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The Effects of Different Strength Training Programs on Field Tests in Individuals Aged 18-20

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**This study is based on the PhD thesis titled "The Effect of Different Strength Training on the Performance and Detraining Levels of Individuals in the 18-20 Age Group," published in 2024.*
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Abstract

This study examined the effects of different strength training programs applied over a 12-week period on various performance values in young individuals aged 18-20, as well as the performance values following a 1-month detraining period. The research involved 30 male volunteers studying at Selçuk University in Konya. After initial measurements, participants were randomly assigned to one of three groups: a control group (CG), a plyometric strength training group (PSTG), and a resistance band strength training group (RBSTG).

The training groups performed the prescribed 8 training modalities 3 days per week for 12 weeks, with 10 repetitions and 4 sets each session. Following the training period, post-tests were conducted and the detraining period began. After a 1-month detraining period, detraining tests were conducted, and statistical analyses were performed. Results were analyzed using SPSS (IBM SPSS Statistics 26). Mean and standard deviations for all variables were calculated. Differences within groups for pre-test, post-test, and detraining test measurements were assessed using 'Repeated Measures ANOVA'. Differences between groups for each period (pre-test, post-test, and detraining test) were determined using 'One-Way ANOVA'. To identify which group contributed to the differences, the "Duncan" post-hoc test was applied. A significance level of $P<0.05$ was considered statistically significant.

Significant differences were observed within the plyometric training group for aerobic power testing ($P<0.05$). In speed tests, the control group showed negative changes, while the training groups showed supportive improvements ($P<0.05$). Reaction tests revealed significant changes within the training groups ($P<0.05$). Between-group comparisons showed that the plyometric training group had statistically significant results in post-tests ($P<0.05$). In agility testing, significant changes were observed within the training groups, with the resistance band training group showing statistically significant results post-tests ($P<0.05$).

In conclusion, plyometric training is effective in improving aerobic capacity, while resistance band training shows limited impact. Furthermore, it highlights that the effects of these training methods may vary depending on individual factors such as age, gender, and training history.
Keywords: Detraining, Strength, Performance.

Farklı Kuvvet Antrenmanlarının 18-20 Yaş Grubu Bireylerin Saha Testleri Üzerine Etkileri

Özet

Bu çalışmada, 18-20 yaş arasındaki genç bireylerde farklı kuvvet antrenmanlarının 12 haftalık bir süre boyunca uygulanmasının antrenman sonrası bazı performans değerleri üzerindeki etkisi ve ardından 1 aylık detraining dönemi sonrası performans değerleri incelenmiştir. Araştırmaya, Konya Selçuk Üniversitesi'nde öğrenim gören 30 erkek birey gönüllü olarak katılmıştır. Katılımcılar, ilk ölçümleri alındıktan sonra rastgele bir şekilde kontrol grubu (KG), pliometrik kuvvet antrenman grubu (PKAG) ve direnç lastiği kuvvet antrenman grubu (DLKAG) olmak üzere 3 gruba ayrıldı.

Antrenman grupları, belirlenen 8 antrenman şeklini ilk testlerin ardından haftada 3 gün boyunca 12 hafta boyunca 10 tekrar 4 set şeklinde uygulamıştır. Antrenman dönemi sona erdikten sonra son testler yapılmış ve detraining dönemine geçilmiştir. 1 aylık detraining dönemi sonrasında detraining testleri yapılarak istatistiksel analizler gerçekleştirilmiştir. Çalışmanın sonuçları, SPSS (IBM SPSS Statistics 26) paket programında değerlendirilmiştir. Tüm değişkenlere ait verilerin ortalama ve standart sapmaları hesaplanmıştır. Ön test, son test ve detraining test dönemlerinde alınan ölçümler için grup içindeki farklılığın belirlenmesinde, 'Tekrarlı Ölçümlerde Varyans Analizi' (Repeated Measures ANOVA) testi uygulanmıştır. Her bir dönem için (ön test, son test ve detraining test), gruplar arasındaki farklılığın belirlenmesinde ise 'Tek Yönlü Varyans Analizi (One Way ANOVA)' kullanılmıştır. Farklılığın hangi gruptan kaynaklandığının belirlenmesinde ise Post-hoc testlerden "Duncan" testi uygulanmıştır. İstatistiksel analizlerin değerlendirilmesinde, $P<0,05$ olduğu durumlar anlamlı değer olarak kabul edilmiştir.

Aerobik güç testinde pliometrik antrenman grubunda grup içi ölçümler arasında anlamlılık gözlemlenmiştir ($P<0,05$). Sürat testinde kontrol grubunda negatif yönde, antrenman gruplarında ise destekleyici yönde anlamlılık tespit edilmiştir ($P<0,05$). Reaksiyon testinde antrenman gruplarında grup içi ölçümlerde anlamlılık gözlemlenmiştir ($P<0,05$). Gruplar arası ölçümlerde ise son testler sonrasında PKAG istatistiksel olarak önemli ölçüde anlamlı bulunmuştur ($P<0,05$). Çeviklik testinde antrenman gruplarında grup içi ölçümlerde anlamlılık bulunmuştur. Gruplar arası ölçümlerde ise son testler sonrasında DLKAG istatistiksel olarak önemli ölçüde anlamlı bulunmuştur ($P<0,05$).

Sonuç olarak, pliometrik antrenmanın aerobik kapasiteyi artırmada etkili olduğunu, direnç bandı antrenmanının ise sınırlı bir etkisi bulunduğunu göstermektedir. Ayrıca, bu antrenman yöntemlerinin etkilerinin yaş, cinsiyet ve antrenman geçmişi gibi bireysel faktörlere bağlı olarak değişebileceğini vurgulamaktadır.

Anahtar Kelimeler: Detraining, kuvvet, performans.

INTRODUCTION

The effects of strength training on sports performance have become an important research topic for both individual and team sports. These types of training are commonly used to enhance essential performance components such as speed, power, and endurance in athletes (1). It has been proven that resistance training is safe and effective for children and adolescents, and various resistance training modalities have been observed to positively affect sprinting and jumping performance (2).

The ability to perform repeated sprints and change direction is considered an important factor in the performance of individual athletes. These skills are regarded by coaches and researchers as indicators of superior performance in many sports and serve as significant markers of players' fitness levels (3). It has been found that athletes with a higher skill level demonstrate better reactive sprint performance (RSA) compared to those with a lower skill level (4)

Physical fitness stands out as one of the fundamental characteristics of athletes, as they can face high physical work demands (5). Tests for maximal oxygen consumption (VO_2max), considered the gold standard in assessing aerobic capacity, are often not practically applied. Therefore, alternative assessment methods, such as field tests, are utilized (5). Field tests used to determine the effectiveness of strength training are of great importance in assessing the performance capacity of athletes (6). The relationships between isokinetic muscle strength and field-based jump tests are considered important when evaluating athletes' muscle strength and jumping abilities (7).

The balance system involves the coordinated functioning of elements such as vision (eyes), positioning (inner ear), support surface (deep sensation), motor system, central nervous system, and brain. The starting point of the balance system is the perception of our position in space. This perception occurs by activating muscle groups through nerve impulses sent to the brain by sensory receptors located in the eyes, muscles, joints, and inner ear, thus maintaining balance (8).

Reaction times also play a significant role in the performance of individual athletes. Simple reaction time (SRT) describes a straightforward response to a single stimulus, while recognition reaction time (RRT) and cognitive reaction time (CRT) involve more complex cognitive processes (9). Moreover, the relationship between individual athletes' hand dominance is a significant factor in the optimization of their motor skills (9).

Endurance parameters such as maximal oxygen consumption (VO_2max) are considered one of the determining factors of performance, especially in sports like soccer that require high aerobic capacity. Evaluating VO_2max in both laboratory settings and field tests necessitates the comparison of different methods to ensure the most accurate assessment of this capacity (10). Studies on the requirements of individual sports and the impact of these requirements on training programs assist coaches in developing specialized training programs tailored to the needs of athletes (3).

Plyometric training is a training method used to enhance explosive strength and plays a significant role in improving performance in both individual and team sports. Explosive strength is defined as the capacity of muscles to produce maximum force in the shortest possible time, and plyometric training facilitates rapid and powerful muscle contractions (11). In team sports such as football, volleyball, handball, and basketball, as well as in individual sports like athletics, wrestling, tennis, judo, and taekwondo, plyometric training includes exercises aimed at enhancing speed, agility, and strength (12, 13).

In general, plyometric training is used across various sports as a method to enhance explosive strength, reactive strength, and movement speed. This training method is particularly applied to elevate athletic performance to a high level and significantly contributes to the development of motor skills. The benefits of plyometric exercises include the rapid conversion of elastic energy into mechanical energy during muscle tension, thereby increasing the movement efficiency of athletes and improving their performance (14). It has been demonstrated through numerous scientific studies that plyometric training is a significant determinant of athletic success in both team and individual sports (15).

Resistance band training is a form of exercise that has gained popularity in recent years and is particularly effective for strength development. These workouts are performed using elastic bands that provide resistance, allowing for greater muscle contractions and targeting strength increases. Research has shown that resistance band training enhances both the isometric and dynamic strength capacities of athletes (14).

Training with resistance bands is noted for allowing muscles to work in a more controlled and efficient manner by placing a low load on the musculoskeletal system. For this reason, they are widely used in both rehabilitation processes and strength training (16). Additionally, resistance band training is said to carry a lower risk of injury compared to bodyweight training, as it promotes flexibility and ensures balanced strength development among muscle groups (15).

Especially when used in conjunction with strength training, resistance band exercises are effective in enhancing performance determinants such as maximal strength, explosive strength, and muscular endurance in athletes. The literature indicates that resistance band training directly contributes to strength development by targeting various muscle groups in the body, thereby improving sports performance (14, 16). In this context, scientific studies have proven that resistance band training is an effective tool for increasing athletes' strength capacities.

This study aimed to investigate the effects of different strength training methods on the field test results of individuals aged 18-20 and evaluated the effectiveness of the relevant testing methods based on the findings of the aforementioned studies.

METHOD

Participants

Thirty male individuals aged 18-20, who had been involved in sports for at least five years and had entered a sedentary period for various reasons, participated in this study at the Faculty of Sports Sciences of Selçuk University in Konya. Measurements of the participants were conducted at the Performance and Kinanthropometry Laboratory of the Faculty of Sports Sciences as well as in the university's sports facilities. General information about the study was provided to the volunteers, and they were asked to sign a consent form confirming their voluntary participation. The study was approved by the Ethics Committee of Selçuk University, Faculty of Sports Sciences, Konya, Turkey (Protocol number 07, 25 January 2016).

Procedure

Training Protocol: The measurements taken from the participants and the determined loading levels formed the basis of the study. The research was conducted according to a training protocol applied three days a week for a total duration of 12 weeks. Preliminary trials offered opportunities for familiarization with the tests and review of the training protocols. The frequency of the training program was three days a week, with a total of four sets and repetitions ranging from 8 to 10. The groups were randomly assigned following the pre-tests.

20-Meter Shuttle Run Test: Participants will run between two lines placed 20 meters apart while keeping pace with pre-recorded audio signals. The initial speed is set at 9.0 km/h, increasing by 0.5 km/h every minute. If a participant fails to keep up with the audio signals twice in succession or stops due to fatigue, the test will be terminated. Results will be recorded at the nearest stage (17). Participants were provided with the necessary explanations before the test and were given a 5-10 minute period to warm up.

60 Meter Speed Test: To assess the speed performance of the participants, a 60-meter sprint test was conducted. The test took place on a tartan track, utilizing electronic photo cells placed at the 0-60 meter distances. Each participant was given two attempts in the 60-meter sprint test, and the best time achieved was recorded as the test result. All participants performed a warm-up exercise before the sprint test (18).

Reaction Test: Five Fitlight lights have been fixed to the ground for the test. Two lights are placed 50 cm to the right and left of the spot where the participant will stand, followed by two lights 50 cm further ahead and one light 50 cm ahead of those two. The participant will stand in the middle of the lights and will be required to extinguish the red lights that will turn on 10 times using their dominant foot after the test begins. Each light is set to stay on for 5 seconds, and immediately after one light is turned off, another light will be activated. (19). The lights are set to detect the foot from a distance of 10 cm. Each participant is given one trial, followed by two tests conducted at 2-minute intervals, and the best result from these tests is recorded for analysis.

AgilityT-Test: The athlete will start in a proper stance at cone 1. Each athlete used the same starting position, running towards cone 2 while touching the top of the cone with their right hand. They then ran sideways to cone 3 and touched the top of cone 3 with their left hand. The athlete moved laterally towards cone 4, touching it with their right hand, and then touched cone 2 with their left hand while returning. Finally, the athlete ran backward from the starting line to cone 1. The timing began at the start and was stopped when the athlete crossed the starting line. Each participant was given one trial, followed by two tests, with the best result from these tests recorded for analysis (20).

Statistical Analysis: The results of the study were analyzed using SPSS (IBM SPSS Statistics 26) software. The mean and standard deviation values for all variables were calculated, and the 'Repeated Measures ANOVA' test was used to determine differences within the group for measurements obtained during the pre-test, post-test, and detraining test periods. For determining the differences between groups for each period (pre-test, post-test, and detraining test), the 'One-Way ANOVA' method was applied. To identify the source of the differences, the "Duncan" test was preferred among the post-hoc tests. In the statistical analysis results, values of $P<0.05$ were considered significant.

Ethical approval and institutional permission

The study was approved by the local ethics committee (Protocol number 07, 25 January 2016, Ethics Committee of Selcuk University, Faculty of Sports Science, Konya, Turkey) in accordance with the Declaration of Helsinki. Before the assessment, every participant received the same detailed information about the testing procedure. Every participant signed the informed consent.

FINDINGS

The performance outcomes of the measurements taken from our participants were compared in the tables created below after the analysis.

Table 1. Demographic characteristics of the participants.

		Control Group (n:10)		Plyometric Group (n:10)	Resistance Band Group (n:10)	P
Age (years)	**Pre-Test**	18.70 ± 0.67		18.70 ± 0.67	19.10 ± 0.87	0.39
	Post-Test	18.70 ± 0.67		18.70 ± 0.67	19.10 ± 0.87	0.39
	Detraining	18.70 ± 0.67		18.70 ± 0.67	19.10 ± 0.87	0.39
	P					
Height (cm)	**Pre-Test**	178.76 ± 7.38		176.90 ± 5.64	174.70 ± 6.12	0.42
	Post-Test	178.76 ± 7.38		176.90 ± 5.64	174.70 ± 6.12	0.42
	Detraining	178.76 ± 7.38		176.90 ± 5.64	174.70 ± 6.12	0.42
	P					
Body Weight (kg)	**Pre-Test**	71.40 ± 8.82	**C**	69.00 ± 6.58	68.70 ± 12.65	0.79
	Post-Test	73.00 ± 9.34	**B**	70.00 ± 6.56	69.30 ± 11.55	0.64
	Detraining	74.00 ± 9.15	**A**	70.60 ± 6.56	69.50 ± 11.28	0.53
	P	**0.00**		0.08	0.41	

A, B, C:Differences within group means in the same column that contain different letters are significant (P<0.05).
x, y, z:Differences between group means in the same row that contain different letters are significant (P<0.05).
P<0.05

According to Table 1, when examining the age and height values of the participants, no significant differences were found among the groups during the pre-test, post-test, and detraining periods (P > 0.05). A stable profile was observed in age values across all groups (P = 0.39). Similarly, no significant difference was found among the groups in terms of height measurements (P = 0.42). Looking at body weight values, a significant increase was observed over time in the Control Group (P = 0.00). However, no significant differences were detected in the Plyometric and Resistance Band Groups (P > 0.05). It is noteworthy that there was a significant increase in weight during the post-test and detraining periods in the Control Group, while this increase was less pronounced in the Plyometric and Resistance Band Groups.

Table 2. Descriptive statistical analysis table showing the speed test values of the participants.

Speed Test		Control Group (n:10)		Plyometric Group (n:10)		Resistance Band Group (n:10)		P
60-Meter Speed Test (s)	**Pre-Test**	8.19 ± 0.28	**A**	8.45 ± 0.39	**B**	8.21 ± 0.75	**B**	0.47
	Post-Test	8.19 ± 0.29	**A**	7.91 ± 0.37	**A**	7.70 ± 0.67	**A**	0.08
	Detraining	8.32 ± 0.32	**B**	8.40 ± 0.42	**B**	8.48 ± 0.94	**C**	0.85
	P	**0.01**		**0.00**		**0.00**		

A, B, C:Differences within group means in the same column that contain different letters are significant (P<0.05).
x, y, z:Differences between group means in the same row that contain different letters are significant (P<0.05).
P<0.05

According to Table 2, when examining the speed test results of the participants, no statistically significant difference was found among the groups in the pre-test values (P = 0.47). According to the post-test results, significant improvements were recorded in the Plyometric and Resistance Band Groups (P < 0.05), while no significant change was observed in the Control Group. The difference between the Plyometric and Resistance Band Groups was not significant (P = 0.08). During the detraining period, performance declines were observed in all three groups, with the Resistance Band Group showing the largest decrease (P = 0.85). In within-group comparisons, significant improvements were particularly noted in the Plyometric and Resistance Band Groups (P = 0.00).

Table 3. Descriptive statistical analysis table showing the reaction test values of the participants.

Reaction Test		**Control Group (n:10)**		**Plyometric Group (n:10)**		**Resistance Band Group (n:10)**		**P**
Fitlight (s)	**Pre-Test**	0.48 ± 0.02		0.46 ± 0.02	**A**	0.49 ± 0.02	**A**	0.11
	Post-Test	0.47 ± 0.02	**/x**	0.43 ± 0.02	**B/y**	0.46 ± 0.02	**C/xy**	0.00
	Detraining	0.48 ± 0.02		0.46 ± 0.01	**A**	0.48 ± 0.03	**B**	0.10
	P	0.06		**0.00**		**0.00**		

A, B, C:Differences within group means in the same column that contain different letters are significant (P<0.05).
x, y, z:Differences between group means in the same row that contain different letters are significant (P<0.05).
P<0.05

According to Table 3, when evaluating the reaction test results of the participants, it was observed that there was no significant difference among the groups in the pre-test values (P = 0.11). In the post-test results, the Plyometric Group showed a statistically significant improvement compared to the Control and Resistance Band Groups (P < 0.05). However, there was no significant difference between the Control Group and the Resistance Band Group in the post-test results (P = 0.00). When evaluating the detraining period, a decline was observed in the Plyometric Group compared to the post-test results, but this decline was not found to be statistically significant (P = 0.10). In within-group comparisons, statistically significant improvements were recorded in the post-test values, particularly in the Plyometric and Resistance Band Groups (P = 0.00).

Table 4. Descriptive statistical analysis table showing the agility test values of the participants.

Agility T Test		**Control Group (n:10)**		**Plyometric Group (n:10)**		**Resistance Band Group (n:10)**		**P**
T- Testi (s)	**Pre-Test**	10.98 ± 0.69		10.97 ± 0.72	**C**	10.58 ± 0.56	**C**	0.33
	Post-Test	10.82 ± 0.71	**y**	10.29 ± 0.76	**A/xy**	9.96 ± 0.54	**A/x**	**0.02**
	Detraining	10.90 ± 0.64		10.68 ± 0.79	**B**	10.42 ± 0.61	B	0.31
	P	0.32		**0.00**		**0.00**		

A, B, C: Differences within group means in the same column that contain different letters are significant (P<0.05).
x, y, z:Differences between group means in the same row that contain different letters are significant (P<0.05).
P<0.05

According to Table 4, when examining the pre-test values of the participants' agility test results, it was observed that there was no significant difference among the groups (P = 0.33). In the evaluation of the post-test results, the Plyometric and Resistance Band Groups showed significant improvements compared to the Control Group (P = 0.02). Although the post-test results of the Plyometric Group were lower than those of the Resistance Band Group, both groups performed better than the Control Group. During the detraining period, a certain decline was observed in the Plyometric and Resistance Band Groups; however, these declines were not found to be significant (P = 0.31). In within-group comparisons, statistically significant differences were recorded, particularly between the pre-test and post-test values of the Plyometric and Resistance Band Groups (P = 0.00).

Table 4. Descriptive statistical analysis table showing the agility test values of the participants.

Aerobic Power Test		**Control Group (n:10)**	**Plyometric Group (n:10)**		**Resistance Band Group (n:10)**	**P**
20-Meter Shuttle Run Test (MaxVo2) ml/kg/min	**Pre-Test**	48.63 ± 3.33	47.47 ± 4.36	**B**	48.83 ± 5.95	0.78
	Post-Test	48.76 ± 3.66	50.40 ± 4.33	**A**	52.32 ± 4.07	0.16
	Detraining	47.10 ± 3.56	49.22 ± 3.99	**AB**	49.47 ± 4.70	0.38
	P	0.23	**0.01**		0.12	

A, B, C:Differences within group means in the same column that contain different letters are significant (P<0.05).
x, y, z:Differences between group means in the same row that contain different letters are significant (P<0.05).
P<0.05

According to Table 5, when examining the results of the 20-meter shuttle run test (MaxVO2), no significant differences were observed among the groups during the pre-test period (P = 0.78). In the evaluation of the post-test results, significant improvements were recorded in the Plyometric and Resistance Band Groups. The Plyometric Group showed a significant increase in the post-test (P = 0.01), while the Resistance Band Group also showed improvement (P = 0.12), although this improvement was not found to be statistically significant. In the Control Group, no significant changes were detected in the post-test results (P = 0.23). During the detraining period, both the Plyometric and Resistance Band Groups maintained their performance compared to the pre-test results, but no significant differences emerged among the groups (P = 0.38).

DISCUSSION AND CONCLUSION

Considering that strength development and sensory-motor system responses can vary according to the type and intensity of exercise (21), it is clear that resistance band training can enhance skills such as dynamic balance and reaction. This research emphasizes the importance of cognitive functions and reaction speed on athletic performance and offers insights into the integration of plyometric and resistance training (22).

Similar inferences hold true for the speed factor as well. In our study, performance improvements were observed in both the plyometric and resistance band training groups in the 60m sprints, as expected. The enhancing effects of plyometric training on short-distance running speeds have been demonstrated in numerous previous studies (23-25). In this context, it appears that resistance band training can also enhance running speed (26).

The direct relationship between running speed and explosive power, along with the similar effects of these two training types, suggests that both methods can equally enhance speed. However, definitive conclusions cannot be drawn, as there is no study comparing the effects of plyometric and resistance band training on physical performance following the cessation of sports activity. Some studies that address differences in short-distance sprints consider distances as short as 10m as sprint distances, while others evaluate 100 meters (27). Our study is similar to those evaluating longer sprints, such as 50m (28), and has shown that elastic strength training and other training methods can improve 50m speed performance to similar extents.

Additionally, there are studies suggesting that resistance band training may produce similar effects to all forms of strength training except plyometric training (29, 30). It has been noted that plyometric and resistance band training may have similar effects in terms of muscle contraction principles (31).

Significant differences between groups were observed in agility performances involving high-intensity sprints. The resistance band training group showed a significant improvement in agility performance after the intervention. This finding indicates that resistance band training can enhance agility performance (30, 32). However, there is no study demonstrating greater improvements in agility when compared to plyometric training. The amortization phase between eccentric and concentric contractions in resistance band training, which can be performed with a higher resistance than in plyometric training, may have contributed to the enhancement of agility performance.

In summary, the lack of significant differences in speed performance without direction changes between plyometric and resistance band training can be interpreted to suggest that resistance band training may be more effective in agility performances involving direction changes. However, this perspective needs to be supported by scientific data. Additionally, it should be noted that periods of inactivity may lead to dramatic performance losses for both groups, resulting in final values dropping to similar levels.

In our study, the aim was to examine all components of physical fitness, including aerobic capacity. Significant improvements were observed only in the plyometric training group for the 20-meter shuttle run performance. It has been previously reported that plyometric training can positively affect not only anaerobic performance but also aerobic performance (33). However, the effects of plyometric training on aerobic capacity may vary depending on the intensity and duration of the training (34). There is insufficient data regarding the effects of resistance band training on aerobic performance.

In conclusion, it was observed that both plyometric training and theraband training may have similar effects on muscular and overall anaerobic performance. Although no exceptionally strong outcomes were reported, plyometric training appeared to be more effective than theraband training for aerobic performance, while theraband training seemed to have a greater impact on agility development compared to plyometric training. However, due to the limited studies in the relevant literature, these findings cannot be strongly supported. Additionally, it was clearly evident that neither of these training methods had an advantage in preserving performance loss resulting from inactivity. Further research is needed to clearly establish the effects of theraband training on aerobic or anaerobic performance and the changes in these effects following a period of inactivity.

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