Investigation of the Effect of Educational Games Applied Through Two Different Methods on the Biomotor and Cognitive Development of Inclusion Students[*,**]

Kaynaştırma Öğrencilerine İki Farklı Yöntemde Uygulanan Eğitsel Oyunların Biyomotor ve Bilişsel Gelişimlerine Etkisinin İncelenmesi

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ABSTRACT: The growing number of students participating in inclusion programs has underscored the need for evidence-based instructional strategies that support their motor and cognitive development. This study aimed to compare the effects of educational games delivered through two different methods—developmentally adapted games and standard curriculum-based games—on the biomotor and cognitive performance of inclusion students. A total of 29 full-time middle school inclusion students participated in the study and were randomly assigned to an experimental group (n=15) and a control group (n=14). The experimental group received educational games that were simplified and reconstructed based on individual proficiency levels, while the control group participated in standard games used in physical education classes. The 8-week intervention consisted of two 60-minute sessions per week. Biomotor skills (balance, flexibility, speed, jump, endurance) were assessed using the Eurofit Test Battery, cognitive performance was measured using ÇAĞIN Hand and Foot Reaction Tests, and selective attention was evaluated using the Flanker Test. The results indicated a significant group × time interaction only for balance (p=.020), in favor of the experimental group. No significant interaction effects were found for other biomotor or cognitive variables (p>0.05), although both groups demonstrated improvements over time. These findings suggest that educational games are beneficial for inclusion students regardless of structural modification, but adapted games did not yield superior outcomes except for balance. Future research should incorporate longer interventions and more cognitively complex game designs to better evaluate differential effects.

Keywords: educational games, inclusion students, cognitive performance.

ÖZ: Kaynaştırma programlarına katılan öğrenci sayısının artması, motor ve bilişsel gelişimlerini destekleyen kanıta dayalı öğretim stratejilerine olan ihtiyacı vurgulamıştır. Bu çalışma, gelişimsel olarak uyarlanmış oyunlar ve standart müfredata dayalı oyunlar olmak üzere iki farklı yöntemle sunulan eğitsel oyunların, kaynaştırma öğrencilerinin biyomotor ve bilişsel performansı üzerindeki etkilerini karşılaştırmayı amaçlandı. Çalışmaya toplam 29 tam zamanlı ortaokul kaynaştırma öğrencisi katılmış ve rastgele bir şekilde deney grubuna (n=15) ve kontrol grubuna (n=14) atandı. Deney grubu, bireysel yeterlilik düzeylerine göre basitleştirilmiş ve yeniden yapılandırılmış eğitsel oyunlar oynarken, kontrol grubu beden eğitimi derslerinde kullanılan standart oyunları oynadı. Eğitsel oyunlar 8 hafta boyunca haftada iki kez 60 dakikalık oturumdan oluşacak şekilde dizayn edildi. Biyomotor beceriler (denge, esneklik, hız, sıçrama, dayanıklılık) Eurofit Test Bataryası ile, bilişsel performans ÇAĞIN El ve Ayak Reaksiyon Testleri ile, seçici dikkat ise Flanker Testi ile değerlendirildi. Sonuçlar incelendiğinde ise sadece denge parametresinde deney grubu lehine anlamlı bir grup × zaman etkileşimi olduğunu gösterdi (p=.020). Diğer biyomotor veya bilişsel değişkenler için anlamlı bir etkileşim etkisi bulunmadı (p>0.05), ancak her iki grup da zamanla iyileşme gösterdi. Bu bulgular, eğitsel oyunların yapısal değişiklikten bağımsız olarak kaynaştırma öğrencileri için faydalı olduğunu, ancak uyarlanmış oyunların denge dışında üstün sonuçlar üretmediğini göstermektedir. Gelecekteki araştırmalar, farklı etkileri daha iyi değerlendirmek için daha uzun müdahaleleri ve bilişsel olarak daha karmaşık oyun tasarımlarını içermesi gerektiği düşünülmektedir.

Anahtar Kelimeler: eğitsel oyunlar, kaynaştırma öğrencileri, bilişsel performans.

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1. INTRODUCTION

Education is a fundamental human right and a need that supports human life. This need is important not only for children in general but also for children with special needs, who likewise have the right to quality education suited to their circumstances (*Adityatama & Faizah, 2024*). Physical education, physical activity, and sport are basic rights for everyone, and every individual holds this right equally, without discrimination (*UNESCO, 2015*). Because the term "inclusive education" carries multiple meanings, it is often regarded as a contested concept (*Petrie et al., 2018*). This raises crucial questions such as: "by whose standards?", "inclusion into what?" and "for whose benefit?" (*Spaaij et al., 2014*). Indeed, the literature on physical education contains numerous statements related to inclusive education (*Eşkil et al., 2022*). These encompass ideas such as focusing on social justice, the principle of equal opportunity, emphasizing a person's sense of belonging and acceptance, or placement in an educational setting (*Fitzgerald, 2009; Haegele et al., 2021*). Adityatama and Faizah (2024) define inclusive education as a model grounded in social-justice principles that seeks to ensure every student has equal access to quality education, regardless of physical, mental, social, or emotional differences, and that supports individuals in developing their potential. Türkiye's Ministry of National Education (MoNE) describes inclusive education as an approach that, through supportive arrangements, provides education for learners with special needs alongside their peers, thereby fostering social integration and individual development. In MoNE's Regulation on Special Education Services, education through inclusion is defined as "special-education practices based on the principle that individuals who need special education continue their education together with peers without disabilities in public and private pre-school, primary, secondary and non-formal education institutions, while also receiving support-education services" (*MEB, 2010a*). In recent years, the importance of inclusive education has grown worldwide (*Qi & Ha, 2012*), and Türkiye has followed this trend. Whereas the number of primary-level inclusion students in Turkey was 84.580 in 2010, it had risen more than four-fold to 345.623 in 2024 (*MEB, 2010b, 2024*). This underscores the importance of studying mainstreamed students. Such learners often encounter physical barriers that affect daily activities and can isolate them socially. The Physical Education and Sports course can help these students develop their skills and overcome these hurdles (*Eşkil et al., 2022*).

The Physical Education and Sports course help inclusion students enhance their motor skills, independence, social interaction, and cognitive attributes. Sport, in turn, supports self-confidence and psychological well-being alongside physical health (*Adityatama & Faizah, 2024*). The basic biomotor qualities of a person are the sum of one's bodily power, aptitude, and complex characteristics. These qualities, namely endurance, mobility, speed, strength, and coordination, describe the ability to perform movements. Supporting biomotor qualities within inclusive education will improve and heighten a student's performance (*Koruç & Bayar, 1992*). Motor skills are regarded as the building blocks of sports abilities and advanced movement skills (*Payne, 2017*). They are essential for children's participation in play and sport, where they are used in actions such as jumping, running, and object control and catching (Bishop & Pangelinan, 2018). Motor skills have numerous positive effects on children (*Logan et al., 2012*). When previous studies examining the effects of motor competence in childhood is reviewed, it is seen that it is associated with physical activity, cardiorespiratory fitness and the prevention of obesity (*Kantomaa et al., 2013*), higher levels of physical-activity participation throughout life (Williams et al., 2008), greater satisfaction and lower performance anxiety (*Walling et al., 1993*) and outcomes such as perceived sport competence, social acceptance and academic adequacy (*Valentini & Rudisill, 2004*). These findings can also be cited as evidence of just how important motor skills are in inclusive education. Fundamental motor skills do not develop solely with age, they must be taught and practiced (*Haywood & Getchell, 2001*). From this standpoint, play has an important place in the development of motor skills in children, and while playing the child develops both physically and mentally. Looking at its definition, play is described as an enjoyable, actively participatory educational tool. In every branch of basic education and particularly in the physical education course, it serves both as a teaching method and as a teaching aid. In this setting, the child learns by thinking and from the experiences that arise in various situations (*Hazar, 2017*). Motor skills are in fact the product of many cooperating subsystems that influence a child's motor-skill development. There is a strong bond between cognitive development and motor skills (*Çağın, 2025*). This relationship begins when children, at an early age, start to explore and control their own bodies (*Goodway*

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et al., 2003; Martínez & Antón, 2018). From a neurological perspective, it is observed that there is a dynamic relationship between cognitive processes and executive cognition in the execution of complex, coordinated motor behavior. Executive functions basically consist of components such as attention regulation, problem analysis, mental flexibility, and short-term memory. One of the fastest periods of executive-function development is experienced between the ages of six and ten, and during adolescence these processes develop into more complex planning and problem-solving skills (*Welsh et al., 2006*). When the literature is examined (*Best, 2010; Tomporowski et al., 2011*), it is revealed that in typically developing children, physical activity plays a critical role not only in bodily health but also in cognitive and academic performance.

Studies in the literature concerning students in inclusive education have mostly focused on subjects such as teachers' opinions and attitudes toward inclusion students (*Doğaroğlu & Dümenci, 2015; Eşkil et al., 2022*) and the development of the social skills of inclusion students (*Sucuoğlu & Özokçu, 2005*). Moreover, previous studies on inclusion students have generally been limited to motor skills. To date, no empirical study in the literature has directly compared the effectiveness of adapted educational games designed specifically for students with special educational needs and standard educational games developed for typically developing children. In this context, the primary aim of the present study is to examine the differential effects of these two instructional approaches on the biomotor and cognitive development of mainstreamed students. Over an eight-week intervention period, two distinct educational game models will be implemented: (1) simplified and developmentally adapted games tailored to the needs of inclusive students, and (2) standard educational games originally intended for typically developing peers. Through this comparative research design, the study seeks to determine the extent to which structural game modifications enhance developmental outcomes in this population. It is anticipated that the findings will provide valuable contributions to both the literature and educational practice by informing differentiated game-based instructional strategies and supporting the development of evidence-based intervention programs for students with special educational needs.

2. METHOD

2.1. Study Design

The necessary permission and approval for the study were obtained from the Gazi University Ethics Committee (E-77082166-604.01-861335), and the study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from the parents/legal guardians of all participants before their inclusion in the study. Participants were randomly assigned to an experimental group of 15 (10 boys, 5 girls) and a control group of 14 (10 boys, 4 girls). Baseline (pre-test) measurements were collected before the intervention. The determined educational games were applied in a standard order to the control group students, while these games were restructured according to the proficiency levels of these students in the experimental group. After the 8-week intervention, post-test measurements were taken, and the study was terminated.

2.2. Study Group

The study included 29 full-time inclusion students enrolled in middle-school education. The criteria for including the students were as follows:

- Having filled out the parental consent form,
- Attending the specified middle school as an inclusion student,
- Not having any vision problems such as color blindness,
- Not having any acute disability,
- Not having any history of failure due to absenteeism.

Table 1 presents descriptive statistics for age, height, and weight across the experimental and control groups. The mean age was 11.27±0.46 years in the experimental group and 11.50±0.52 years in the control group. The average height was 147.20±8.95 cm in the experimental group and 150.57±8.03 cm in the control group. Weight averages were 41.85±17.18 kg for the experimental group and 38.51±7.12 kg for the control group. These findings indicate that the groups are comparable at baseline in terms of demographic characteristics.

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Table 1

Descriptive Statistics for Age, Height, and Weight by Group

Variable	Group	n	M	SD
Age (years)	Experimental	15	11.27	0.46
	Control	14	11.50	0.52
Height (cm)	Experimental	15	147.20	8.95
	Control	14	150.57	8.03
Weight (kg)	Experimental	15	41.85	17.18
	Control	14	38.51	7.12

2.3. 8-Week Educational Game Program (Experimental and Control Groups)

Table 2

8-Week Educational Game Program (Experimental and Control Groups)

Week	Game	Target Skills	Experimental Group Adaptation	Control Group Implementation
1	Hop & Pop	Attention, coordination, physical fitness	Tasks simplified, visual cues increased, repeated reinforcement provided	Implemented in standard format
2	Giggling Time	Attention, self-control, physical fitness, social interaction	Sensory-sensitive materials used, verbal prompts increased	Conducted according to original rules
3	Tweet Little Bird	Auditory attention, environmental awareness, physical fitness	Auditory instructions simplified and supported with rhythmic repetition	Performed in standard format
4	Up and Away	Attention, visual–auditory coordination, physical fitness	Multisensory cues synchronized, step-by-step instructions used	Conducted in typical sequence
5	Who is Missing?	Visual attention, memory, physical fitness	Visual cues emphasized, task duration adjusted to individual needs	Implemented in standard version
6	Red–Blue–Yellow	Reaction speed, color discrimination, motor coordination	Color-matching tasks simplified and supported with modeling	Applied in original design
7	Air Catch	Response accuracy, hand–eye coordination, agility	Throw–catch distance and tempo adjusted, error tolerance increased	Performed with standard rules
8	Come or Freeze	Selective attention, decision-making, physical fitness	Additional cues provided during selective response tasks, decision-making support offered	Conducted in original format

This study implemented an 8-week educational game-based intervention to support the biomotor and cognitive development of inclusive education students. The program was delivered twice a week, with each session lasting 60 minutes. The experimental group received games adapted and reconstructed according to individual developmental needs, whereas the control group played the same games in their standard format designed for typically developing children.

2.4. Data Collection

The participants were administered the following tests from the Eurofit Test Battery: sit-ups, balance, flexibility, 20-meter sprint, and standing long jump. Hand and foot reaction performances, specifically simple, selective, and discriminative reactions, were measured using the ÇAĞIN Reaction Tests with the Fitlight Trainer (CA, Ontario) system. Selective attention performance was assessed using the Flanker Test from the PEBL 2.1 test battery.

2.5. Data Collection Tools

2.5.1. Euro Fit Test Battery

The Eurofit Test Battery was used in the present study to assess the motor skill levels of the students. This test was developed by the Council of Europe (1993) to evaluate the cardiorespiratory and motor fitness of children aged 6 to 18, and it is generally recommended for use with children over the age of 10. The tests used in this study were the 30 Second Sit-Up Test, the Flamingo Balance Test, the Sit and Reach Flexibility

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Test, the 20 Meter Sprint Test, and the Standing Long Jump Test.

2.5.1.1. 30 Second Sit-Up Tests

In the 30 Second Sit-Up Test, the individual lies in a supine position on a gymnastics mat or exercise mat. The knees are drawn toward the abdomen at a 90-degree angle, with the soles of the feet in full contact with the ground. The hands must be clasped behind the neck. As the individual rises, the elbows should move forward and make contact with the knees at the top of the movement. When restarting the movement, the shoulders must extend back far enough to touch the mat. The goal is to achieve as many repetitions as possible within 30 seconds. At the end of the time, the number of repetitions is recorded as the score (*Kamar, 2003*).

2.5.1.2. Flamingo Balance Test

The Flamingo Balance Test is measured using a non-slip balance apparatus made of iron, 50 cm in length, 3 cm in width, and 4 cm in height. To keep the apparatus stable, support pieces measuring 15 cm in length and 2 cm in width are attached to both ends. The individual being tested steps onto the apparatus with either foot (right or left). The other leg is held behind the body, bent fully, and grasped by the hand on the same side. To maintain balance, the individual may use the free hand for support until full balance is achieved. Once full balance is established, a 1-minute timer is started. During this time, if the individual releases the foot being held or if any part of the body touches the ground, balance is considered lost, the timer is stopped, and a fault point is recorded. Once full balance is regained, the timer resumes from where it stopped and continues in this manner until the full minute is completed. At the end of 1 minute, the total number of fault points is recorded (*Kamar, 2003*).

2.5.1.3. Flexibility (Sit and Reach) Test

In the flexibility measurement, the box used is 55 cm in length and 45 cm in width. The top panel of the box is marked at 1 cm intervals up to 50 cm. During the measurement, the individual places their bare feet against the flexibility box with the soles in full contact. Without bending the knees, the torso is pushed forward, and the individual tries to reach the farthest point possible with the hands. The position is held steady for a few seconds and the measurement is taken. Bouncing or jerking stretching movements should be avoided. Two measurements are taken, and the best score is recorded (*Kamar, 2003*).

2.5.1.4. 20 Meter Sprint Test

In the 20 Meter Sprint Test, a track is set up with clearly marked start and finish lines over a distance of 20 meters. Photocell devices or a stopwatch may be used. The individual waits ready behind the starting line. The starting position is a standing start. When the participant is ready, they raise a hand and begin after receiving the start command, aiming to complete the distance in the shortest possible time. Additionally, a deceleration zone must be provided beyond the finish line. Two attempts are allowed, and the best time is recorded as the score (*Kamar, 2003*).

2.5.1.5. Standing Long Jump Test

In the Standing Long Jump Test, the individual stands slightly behind the take-off line with feet together and toes aligned. The knees are bent, and the arms are swung backward. In this position, when the individual feels ready, they push off with the legs and swing the arms forward to jump as far as possible. Upon landing, the feet must remain together, and the individual must not fall backward. The measurement is taken twice, and the highest score is recorded (*Kamar, 2003*).

2.5.2. ÇAĞIN Hand and Foot Reaction Tests

The ÇAĞIN Hand and Foot Reaction Test Battery is a reaction test battery administered using FitLight Trainer or BlazePod devices to determine the simple, selective, and discriminative reaction performance of participants. The ÇAĞIN Hand and Foot Reaction Tests are highly valid and reliable, with a reliability coefficient ranging from r = 0.70 to 0.90 (*Çağın et al., 2024*).

2.5.2.1. ÇAĞIN Hand Simple Reaction Test

Sensors with measures in accordance with the protocol and blue cups are placed on the table. The participant is asked to turn off the blue lights, which will light up in a randomized manner for 20 seconds. After each light is turned off, the participant must switch hands and touch the cup to the half of the table closest to themselves. Lights turned off without switching hands or without touching the designated area are counted as errors (1 point per error). At the end of 20 seconds, the participant's reaction time, number of lights turned off, and number of errors are recorded and analyzed. The test is administered twice, and the best score is taken into account.

2.5.2.2. ÇAĞIN Hand Selective Reaction Test

Sensors with measures in accordance with the protocol and blue, red, yellow, and green cups are

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placed on the table. The participant is asked to turn off the lights according to their colors by using the corresponding-colored cup during the 20-second test. After each light is turned off, the participant must switch hands and touch the cup to the half of the table closest to themselves. Not switching hands, not touching the correct area, or using the wrong-colored cup results in an error point (1 point per error). At the end of 20 seconds, the participant's reaction time, number of lights turned off, and number of errors are recorded and analyzed. The test is administered twice, and the best result is taken into account.

2.5.2.3. ÇAĞIN Hand Discriminative Reaction Test

Sensors with measures in accordance with the protocol and red cups are placed on the table. During the 20-second test, lights of different colors (blue, red, green, and yellow) light up simultaneously, and the participant is asked to turn off only the red ones. After each light is turned off, the participant must switch hands and touch the cup to the half of the table closest to themselves. Not switching hands, failing to touch the correct area, or turning off the wrong light is counted as an error (1 point per error). At the end of 20 seconds, the participant's reaction time, number of lights turned off, and number of errors are recorded and analyzed. The test is administered twice, and the best score is taken into account.

2.5.2.4. ÇAĞIN Foot Simple Reaction Test

Sensors with measures in accordance with the protocol and blue rectangular paper are placed on the floor. The participant is asked to turn off blue lights that light up in a randomized manner for 20 seconds. After each light is turned off, the participant must switch the foot placed on the paper. Lights turned off without switching feet are counted as errors (1 point per error). At the end of 20 seconds, the participant's reaction time, number of lights turned off, and number of errors are recorded and analyzed. The test is administered twice, and the best result is taken into account.

2.5.2.5. ÇAĞIN Foot Selective Reaction Test

Sensors with measures in accordance with the protocol and blue, red, yellow, and green rectangular papers are placed on the floor. The participant is asked to turn off lights according to their colors by stepping on the corresponding-colored paper during the 20-second test. After each light is turned off, the participant must switch the foot placed on the paper. Not switching feet or turning off a light by stepping on the wrong color paper is counted as an error (1 point

per error). At the end of 20 seconds, the participant's reaction time, number of lights turned off, and number of errors are recorded and analyzed. The test is administered twice, and the best result is considered.

2.5.2.6. ÇAĞIN Foot Discriminative Reaction Test

Sensors with measures in accordance with the protocol and red rectangular paper are placed on the floor. During the 20-second test, lights of different colors (blue, red, green, and yellow) light up simultaneously, and the participant is asked to turn off only the red ones. After each light is turned off, the participant must switch the foot placed on the paper. Not switching feet or turning off the wrong light is counted as an error (1 point per error). At the end of 20 seconds, the participant's reaction time, number of lights turned off, and number of errors are recorded and analyzed. The test is administered twice, and the best result is recorded.

2.5.2.7. Statistical Analysis of the ÇAĞIN Hand and Foot Reaction Tests

The ÇAĞIN Hand and Foot Reaction Tests allow the identification of participants' average reaction time, total number of touches, and number of errors. Based on these data, the average reaction time and correct and incorrect reaction ratios of the participant can be determined (*Çağın et al., 2024*).

Average Reaction Time: Automatically calculated by the FitLight Trainer device at the end of the 20-second test (for example, 0.666 seconds).

Correct and Incorrect Reaction Ratio: Calculated based on the ratio between the total number of touches and the number of errors. For example, if the participant touched 20 times and made 5 errors, the correct reaction ratio is recorded as 75%, and the incorrect reaction ratio as 25%.

2.5.3. Flanker Test

The Flanker Test was administered using version 2.1 of the PEBL cognitive test battery on a computer. On the computer screen, arrows appear either as single items or in horizontal groups of five. When a single arrow is shown, the participant is asked to press the "Right Shift" or "Left Shift" key on the keyboard based on the direction of the arrow. When a group of five arrows is shown, the participant is asked to press the "Right Shift" or "Left Shift" key based on the direction of the center arrow.

2.6. Data Collection

The data obtained were transferred to the SPSS package software, where descriptive statistics and Repeated Measures ANOVA tests were conducted. For the present study, the significance level was set at $p<0.05$.

3. RESULTS

Statistics and interaction analyses for the experimental and control groups are presented in Table

3. A significant group × time interaction was observed for balance performance (F=6.085, P=.020, η^2 = .184). Interaction effects were not significant for flexibility (F=.015, p=.905, η^2 = .001), endurance (F= 3.086, p=.090, η^2=.103), jump performance (F=1.256, p=.272, η^2=.044), and speed (F= .044, p=.836, η^2 =.002). In contrast, significant main effects of time were found for flexibility (F=10.114, p=.004, η^2=.273) and endurance (F=22.469, p=.001, η^2=.454).

Table 3

Biomotor Skills of the Participants by Educational Game Group

Parameters	Variables	n	Pre-Test M±SD	Post-Test M±SD	Total M±SD	%Δ	F	p
Balance (number of errors)	Experimental	15	15.20±9.12	11.67±9.83	13.43±2.09	%-23.22		
	Control	14	10.29±6.60	12.64±8.89	11.46±2.17	%22.83	.426	.520
	Total	29	12.83±8.25	12.14±9.24				
	F=.243; p=.626					Group X Time Interaction F=6.085; p=.020		
Flexibility (cm)	Experimental	15	17.33±5.44	19.80±6.21	18.56±1.53	%14.25		
	Control	14	16.64±7.06	18.93±6.34	17.78±1.58	%13.76	.125	.727
	Total	29	17.00±6.17	19.38±6.17				
	F=10.114; p=.004					Group X Time Interaction F=.015; p=.905		
Jump (cm)	Experimental	15	105.8±15.9	108.33±17.0	107.1±4.74	%2.39		
	Control	14	109.7±28.1	105.2±17.5	107.5±4.91	%-4.10	.003	.954
	Total	29	107.7±22.3	106.8±17.0				
	F=.102; p=.752					Group X Time Interaction F=1.256; p=.272		
Endurance (number of sit-ups)	Experimental	15	13.00±3.76	15.80±3.87	14.40±.93	%21.53		
	Control	14	15.43±3.97	16.71±3.64	16.07±.97	%8.29	1.530	.227
	Total	29	14.17±3.99	16.24±3.72				
	F=22.469; p=.001					Group X Time Interaction F=3.086; p=.090		
Speed (sec)	Experimental	15	4.48±.43	4.38±.41	4.43±.12	%-2.23		
	Control	14	4.45±.64	4.37±.51	4.41±.12	%-1.79	.009	.923
	Total	29	4.46±.53	4.37±.45				
	F=2.509; p=.125					Group X Time Interaction F=.044; p=.836		

Descriptive statistics and interaction analyses for the mean reaction time of the experimental and control groups are presented in Table 4. For hand simple reaction time, the group × time interaction was not significant (F=.023, p=.881, η^2=.001), indicating that the change over time in the experimental group did not differ from that of the control group. Both groups demonstrated similar levels of improvement across measurements. For hand selective reaction time, the group × time interaction was not significant (F=.102, p=.752, η^2=.004). However, the main effect of time was significant (p=.003), suggesting that both groups showed significant improvement across measurements, although this improvement was not dependent on group type. For discriminative reaction time, the group × time interaction was not statistically significant (F=1.176, p=.288, η^2=.042). Although the experimental group improved by 13.5%, the control group showed

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no change; however, the difference was not significant at the interaction level. For foot simple reaction time, the group × time interaction was not significant (F=.763, p=.390, η²=.027). The main effect of time was significant (p=.005), yet the pattern of improvement was similar between the experimental (14.01%) and control (25.47%) groups. For foot selective reaction time, the group × time interaction was not significant (F=1.993, p=.169, η²=.069). The main effect of time was significant (p=.001), indicating that both groups improved across measurements, but the experimental group did not demonstrate a statistically different change compared to the control group. For discriminative reaction time, the group × time interaction was not significant (F=2.836, p=.104, η²=.095). The time effect was significant (p=.001), reflecting improvement in both groups, but the magnitude of change did not differ significantly between them.

Table 4

Hand And Foot Reaction Times of the Participants by Educational Game Group

Parameters	Variables	n	Pre-Test M±SD	Post-Test M±SD	Total M±SD	%Δ	F	p
Hand Simple R.T. (sec)	Experimental	15	.82±.20	.85±.16	.84±.03	%3.65		
	Control	14	.81±.12	.85±.16	.83±.04	%4.93	.016	.899
	Total	29	.82±.16	.85±.15				
	F=1.359; p=.254					Group X Time Interaction F=.023; p=.881		
Hand Selective R.T. (sec)	Experimental	15	1.37±.22	1.25±.20	1.31±.04	%-8.75		
	Control	14	1.36±.21	1.21±.12	1.28±.04	%-11.02	.260	.614
	Total	29	1.36±.21	1.23±.16				
	F=11.053; p=.003					Group X Time Interaction F=.102; p=.752		
Hand Discriminative R.T. (sec)	Experimental	15	.96±.35	.83±.16	.89±.04	%-13.54		
	Control	14	.86±.22	.86±.15	.86±.04	%0	.256	.617
	Total	29	.91±.29	.85±.16				
	F=.996; p=.327					Group X Time Interaction F=1.176; p=.288		
Foot Simple R.T. (sec)	Experimental	15	1.07±.31	.92±.36	1.00±.05	%-14.01		
	Control	14	1.06±.18	.79±.15	.93±.05	%-25.47	1.000	.326
	Total	29	1.07±.25	.86±.28				
	F=9.308; p=.005					Group X Time Interaction F=.763; p=.390		
Foot Selective R.T. (sec)	Experimental	15	1.48±.40	1.30±.34	1.39±.07	%-12.16		
	Control	14	1.60±.35	1.24±.21	1.42±.07	%-22.5	.069	.795
	Total	29	1.54±.37	1.27±.28				
	F=17.296; p=.001					Group X Time Interaction F=1.993; p=.169		
Foot Discriminative R.T. (sec)	Experimental	15	.93±.18	.79±.18	.86±.05	%-15.05		
	Control	14	1.07±.31	.78±.24	.93±.05	%-27.10	.744	.396
	Total	29	1.00±.26	.79±.21				
	F=23.711; p=.001					Group X Time Interaction F=2.836; p=.104		

R.T.: Reaction Time

The descriptive statistics and interaction analyses for the reaction correct percentage of the experimental and control groups are presented in Table 5. The group × time interaction for hand simple reaction correct percentage was not significant (F=.006, p=.940, η²=.000), indicating that both groups exhibited similar

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changes over time. The main effect of time was also not significant ($F=.025$, $p=.875$, $η²=.001$). For hand selective reaction correct percentage, the group × time interaction was non-significant ($F=2.502$, $p=.125$, $η²=.085$). However, the main effect of time was significant ($F=35.525$, $p=.001$, $η²=.568$), demonstrating time-dependent improvement in both groups, although this change was not dependent on group type. In hand discriminative reaction correct percentage, the group × time interaction was not significant ($F=.087$, $p=.771$, $η²=.106$), and the main effect of time was also non-significant ($F=3.215$, $p=.084$, $η²=.106$), indicating no statistically significant change across measurements. For foot simple reaction correct percentage, the group

× time interaction was not significant ($F=2.679$, $p=.113$, $η²=.090$). The main effect of time approached significance ($F=4.036$, $p=.055$, $η²=.130$). In foot selective reaction correct percentage, the group × time interaction approached but did not reach significance ($F=3.749$, $p=.063$, $η²=.122$). However, the main effect of time was significant ($F=5.407$, $p=.028$, $η²=.167$), suggesting improvement over time in both groups regardless of group condition. Finally, the group × time interaction for foot discriminative reaction correct percentage was not significant ($F=.015$, $p=.903$, $η²=.001$), nor was the main effect of time ($F=2.557$, $p=.121$, $η²=.087$).

Table 5

Hand and Foot Correct Reaction Percentages of the Participants by Educational Game

Parameters	Variables	n	Pre-Test M±SD	Post-Test M±SD	Total M±SD	%Δ	F	p
Hand Simple R.T. Correct Percentage (%)	Experimental	15	89.06 ±.14.0	91.24±8.98	90.14±1.89	%2.44		
	Control	14	89.69±8.96	91.48±7.11	90.58±1.96	%1.99	.025	.875
	Total	29	89.36±11.6	91.35±7.99				
	F=.571; p=.457					Group X Time Interaction F=.006; p=.940		
Hand Selective R.T. Correct Percentage (sec)	Experimental	15	66.23±20.0	89.05±10.1	77.64±3.90	%34.45		
	Control	14	68.56±22.2	81.81±13.7	75.18±4.04	%19.32	.191	.666
	Total	29	67.36±20.7	85.56±12.3				
	F=35.525; p=.001					Group X Time Interaction F=2.502; p=.125		
Hand Discriminative R.T. Correct Percentage (%)	Experimental	15	84.69±24.3	94.11±7.24	89.39±3.52	%11.12		
	Control	14	85.15±24.5	91.91±9.22	88.53±3.64	%7.93	.029	.865
	Total	29	84.91±24.0	93.05±8.18				
	F=3.215; p=.084					Group X Time Interaction F=.087; p=.771		
Foot Simple R.T. Correct Percentage (%)	Experimental	15	87.77±15.5	97.37±3.31	92.56±1.98	%10.93		
	Control	14	92.78±11.8	93.76±6.74	93.26±2.05	%1.05	.060	.809
	Total	29	90.19±13.8	95.63±5.32				
	F=4.036; p=.055					Group X Time Interaction F=2.679; p=.113		
Foot Selective R.T. Correct Percentage (%)	Experimental	15	79.69±15.1	92.79±7.58	86.24±2.63	%16.43		
	Control	14	83.86±16.1	85.06±12.1	84.45±2.73	%1.43	.220	.643
	Total	29	81.70±15.5	89.06±10.6				
	F=5.407; p=.028					Group X Time Interaction F=3.749; p=.063		
Foot Discriminative R.T. Correct Percentage (%)	Experimental	15	89.89±12.6	95.97±4.97	92.92±2.66	%6.76		
	Control	14	86.34±25.8	93.44±9.43	89.88±2.76	%8.22	.627	.435
	Total	29	88.18±19.8	94.7±7.44				
	F=2.557; p=.121					Group X Time Interaction F=.015; p=.903		

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R.T.: Reaction Time

Descriptive statistics and interaction analysis results for selective attention error scores in the experimental and control groups are presented in Table 6. A reduction in error scores over time was observed in both groups. However, the group × time interaction was not significant (F=.044, p=.836, η²=.002), indicating that the magnitude of change did not differ between the experimental and control groups. Conversely, the main effect of time was significant (F=28.929, p =.001, η²=.517), suggesting that both groups demonstrated a significant improvement from pre-test to post-test regardless of group assignment. While the error rate decreased by 33.7% in the experimental group and by 44.7% in the control group, this difference was not statistically significant at the interaction level.

Table 6

Selective Attention Performances of the Participants by Educational Game Group

Parameters	Variables	n	Pre-Test	Post-Test	Total	%Δ	F	p
			M±SD	M±SD	M±SD			
Selective Attention (Number of Errors)	Experimental	15	52.13±33.9	34.53±22.5	43.33±6.00	%-33.7		
	Control	14	36.29±22.5	20.00±16.92	28.14±6.21	%-44,7	3.089	.090
	Total	29	44.48±29.61	27.52±20.60				
	F=28.929; p=.001					Group X Time Interaction F=.044; p=.836		

4. DISCUSSION

As a result of the study, when the changes in the basic biomotor parameters of the inclusion students were examined, it was determined that there was a significant improvement in the experimental group compared to the control group only in the balance parameter (p<0.05). Although the differences in the other parameters were not statistically significant, positive changes were observed in all skills within the experimental group. When the literature is reviewed, in the study conducted by Logan et al. (*2012*) examining the effects of fundamental motor skills in children, it was found that movement skills showed a significant improvement in the post-test (p<0.05), and these improvements were positive, while the control group did not show any significant changes (p>0.05). Similarly, in a six-week study conducted by Taunton et al. (*2017*) involving both children with and without disabilities, it was reported that the motor skills of children in the experimental group improved significantly (p<0.05), whereas the control group did not gain any significant improvements (p>0.05). Goodway et al. (*2003*) reported that in a nine-week inclusion program, the experimental group showed statistically significant improvements in both locomotor and object control skills compared to the control group in the post-test. These findings are similar to and supportive of those found in this study. However, there are also studies in the literature that yielded results different from the present study. In the study conducted by Lupu (*2020*) on inclusion students, no significant difference was found between the experimental and control groups (p>0.05). This lack of difference may be attributed to the type of training provided or the duration of the intervention.

According to the findings, no significant differences were found between the control and experimental groups in reaction time, correct reaction percentages, and selective attention based on pre-test and post-test performances (p>0.05). However, when the performances were analyzed within groups, significant differences were found in hand selective reaction time, and in foot simple, selective, and discriminative reaction times, as well as in hand selective and foot selective correct reaction percentages, and selective attention (p<0.05). These within-group differences were found to favor the control group. The findings suggest that traditional educational games used in physical education and sports courses may have a greater effect on students' reaction times than the redesigned games. It can be stated that playing games already included in the regular curriculum provides better outcomes for inclusion students. When the literature is reviewed, it becomes evident that studies measuring the cognitive skills of inclusion students are limited. In the study conducted by Westendorp et al. (*2014*) on the effects of coordinative exercises on the cognitive functions of children with learning difficulties, no statistically significant differences were found in cognitive parameters. These findings are similar to those of the

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present study. Budde et al. (*2008*) examined the effects of coordinative exercises on attention and concentration performance in adolescents and found that coordinative exercises had a greater impact than non-coordinative, simple exercises. The researchers emphasized the importance of problem-solving and executive function in dynamic team and group games where the focus of attention constantly shifts. In the present study, the lack of significant differences in reaction percentages and selective attention percentages may be due to the use of simple educational games rather than dynamic team and group games.

In conclusion, this study comparatively examined the effects of different game-based instructional methods on the biomotor and cognitive development of inclusion students and revealed that the reconstructed educational games provided a statistically significant advantage only in the balance parameter. The fact that the improvements observed in motor and cognitive domains did not reach statistical significance may be associated with the limited duration of the intervention, the sample size, or the nature of the game content used. Nevertheless, the positive trends recorded in both groups indicate that educational game approaches hold potential as a developmental tool for inclusion students. Although the findings are largely consistent with previous research, the presence of studies reporting divergent outcomes suggests that the effectiveness of educational games is highly sensitive to contextual variables. In particular, the lack of expected superiority in the cognitive performance outcomes of the experimental group highlights the need to reconsider the structural features and cognitive load levels of the games. Future research incorporating longer intervention periods, alternative game designs, and larger samples is expected to make substantial contributions to the knowledge base in this field. In this context, the development of game-based instructional models tailored to the needs of inclusion students is of critical importance for both academic and applied settings.

5. ACKNOWLEDGMENTS

6. ETHICS STATEMENT

The necessary permission and approval for the study were obtained from the Gazi University Ethics Committee (E-77082166-604.01-861335), and the study was conducted in accordance with the Declaration of Helsinki.

7. AUTHOR CONTRIBUTIONS

Research Design- MÇ, İY; Data Collection- MÇ, KE, KGE; Statistical analysis- MÇ; Article preparation- MÇ, KE, KGE

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