DOI 10.26773/smj.250619

SportMont

ORIGINAL SCIENTIFIC PAPER

The Effect of Fundamental Movement Skills Training Implemented with the Differential Learning Approach on the Attention Skills of Elementary School Students

Sena Kırlangıç[1], Sinan Bozkurt[1]

[1]Marmara University, Department of Physical Education and Sports Teaching, Istanbul, Türkiye

Abstract

Physical activity is essential for the healthy growth and development of children, supporting motor skills as well as cognitive and psychosocial abilities. Research has demonstrated that children who engage in regular physical activity show improvements in executive functions, memory, and attention. The Differential Learning approach promotes variability in movement experiences, minimizing explicit instructions and corrections, which encourages adaptability and cognitive-motor interactions crucial for attention development. This study aims to examine the impact of a fundamental movement skills training program based on the Differential Learning approach on the attention skills of elementary school students. The sample consisted of 24 students (13 male, 11 female, aged 8-9 years) from the 3rd grade of a school in Beykoz, Istanbul. The program, lasting 13 weeks with two hours of weekly sessions, utilized Yellow Cards from Physical Activity Cards and focused on fundamental movement skills. Attention was assessed using the D2 Test of Attention as both a pre-test and post-test. Descriptive statistics and a Paired Sample T-test were used to analyze the data, revealing significant differences in psychomotor speed, quality of work, and attention balance speed ($p<0.05$). The mean scores for psychomotor speed increased from 2.50 to 4.54, work quality from 2.17 to 3.33, and speed-attention balance from 2.04 to 4.54, indicating a statistically significant improvement in these subdimensions. These results suggest that the Differential Learning approach effectively contributes to the development of attention skills in 3rd grade students.

Keywords: *differential learning, motor development, attention, physical activity, cognitive skills*

Introduction

Physical activity is a key factor that plays a central role in the healthy growth and development of children. Regular physical activities not only support the development of motor skills but also positively contribute to cognitive and psychosocial abilities (Diamond, 2015; Lubans et al., 2016). Research has shown that children who regularly engage in physical activity show improvements in executive functions, memory, and attention processes (Best, 2010; Pesce, 2012). At the core of this effect are the positive impacts of physical activity on brain structure and function.

Regular exercise leads to structural and functional changes in brain areas responsible for cognitive functions, such as the prefrontal cortex and hippocampus, thereby enhancing attention skills (Erickson et al., 2011). Furthermore, physical activity has been shown to support neuroplasticity by increasing connections between nerve cells, which in turn makes cognitive functions more efficient (Hillman et al., 2014). In this context, regular participation in physical activity at an early age is emphasized as potentially having long-term effects on

Correspondence:

S. Kırlangıç
Marmara University, Faculty of Sport Sciences, Anadoluhisarı Campus, Cuma Yolu Street, No:1, Göksu Neighborhood, P.O. Box 34815, Beykoz/İstanbul, Turkey
E-mail: kirlangicsena@gmail.com

attention skills (Tomporowski et al., 2011).

Children in elementary school age go through a critical period in terms of both motor and cognitive development (Van der Fels et al., 2015). Acquiring fundamental movement skills at this age lays the foundation for lifelong physical activity habits, while also contributing to the development of cognitive functions (Gallahue & Donnelly, 2003). The development of children's fine and gross motor skills is directly related to cognitive processes such as executive functions, attention, memory, and problem-solving (Diamond & Lee, 2011).

The Ministry of National Education (MEB) has developed Physical Activity Cards under the International Inspiration Project as part of the Primary School Physical Education and Play course curriculum, which has been gradually implemented starting from the 1st grade since the 2012-2013 academic year (MEB, 2012a; MEB, 2012b). This program aims to contribute to the psychomotor, cognitive, and affective development of students through play and physical education. Through the cards, students are given the opportunity to develop their movement skills interactively, both individually and in group activities. İrez et al. (2013) also stated that Physical Activity Cards (PAC) are highly useful materials for skill development in physical education classes.

Physical education classes should not only be viewed as an activity domain that enhances children's physical fitness levels, but also as a holistic educational area that supports their cognitive and psychosocial development. Specifically, it has been noted that game-based and movement-focused activities strengthen children's problem-solving skills, creativity, and social interactions (Lakes & Hoyt, 2004). However, an important question arises regarding how much the teaching models applied in physical education classes support students' individual learning processes.

Traditional physical education approaches typically standardize teaching by offering the same methods to all students. However, this approach may not adequately address the individual differences of students and might include limited elements that support cognitive development (Rink, 2013). In traditional models, repetitive routine activities and teacher-centered guidance dominate, while there is a noticeable lack of personalized feedback for students and teaching methods adapted to individual learning paces (Kirk, 2010). On the other hand, contemporary educational approaches suggest that practices that encourage active student participation, stimulate cognitive processes, and enrich individual learning experiences could be more effective (Metzler, 2017).

At this point, the necessity of implementing the Differential Learning approach arises. Applying the Differential Learning approach in physical education classes could provide more benefits for students' motor skill and cognitive development. This approach aims to shape the teaching process by considering students' individual learning speeds, interests, and physical capabilities (Schempp & McCullick, 2010).

Differential Learning departs from traditional repetition-based teaching by offering a learning environment based on individual and variable experiences (Schöllhorn, 2016). In this approach, the natural variability of movements is supported with minimal repetition, and individual differences are prioritized in the learning process. In Differential Learning, instead of repeatedly practicing the same movement, students are encouraged to experience different variations continuously, creating more flexible, adaptable, and lasting learning processes (Henz & Schöllhorn, 2016). This method not only aims to develop individuals' motor skills but also actively encourages them to use cognitive processes (Schöllhorn et al., 2009).

Attention refers to the ability of individuals to focus on and respond to stimuli in their environment. Attention plays a critical role in educational and developmental processes, as efficient learning requires the individual to be able to focus on a specific subject. Attention can be studied in various types, and these types may influence individuals' learning processes in different ways (Posner & Petersen, 1990).

Recent studies have shown that the Differential Learning Approach (DL) can have positive effects not only on motor skills but also on cognitive functions and attention processes (Schöllhorn et al., 2009; Henz & Schöllhorn, 2016). One of the most important aspects of this approach is its encouragement of individuals to consciously plan their movements and continuously generate new solutions to changing stimuli (Wagner & Schöllhorn, 2014). Activating cognitive processes in this way can contribute to the development of executive functions, problem-solving skills, and attention processes (Henz & Schöllhorn, 2017).

Specifically, when examining attention skills, the Differential Learning approach has been noted to improve children's ability to focus, adapt to changing environmental factors, and sustain attention (Buszard et al., 2017). Individuals who are constantly exposed to variable stimuli must actively direct their attention during the learning process, which helps develop their attention control mechanisms (Henz, Wagner, & Schöllhorn, 2018). Furthermore, the constant variation and movement experiences brought by the Differential Learning approach contribute to the holistic development of attention and cognitive processes by strengthening problem-solving skills (Schöllhorn, 2016).

This study examines the effect of the Differential Learning approach-based movement skills training program on the development of attention characteristics in elementary school students. The research uses a pre-test/post-test model to evaluate changes in the students' attention levels. In this context, the study is expected to contribute to understanding the effects of different teaching approaches in physical education and sports on cognitive development. The aim of this study is to investigate the effects of a basic movement skills training program implemented with the Differential Learning approach on the development of attention characteristics in elementary school students.

Material and methods

The ethical approval for the study was obtained from the Ethics Committee of a state university (Ethics Committee Approval Date and Number: 31.08.2022 / 06-2). In addition, the necessary official permissions were obtained from the Provincial Directorate of National Education (Ethics Committee Protocol No: 359829) and the school administration where the study was conducted. The parents of the students participating in the study signed written consent forms. It was clearly stated to the participating students and their parents that their performance during the implementation process would not affect their grades in any way. All participants voluntarily participated in the study. The research was conducted in the fall semester of the 2022-2023 academic year, with the students in the sample group during class hours under the supervision of their classroom teacher.

Research Design

The research is designed based on a single-group pre-test/post-test model, which is one of the experimental approaches. Experimental research is used to examine the effect of the program applied by the researcher (independent variable – basic movement skills training with the differential learning approach) on the specified study group (dependent variable – attention characteristics) (Campbell & Stanley, 1963).

Participants

In this study, the sample group consists of 24 students (13 male students and 11 female students) from a 3rd-grade class of 9-year-olds at an elementary school in Beykoz district, Istanbul. The students' average age was 8.63±0.50 years, their average height was 136.21±5.20 cm, and their average weight was 35.17±6.31 kg.

D2 Test of Attention

The D2 Test of Attention was used to determine the attention characteristics of the students. The adaptation and norm studies of the D2 Test of Attention in Turkey were carried out by Toker (1993). The test's split-half reliability was found to be 0.94. In the validity study, a correlation of 0.44 was found between the total score and the WISC-R coding subtest (Kirici, 2008).

D2 Test of Attention, is a psychological test developed by Brickenkamp and Zillmer in 1982 (Brickenkamp & Zillmer, 1998). This test is used to assess individuals' selective attention and concentration abilities (Baysal, 2019). The test consists of a single-page form with 14 rows, each containing 47 figures, totaling 658 figures. The test uses the letters 'd' and 'p.' Some of the letters may have one, two, three, or four dots above or below them. The letters, which can appear in 16 different ways, vary based on the position and number of dots. The main task for the person taking the test is to identify the 'd' letter with exactly two dots. These letters can appear in three different forms in the test. The participant is given 20 seconds to complete the task in each row. The total administration time for the test is approximately eight minutes. In group applications, an additional 7-8 minutes may be required for preparation, ensuring the instructions are understood, and conducting a sample trial (Öcal & Aybek, 2023).

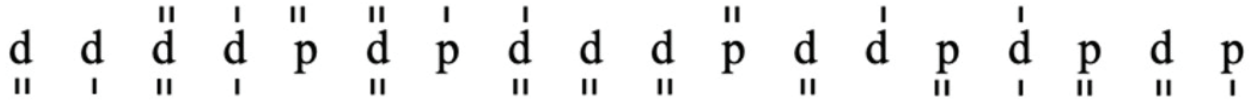

FIGURE 1. Examples of letters found in the D2 Test of Attention

Test scores are calculated using two separate scoring keys. Six different scores are obtained during the test. These are: TN (total number of figures marked), E1 (number of figures skipped), E2 (number of incorrectly marked figures), CP (number of correctly marked figures), TN-E (test performance), and E% (error rate).

Experimental treatment

The physical activity exercises and games based on fundamental movement skills included in the physical activity cards were implemented during the fall semester of the 2022-2023 academic year in physical education and play classes for 13 weeks, with two hours per week, totaling 26 class hours. During the implementation process, attendance was taken at the beginning of each lesson, and students who demonstrated regular participation throughout the 13-week period were identified. Students who missed three consecutive lessons were excluded from the study due to absenteeism and were not included in the groups.

The topics in the physical activity cards (displacement movements, balancing movements, object control movements, and combined movements) were implemented based on the Differential Learning approach, with no routine repetitions or corrective external feedback provided. The exercises were diversified through various activities, including different surfaces such as artificial turf, asphalt, and tiled floors, small and large spaces, various cognitive tasks, additional challenges, and the use of materials of various sizes and types (balls, jump ropes, markers, cones, hoops, etc.). These activities were performed under both indoor and outdoor skill conditions, in individual, pair, and group work formats.

The application process of the Differential Learning approach was based on varying the movements and presenting each movement in different variations, rather than repeating the same movements continuously. This approach accelerated students' learning processes and supported skill development. Additionally, changing the directions of the movements aimed to increase the flexibility of the children's motor skills; for example, movements originally performed forward were varied by performing them backward or sideways. Increasing the difficulty level by introducing more complex tasks stimulated students' development without overwhelming their skill levels. Applying the same movement with different technical variations allowed students to understand and apply different forms of the movement by making technical adjustments.

Each session was divided into warm-up, main, and cool-down phases and was applied in the form of games. The tests and game applications in the research were carried out by the researcher, a sports expert and physical education teacher.

Data Analysis

The data analysis was conducted using the SPSS Statistics 25.00 program (IBM Corp., Armonk, NY, USA). In determining the analysis techniques, the skewness and kurtosis values of the variables were considered to evaluate the normality distribution. It was assumed that variables with skewness and kurtosis values within the range of ±2 exhibited a normal distribution (George & Mallery, 2010).

Descriptive statistics, including the arithmetic mean (X), standard deviation (Ss), minimum (Min.), and maximum (Max.) values, were reported. The comparison of pre-test and post-test scores was performed using the Paired Sample t-test. The significance level was set at $p<0.05$.

Results

Table 1 presents the descriptive statistics of the physical characteristics of the participants in the study group.

It was observed that 45.8% of the 24 participants in the

Table 1. Demographic Information

N=24	Participants	
	n	%
Gender		
Female	11	45.8
Male	13	54.2
Handedness		
Right-handed	22	91.7
Left-handed	2	8.3
Age (years)		
Mean±SD		8.63±0.50
Min-Max		8.00-9.00
Height (cm)		
Mean±SD		136.21±5.20
Min-Max		125.00-147.00
Body Weight (kg)		
Mean±SD		35.17±6.31
Min-Max		25.00-47.80

Table 2. Descriptive Statistical Information of the Study Group's D2 Test of Attention Scores

Participants N=24	Pre-Test						Post-Test					
	Mean	SD	Min	Max	Skewness	Kurtosis	Mean	SD	Min	Max	Skewness	Kurtosis
D2 Attention Test												
TN (Psychomotor Speed)	2.50	1.10	1.00	5.00	0.11	-0.37	4.54	0.72	3.00	5.00	-1.30	0.34
E (Quality of Work)	2.17	1.17	1.00	5.00	0.72	-0.19	3.33	1.01	2.00	5.00	0.64	-0.59
TN-E (Speed-Attention Balance)	2.04	0.91	1.00	3.00	-0.09	-1.85	4.54	0.72	3.00	5.00	-1.30	0.34
FR (Sustained Attention Capacity)	2.63	0.97	1.00	4.00	-0.70	-0.49	2.46	0.93	1.00	5.00	0.66	1.23

study group were girls and 54.2% were boys; 91.7% were right-handed and 8.3% were left-handed; the average age was 8.63 years, with an average height of 136.21 cm and an average body weight of 35.17 kg.

Descriptive statistical information regarding the study group's D2 Test of Attention scores is provided in Table 2.

When we look at the pre-test mean scores of the D2 Test of Attention for the study group, the psychomotor speed mean score is 2.50, the work quality mean score is 2.17, the speed-attention balance mean score is 2.04, and the sustained attention power mean score is 2.63.

When we examine the post-test mean scores of the D2 Test of Attention for the study group, the psychomotor speed mean score is 4.54, the work quality mean score is 3.33, the speed-attention balance mean score is 4.54, and the sustained attention power mean score is 2.46.

The results of the comparison between the pre-test and post-test scores of the D2 Test of Attention for the study group are shown in Table 3.

There was no significant difference between the pre-test and post-test scores for attention span ($p>0.05$); however, a significant difference was found between the pre-test and post-test scores for psychomotor speed, work quality, and speed-attention balance ($p<0.05$).

Table 3. Comparison of Pre-Test and Post-Test Scores of the D2 Test of Attention for the Study Group

Participants N=24	Pre-Test		Post-Test		t	p
	Mean	SD	Mean	SD		
D2 Test of Attention						
TN (Psychomotor Speed)	2.50	1.10	4.54	0.72	-8.113	0.000*
E (Quality of Work)	2.17	1.17	3.33	1.01	-7.000	0.000*
TN-E (Speed-Attention Balance)	2.04	0.91	4.54	0.72	-11.519	0.000*
FR (Sustained Attention Capacity)	2.63	0.97	2.46	0.93	0.500	0.622

Note. T - Dependent Samples t-test, $p<0.05$: * - The relationship is significant.

It was found to be statistically significant that the post-test scores for psychomotor speed, work quality, and speed-attention balance of the research group were higher compared to the pre-test scores. These improvements indicate that the intervention had a positive effect on the participants' psychomotor abilities. This difference between the pre- and post-test is also shown in Figure 2.

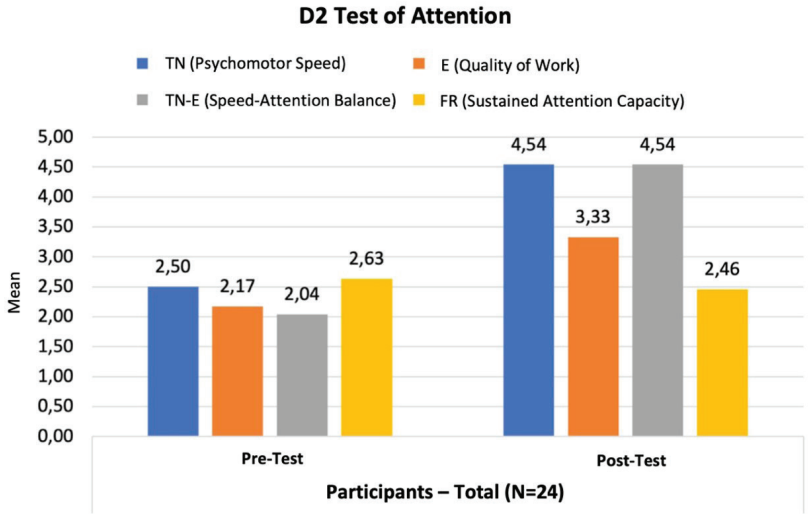

FIGURE 2. Research Group's D2 Test of Attention Scores

Discussion

In this study, the effects of a fundamental motor skills training program based on the Differential Learning approach on primary school students' attention characteristics were examined. As a result of the 13-week intervention, significant improvements were observed in the sub-dimensions of psychomotor speed, work quality, and speed-attention balance ($p<0.01$). These findings indicate that motor skill training positively contributes to children's attention processes.

First and foremost, the significant improvements found in our study can be explained by the neurologically coordinated development of movement and attention processes (Schöllhorn, 1999). The Differential Learning approach, which is based on continuous variability and change, enables children to use their attention processes more flexibly and efficiently, thereby supporting the development of skills such as psychomotor speed and attention balance. As Schöllhorn (2009) emphasizes, the brain is actively engaged in this process, integrating movement and attention functions, which enhances students' attentional performance.

In this regard, the findings of Topsakal et al. (2019) are consistent with our results. They also reported significant improvements in students' attention performance following a 10-week motor skill training program based on the Differential Learning approach. Similarly, Özdemir (2019) showed that physical activity cards and exergaming activities improved the attention levels of 10–11-year-old children, supporting the positive effects of motor skill-oriented programs on attention. These studies reveal that movement diversity and innovative methods stimulate students' attention processes.

Furthermore, a study by Yurdakul et al. (2012), which investigated the effects of movement training on attention and memory development in 8-year-old children, also supports our findings. Following a 12-week movement training program delivered twice a week, significant improvements were observed in attention performance. This suggests that movement is directly related to cognitive processes, and that regular, structured motor activities play a critical role in attention development. Additionally, Akcınlı (2005) reported that movement training had positive effects on attention and memory development in 8-year-old children. Similarly, Adsız (2010) found that primary school students who regularly participated in sports were 83% more attentive than their peers who did not. Göktepe et al. (2016) also reported that planned games based on fundamental movements and movement patterns made a significant contribution to attention and memory development in children participating in sports. These findings support the positive effects of movement and planned physical activities on children's cognitive development.

However, not all studies show consistent findings. For example, in the study by Yaşar et al. (2018) examining the effects of Life Kinetik training on attention and speed-attention balance, no significant changes were observed in some sub-dimensions, whereas our study identified significant improvements in psychomotor speed, work quality, and speed-attention balance. These differences may result from variations in methodology, duration of intervention, or participant age groups. In addition, the content and intensity of Yaşar et al.'s training program may have differed. In such cases, variables such as the quality and intensity of movement programs play a critical role in attention development. Moreover, a study conducted by Kanbir et al. (2024), which investigated the effects of complex motor activities and exergaming games on attention, timing, and hyperactivity, found significant improvements in the complex movement group. This supports the idea that diverse and complex motor activities have a positive effect on attention. The DL-based approach and physical activity cards used in our program may have created a similar stimulating effect by continuously varying and diversifying children's motor actions.

The positive effect of physical activity on attention is widely supported in the literature. Tine and Butler (2012) demonstrated that 12 minutes of aerobic exercise enhanced selective attention in 10–13-year-old children, while Chaddock-Heyman et al. (2013) reported that sports activities increased cognitive control in the prefrontal cortex of 8–9-year-old children. Alesi et al. (2016) emphasized the particularly positive effects of football on attention skills, and Bidzan-Bluma and Lipowska

(2018) showed that regular daily physical activity enhances cognitive functions. These studies provide neurological and psychological foundations for the mechanisms through which motor skill training supports attention development.

Motivational factors may also have played an important role in our findings. Borrego-Balsalobre et al. (2021) emphasized that innovative and constantly varying experiences increase student motivation, which in turn accelerates motor skill development. The DL-based approach applied in our study offered a dynamic learning environment far from monotony and appealing to children's interests, allowing students to maintain more focused and sustained attention.

On the other hand, our study has certain limitations. The most significant limitation is the absence of a control group, which makes it difficult to determine whether the observed effects are specific to the intervention group. In addition, the limited sample size and the fact that participants were selected from a single school restrict the generalizability of the findings. Future research is recommended to employ experimental designs with control groups for comparison with the DL approach. Increasing the sample size and including different age groups would also enhance generalizability. Moreover, examining more detailed sub-dimensions of attention and using different measurement tools could contribute to a deeper understanding of the findings.

In conclusion, this study demonstrates that the Differential Learning approach is effective in improving attention characteristics among primary school students. The underlying mechanism of this effect may be attributed to the incorporation of continuous variation and novelty in movements, balanced cognitive load, and increased motivation. Therefore, integrating the Differential Learning approach into the design of motor skill programs in education may significantly contribute to the attention and psychomotor development of children.

Conclusion

This study highlights the impact of a fundamental movement skills training program applied with the differential learning approach on the attention characteristics of 9-year-old students. The research findings indicate that variable and continuously renewed movement experiences contribute to students' ability to manage their attention processes more flexibly and effectively. Additionally, the reduction of cognitive load, increased motivation, and the integration of motor skills with attention processes are key factors that make this approach effective. In this context, the differential learning approach can be considered an innovative learning model that helps strengthen cognitive processes. Based on the results obtained, it is recommended that more comprehensive research be conducted on the application of this method in different age groups and educational settings.

Acknowledgements

This study is a part of the doctoral dissertation titled "An Investigation of Primary School Student's Attention Traits, Basic Movement Skills and Game Skills in Terms of Classical and Differential Learning Approaches". Marmara University, 2024.

The author thanks Güzelcehisar Elementary School Directorate for their support in this study and Marmara University undergraduate students for their assistance during the measurement stages.

Conflict of interest

The authors declare that there is no conflict of interest.

Received: 15 Aprile 2025 | **Accepted:** 30 May 2025 | **Published:** 01 June 2025

References

Adsız, E. (2010). *Research on the effect of regular sports on attention in primary school students*. Unpublished Master's Thesis, Institute of Health Sciences, Department of Physical Education and Sports, Ege University, Izmir.

Akcınlı, N. (2005). *The relationship between movement education, attention, and memory development in eight-year-old children*. Unpublished Master's Thesis, Institute of Health Sciences, Department of Physical Education and Sports Teaching, Celal Bayar University, Manisa.

Alesi, M., Bianco, A., Luppina, G., Palma, A., & Pepi, A. (2016). Improving children's coordinative skills and executive functions: The effects of a football exercise program. *Perceptual and Motor Skills, 122*(1), 27-46. https://doi.org/10.1177/0031512515627527

Baysal, Ş. (2019). *The investigation of sports participation motivation and success motivation of secondary school students participating in school sports (Gaziantep case study)* [Master's Thesis]. Ağrı İbrahim Çeçen University, Institute of Social Sciences.

Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. *Developmental Review, 30*(4), 331-351.

Bidzan-Bluma & Małgorzata Lipowska (2018). Physical activity and cognitive functioning of children: A systematic review. *International Journal of Environment Research and Public Health, 15*, 800.

Borrego-Balsalobre, F. J., Martínez-Moreno, A., Morales-Baños, V., & Díaz-Suárez, A. (2021). The influence of the psychomotor profile in the improvement of learning in early childhood education. *International Journal of Environmental Research and Public Health, 18*(23), 12655.

Brickenkamp, R., & Zillmer, E. (1998). *The d2 Test of Attention*. Hogrefe & Huber Publishers.

Buszard, T., Farrow, D., Reid, M., & Masters, R. (2017). Scaling the equipment and play area in children's sport to improve motor skill acquisition: A systematic review. *Sports Medicine, 46*(6), 829-843.

Campbell, D.T., & Stanley, J.C. (1963). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally & Company.

Chaddock-Heyman, L., Erickson, K.I., Voss, M.W., Knecht, A.M., Pontifex, M.B., Castelli, D.M., ... Kramer, A.F. (2013). The effects of physical activity on functional MRI activation associated with cognitive control in children: A randomized controlled intervention. *Front. Hum. Neurosci. 7*, 72.

Diamond, A. (2015). Effects of physical exercise on executive functions: Going beyond simply moving to moving with thought. *Annals of Sports Medicine and Research, 2*(1), 1011.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-964.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., … & Kramer, A. F. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences, 108*(7), 3017-3022.

Gallahue, D. L., & Donnelly, F. C. (2003). *Developmental physical education for all children*. Human Kinetics.

George, D., & Mallery, M. (2010). *SPSS for Windows Step by Step: A Simple Guide and Reference, 17.0 update*.

Göktepe, M., Akalın, C.T., & Göktepe, M.M. (2016). The investigation of attention levels in children who practice skiing. *International Journal of Science Culture and Sport, 4*(3), 722-731.

Henz, D., & Schöllhorn, W. I. (2016). Differential training facilitates early consolidation in motor learning. *Frontiers in Human Neuroscience, 10*, 611.

Henz, D., & Schöllhorn, W. I. (2017). Sensorimotor training and complex motor learning in applied settings: A review. *Current Opinion in Psychology, 16*, 51-55.

Henz, D., Wagner, H., & Schöllhorn, W. I. (2018). Supervised and unsupervised machine learning in human movement science: Comparing self-organizing maps with principal component analysis. *Frontiers in Psychology, 9*, 1280.

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2014). Be smart, exercise your heart: Exercise effects on brain and cognition. *Nature Reviews Neuroscience, 9*(1), 58-65.

IBM Corp. (2017). *IBM SPSS Statistics for Windows, Version 25.0*. Armonk, NY: IBM Corp.

İrez, S. G., Yaman, M., İrez Babayigit, G., & Saygın, Ö. (2013). The effect of physical activity cards on teacher behaviors in primary school physical education classes. *International Journal of Human Sciences, 10*(1), 1717-1724.

Kanbir, Ö., Erkut, A. O., Tekin, R., & Kanbir, L. (2024). The investigation of the effects of complex motor movements and exergame games on

attention, hyperactivity, impulsivity, and timing conditions in middle school students. *Journal of Health and Sports Sciences, 7*(2), 103-125.

Kirici, H. M. (2008). *The effect of an 8-week movement education program on motor performance of 4-6-year-old children in preschool educational institutions* [Master's Thesis]. Institute of Social Sciences.

Kirk, D. (2010). *Physical education futures*. Routledge.

Lakes, K. D., & Hoyt, W. T. (2004). Promoting self-regulation through school-based martial arts training. *Journal of Applied Developmental Psychology, 25*(3), 283-302.

Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., & Biddle, S. (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Pediatrics, 138*(3), e20161642.

MEB (2012a). *Ministry of National Education, Board of Education and Discipline, Decision No. 139, dated 29.08.2012*.

MEB (2012b). *Physical activity and play activities course curriculum (Grades 1-4)*. TTKB State Publishing House. Ankara.

Metzler, M. W. (2017). *Instructional models for physical education*. Routledge.

Öcal, N. K., & Aybek, B. (2023). Problems faced by teachers in philosophy for children (P4C) education. *Educational Sciences Journal, 45*(2), 123-135.

Özdemir, H. (2019). *The effect of physical activity cards and video game console movement activities on attention, screen, and paper reading performance in 10-11-year-old children* [Master's Thesis, Marmara University, Turkey].

Pesce, C. (2012). Shifting the focus from quantitative to qualitative exercise characteristics in exercise and cognition research. *Journal of Sport and Exercise Psychology, 34*(6), 766-786.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13*(1), 25-42. https://doi.org/10.1146/annurev.ne.13.030190.000325

Rink, J. E. (2013). *Teaching physical education for learning*. McGraw-Hill.

Schöllhorn, W. (1999). Differential learning: A new approach to motor learning. In *Proceedings of the International Conference on Motor Learning* (pp. 78-83).

Schöllhorn, W. I. (2009). Differential learning: A revolutionary approach to teaching and training sport and motor skills. In M. Schöllhorn (Ed.), *Movement science and education: The importance of learning with variation* (pp. 17-36). Springer.

Schöllhorn, W. I. (2016). Individualized movement training for sport and health. *Human Movement Science, 47*, 154-162.

Schöllhorn, W. I., Hegen, P., & Davids, K. (2009). The nonlinear nature of learning – A differential learning approach. *Open Sports Sciences Journal, 2*(1), 100-112.

Tine, M. T., & Butler, A. G. (2012). Acute aerobic exercise impacts selective attention: An exceptional boost in lower-income children. *Educational Psychology, 32*, 821–834.

Toker, M. Z. (1993). *Visual perception test d2: Validity and reliability study* (Unpublished master's thesis). Boğaziçi University, Istanbul.

Tomporowski, P. D., McCullick, B., Pendleton, D. M., & Pesce, C. (2011). Exercise and children's cognition: The role of exercise characteristics and a place for metacognition. *Journal of Sport and Exercise Psychology, 33*(5), 602-609.

Topsakal, N., Bozkurt, S., & Akın, H. (2019). The effects of basic movement skills training with the differential learning approach on attention and motoric characteristics in elementary school children. *Journal of Physical Education and Sports Studies, 11*(2), 95-105.

Van der Fels, I. M., Te Wierike, S. C., Hartman, E., Jongmans, M. J., Smith, J., & Visscher, C. (2015). Associations between gross motor skills and cognitive development in toddlers: A systematic review. *Journal of Science and Medicine in Sport, 18*(6), 697–703. https://doi.org/10.1016/j.jsams.2014.09.007

Wagner, H., & Schöllhorn, W. I. (2014). New findings on performance-relevant movement variability in elite sports. *Human Movement Science, 34*, 1-12.

Yaşar, T. S., Beyleroğlu, M., Hazarb, M., & Işık, Ö. (2018). The effect of Life Kinetik training on attention, eye-hand coordination, and shooting performance in archers. *ERPA 2018,* 580.

Yurdakul, N. A., Çamlıyer, H., Çamlıyer, H., Karabulut, N., & Soytürk, M. (2012). The effects of movement training on attention and memory development in eight-year-old children. *Selçuk University Journal of Physical Education and Sports Science, 14*(1), 103-108.