-test	16.76±1.19		20.21±1.37	
Average reaction time (Protocol II)	Pre-test	1.07±0.18	0.001	1.17±0.24	0.261
	Post-test	0.58±0.07		0.97±0.27	

TG: Training group; CG: Control group.

TABLE 2: Independent sample statistics of reaction time of pre- and post-tests for training and control groups.

Parameter		n	Mean±SD	p value
Average reaction time (Protocol I)	Training	8	0.68±0.14	0.020
	Control	7	0.97±0.27	
Total reaction time (Protocol II)	Training	8	18.28±2,24	0.014
	Control	7	21.63±2.32	
Average reaction time (Protocol II)	Training	8	0.57±0.08	0.000
	Control	7	0.90±0.21	
Total reaction time (Protocol II)	Training	8	16.45±1.42	0.001
	Control	7	20.21±1.37	

SD: Standard deviation.

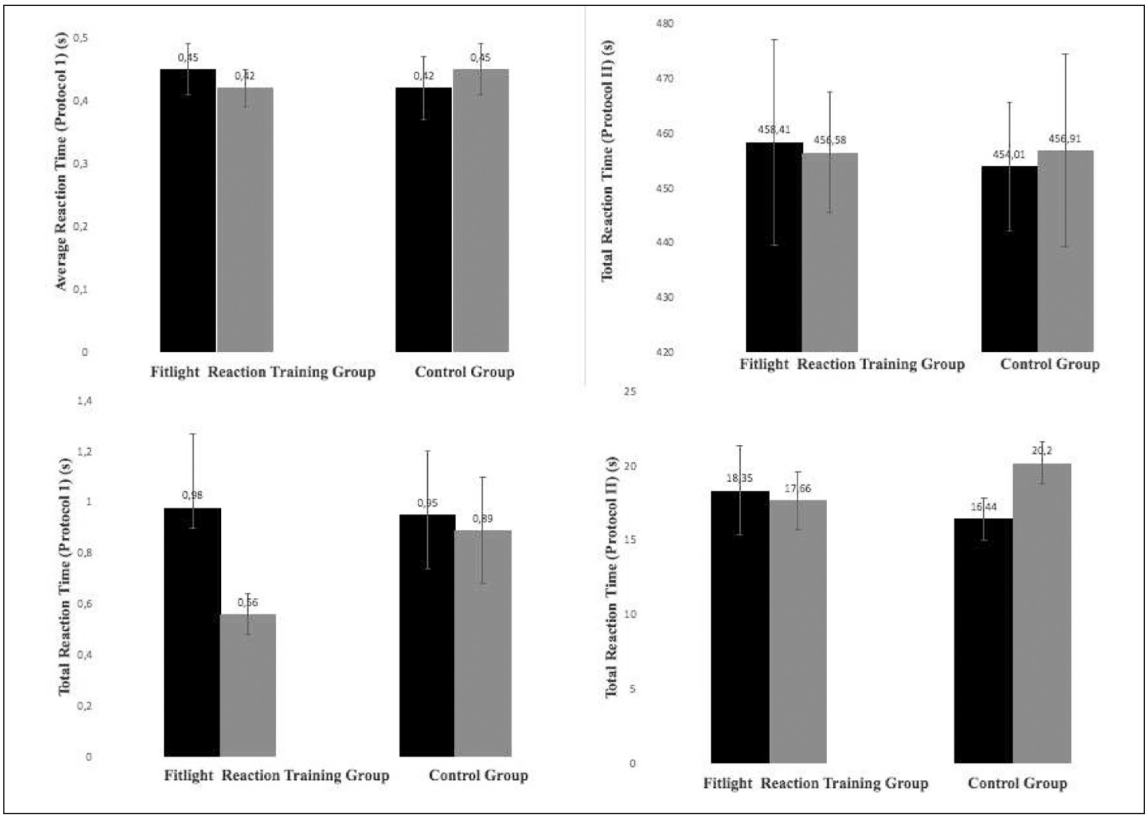

FIGURE 2: Bar graphs of the reaction time tests of badminton players and control group in pre-test and post-tests.

RT tests of badminton players and control group in pre-test and post-tests were shown as bar graph in Figure 2.

DISCUSSION

The aim of this study was to compare the visual-motor RT of badminton players after 8 weeks visual reaction training with the Fitlight Trainer™ system. This study made an emphasis on the importance of examining the supportive visual training in order to improve visual-motor reaction performance at elite sports and visual skills of athletes for visual-motor performance of athletes. The major founding of this study was that especially badminton specific reaction trainings boost the reaction performance than regular badminton training.

All the studies we found in literature were cross-sectional and mainly based on the comparison of RT of elite/non-elite badminton players, top level junior players/ non-playing boys and girls, badminton players/control group.[2-7] According to cross-sectional researches, badminton players showed shorter RTs than non-players, which is probably the result of the regular badminton training.[2-6] Visual and auditory RT was compared between badminton, table tennis and tennis players and non-sport sedentary. Visual and auditory RTs of racquet athletes and sedentary were found similar whereas sedentary was found lower visual and auditory reaction performance than all racquet athletes.[7]

Badminton-specific (backhand) RT was found to be shorter in elite badminton players than non-elite badminton players.[2] Visual RT of elite badminton players was also found shorter than that of non-elite counterparts.[7] Overall, research highlights the importance of RT in badminton players because of the sport dynamics. Since there was no study about visual reaction training in badminton players, comparisons were made in different branches.

In the study, it was determined that there was a positive development in terms of average RT, total RT for Protocol II in badminton players as the result of 8-week training. No positive development was determined in test results related to the average RT, total RT for Protocol II of control group of badminton players had no Fitlight training performed. This result was expected, and may be explained by the badminton specific training with Fitlight Trainer™ system. The sense of distance and neuromuscular control in the limbs of badminton players increase with regular badminton training.[18]

RT is one of the most decisive factors for successful sports performance.[19] Having neuro physical approaches for visual-motor evaluations and developing content for visual training can enhance athlete's RT, especially for sports that require visual-motor development. In many sport branches, movements must be initiated under critical time pressure which requires rapid sensory perception. Especially, athletes competing in teams with a ball have a shorter visual-motor RT. This situation can result from the neuro physical process of the brain. In addition to this, with the recognition of visual-motor signaling of the athletes, and with the understanding of the weakness and strength of motor process, the situation becomes more sophisticated.

RT was found shorter after 12-week visual foot reaction developing training in the children wrestlers at 11-13 age interval.[19] Although the athletes and the reaction developing training are different, the studies in terms of the positive effect of the RT analysis are parallel.

This result was expected, and may be explained by the unique training methods and repeated practice of badminton serves among the badminton players; badminton players' sense of distance and neuromuscular control in their upper limbs could have improved through regular training. Indeed, a previous study reported that skilled badminton players had greater control of their forearm muscles, and this enabled greater accuracy of performance.[20]

RECOMMENDATIONS

In this respect, trainers can decide on the content of the training by determining athletes' individual visual-motor skills. Furthermore, the importance of processing visual perception lays weight on the developing visual training methods. Visual perception sensory of Fitlight Trainer™ system can be recommended to develop visual functions and to improve visual motor reaction performance.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Deniz Şimşek, Elvin Onarıcı Güngör;* ***Design:*** *Berkay Arslan, Kevser Bozkurt, Sina Cem Düzova;* ***Control/Supervision:*** *Deniz Şimşek, Elvin Onarıcı Güngör;* ***Data Collection and/or Processing:*** *Berkay Arslan, Kevser Bozkurt, Sina Cem Düzova;* ***Analysis and/or Interpretation:*** *Elvin Onarıcı Güngör;* ***Literature Review:*** *Deniz Şimşek, Semra Bidil;* ***Writing the Article:*** *Deniz Şimşek, Elvin Onarıcı Güngör;* ***Critical Review:*** *Berfin Serdil Örs, Semra Bidil;* ***References and Fundings:*** *Deniz Şimşek, Semra Bidil;* ***Materials:*** *Deniz Şimşek.*

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