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Influence and Interaction: Game-Based Exercises and Body Balance on Locomotor and Core Muscles Endurance in Children with Down syndrome

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Abstract. Down syndrome (DS) children experience body balance problems that may hinder their locomotor abilities and and core muscle endurance. Exercises through games, however may improve their locomotor abilities and core muscle endurance. Therefore, this study aims to evaluate the differences in the effect between balance levels, between types of exercises, and the interaction between dynamic body balance and exercises on locomotor ability and core muscle endurance. A total of 16 children with DS were sampled and divided into four groups based on dynamic body balance levels (High vs. Low) and the type of exercises (Snake-Leader vs. Engklek). The exercises were conducted in 16 sessions, each for 60 minutes, thrice weekly conducetd in five week period. Dynamic body balance was measured using functional reach test. The locomotor ability assessment was conducted using the gross motor development-2nd edition test, while core muscle endurance was measured using plank test. The locomotor ability and core muscles endurances were assessed before and after the exercise program. The two-way ANOVA technique was conducted using the difference between pre and post test data as the dependent variables while locomotor ability and core stability endurance as factor variables with 5% significance level. The results on locomotor ability showed a significant main effect for the type of exercise, $F(1, 12) = 10.347$, $p = 0.007$, partial $\eta 2 = 0.463$; a significant main effect for balance levels, $F(1, 12) = 38.265$, $p = 0.000$, partial $\eta 2 = 0.761$; and no significant interaction, $F(1, 12) = 3.0$, $p = 0.109$, partial $\eta 2 = 0.2$. The results on core muscular endurance showed a significant main effect for the type of exercise, $F(1, 12) = 2.690$, $p = 0.127$, partial $\eta 2 = 0.183$; a significant main effect for balance levels, $F(1, 12)=37.590$, $p = 0.000$, partial $\eta 2 = 0.758$; and a significant interaction, $F(1, 12) = 8.979$, $p = 0.011$, partial $\eta 2 = 0.428$. Snakes and Ladders game is appropriate for children with DS with a high and low dynamic balance to improve locomotor ability. The Engklek game is right for DS children with a high dynamic balance to increase the endurance of the core muscles, while the Snakes and Ladders game is right for DS children with low dynamic balance.
Keywords: Influence and interaction, game-based exercises, body balance, locomotor ability, core muscle endurance, Down syndrome

Resumen. Los niños con síndrome de Down tienen problemas de equilibrio corporal que pueden dificultar su capacidad locomotora y su resistencia muscular. Sin embargo, los ejercicios mediante juegos pueden mejorar sus capacidades locomotoras y la resistencia de los músculos centrales. Por lo tanto, este estudio pretende evaluar las diferencias en el efecto entre los niveles de equilibrio, entre los tipos de ejercicios y la interacción entre el equilibrio corporal dinámico y los ejercicios sobre la capacidad locomotora y la resistencia de los músculos centrales. Un total de 16 niños con síndrome de Down fueron muestreados y divididos en cuatro grupos basados en los niveles de equilibrio corporal dinámico (Alto vs. Bajo) y el tipo de ejercicios (Snake-Leader vs. Engklek). Los ejercicios se realizaron en 16 sesiones de 60 minutos cada una, tres veces por semana en un periodo de cinco semanas. El equilibrio corporal dinámico se midió mediante la prueba de alcance funcional. La evaluación de la capacidad locomotora se realizó mediante la prueba de desarrollo motor grueso-2ª edición, mientras que la resistencia de los músculos centrales se midió mediante la prueba de la plancha. La capacidad locomotora y la resistencia de los músculos centrales se evaluaron antes y después del programa de ejercicios. La técnica ANOVA de dos vías se realizó utilizando la diferencia entre los datos de antes y después de la prueba como variables dependientes, mientras que la capacidad locomotora y la resistencia de la estabilidad central como variables factoriales con un nivel de significación del 5%. Los resultados sobre la capacidad locomotora mostraron un efecto principal significativo para el tipo de ejercicio, $F(1, 12) = 10{,}347$, $p = 0{,}007$, $\eta 2$ parcial $= 0{,}463$; un efecto principal significativo para los niveles de equilibrio, $F(1, 12) = 38{,}265$, $p = 0{,}000$, $\eta 2$ parcial $= 0{,}761$; y ninguna interacción significativa, $F(1, 12) = 3{,}0$, $p = 0{,}109$, $\eta 2$ parcial $= 0{,}2$. Los resultados sobre la resistencia muscular central mostraron un efecto principal significativo para el tipo de ejercicio, $F(1, 12) = 2{,}690$, $p = 0{,}127$, $\eta 2$ parcial $= 0{,}183$; un efecto principal significativo para los niveles de equilibrio, $F(1, 12) = 37{,}590$, $p = 0{,}000$, $\eta 2$ parcial $= 0{,}758$; y una interacción significativa, $F(1, 12) = 8{,}979$, $p = 0{,}011$, $\eta 2$ parcial $= 0{,}428$. El juego de Serpientes y Escaleras es apropiado para niños con síndrome de Down con un equilibrio dinámico alto y bajo para mejorar la capacidad locomotora. El juego Engklek es adecuado para niños con síndrome de Down con un equilibrio dinámico alto para aumentar la resistencia de los músculos centrales, mientras que el juego Serpientes y Escaleras es adecuado para niños con síndrome de Down con un equilibrio dinámico bajo.
Palabras clave. Influencia e interacción, ejercicios basados en juegos, equilibrio corporal, capacidad locomotora, Resistencia de los músculos centrales, síndrome de down

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Introduction

The World Health Organization (WHO) estimates that there is one case per 1000–1100 births of Down syndrome (DS) with an estimated eight million in the world each year. Cases in Indonesia for children with DS aged 24-59 months have continued to increase, in 2010 it was 0.12%, in 2013 it was 0.13%, and in 2018 it was 0.21% (Riskesdas, 2018). DS is a genetic disorder during the embryonic period due to failure of cell division by forming two copies of chromosome 21, so that the child has 47 chromosomes. This results in a reduced number of central nervous system neurons, delayed myelination, and cell cycle dysregulation causing overproduction of protein precursors and neurotransmission abnormalities, resulting in motor and cognitive impairment (Kim et al., 2017; Ahad et al., 2020).

Motor impairment leads to hypotonia, weak ligaments, decreased muscle strength, inadequate muscle cocontraction, inadequate postural control, and proprioceptive dysfunction (Jain et al., 2022). The combination of weak ligaments and hypotonia can increase the risk of musculoskeletal disorders and delay the acquisition of motor milestones (Foley et al, 2018). Cognitive impairment is experienced in the form of reduced integration processes in the nervous system, decision making takes longer, the ability to integrate multi-sensory information is lower, and simple reaction times are longer (Giustino et al., 2021). These various disorders result in body balance problems (Malak et al. 2013; Atradinal et al., 2019; Lourenco et al., 2021; Jain et al., 2022; Benavides et al., 2023; Lopes et al., 2023).

Dynamic body balance is a foundation and an important element for achieving more complex movement abilities (Bakhtiar et al., 2020; Mocanu et al., 2020). Children with DS achieve standing and walking ability at the age of 2-6 years (Malak et al., 2015). The stages of motor development of children with DS take twice as long, the average age of reaching being able to turn the body is 8.76 months, sitting independently is 11.87 months, and walking independently is 25.04 months (Kim et al., 2017). The existence of dynamic body balance problems makes it difficult for children with DS to control the movements of their limbs, so they often appear to produce movements that seem stiff, hesitant, and at risk of falling, which has an impact on the delay in achieving locomotor abilities and affecting quality of life (Singh et al., 2015; Lengkana et al., 2020; Simahate & Munip, 2020).

Locomotor skills are essential for children with DS aged 8–13 years to achieve independence in completing daily tasks and physical activities. Kashi et al., (2023) stated through the results of their research that a physical exercise package significantly increased the total motor proficiency score of students with DS. Training based on body balance should be provided as early as possible to prevent a longer delay in the achievement of locomotor skills. Besides being related to locomotor ability, dynamic body balance is also related to core muscle endurance. Problems with dynamic body balance lead to premature fatigue during activities, as body balance is achieved based on the performance of core stability, which is related to core muscular endurance (Krishna et al., 2020). Core muscle endurance functions to transfer energy to the lower and upper extremities, weak core muscles have an impact on large postural sway which results in children with DS often making joints stiff through muscle contractions to achieve body balance (Barati et al., 2013; Krishna et al., 2020; Abhilash et al., 2021). Continuous muscle contraction requires more energy which can lead to premature fatigue.

Physical training that will be given to children with DS in an effort to improve locomotor ability and endurance of the core muscles, must adapt the characteristics of being a strong visual learner and must activate more cognitive performance for maximum body balance achievement. Training based on hopping and jumping movements will be very meaningful for children with DS. Playing the Snakes and Ladders game and Engklek will make players do a lot of hopping and jumping movements from one box to another, this will improve locomotor abilities and these repetitive movement activities will have an impact on muscle endurance which plays a role in body balance performance (Utomo and Ismail, 2019: 52). Games that are played by doing hopping and jumping movements repeatedly and presenting various colors, pictures, lines, and numbers can be found in the modified Snakes and Ladders game and the Engklek game.

The hopping and jumping movements in the Snakes and Ladders game are carried out separately while in the Engklek game they are not separate, the difference in the way of practicing this movement also allows differences in the results of locomotor abilities at different levels of dynamic balance. Speed and agility in performing movements are also another difference between the

Snakes and Ladders game and the Engklek game, the Engklek game is played by requiring speed and agility while the Snakes and Ladders game does not require speed and agility, this is expected to provide different results on core muscle endurance at different levels of dynamic balance. These differences are likely due to differences in response and adaptation of cognitive and motor systems.

To measure the growth in locomotor abilities and core muscular endurance, it is required to demonstrate the effect of frequent hopping and jumping workouts using Snakes and Ladders and Engklek games. If the findings are positive, they will be valuable in boosting the independence and quality of life of children with DS. This study intends to Evaluate the difference in influence between the balance levels, between type of games, and the interaction between dynamic body balance and games on locomotor ability and core muscle endurance.

Materials and Methods

Participants and Research Design

Participants research

The research population consisted of 155 children with DS at Pusat Informasi dan Komunikasi (PIK) Persatuan Orang Tua Anak dengan DS (POTADS) Yogyakarta Special Region Province (DIY) who were then chosen to be the sample using a purposive sampling technique based on the criteria, which included being able to understand instructions, standing, and not having several disorders such as heart, atlo-occipital, and leg joint disorders. A total of 30 DS youngsters were gathered and submitted to a dynamic body balancing test utilizing the functional reach test (Kamath and Sandesh TS, 2017). The dynamic balance test results of 30 children with DS were sorted from largest to smallest. Based on Statistical Calculation of Item Discrimination Index, high dynamic body balance was obtained by counting 27% of 30 children with DS, resulting in 8 children with DS based on rankings 1 to 8 with dynamic body balance measurement results of 29–23.5 cm. Meanwhile, low dynamic body balance was obtained by counting 27% of 30 DS children so that children with DS were obtained based on a ranking of 23 to 30 with a dynamic body balance size of 16–12 cm. The total sample used in this study was 16 children with DS. All participants' parents provided written informed consent and the research protocol was approved by the ethics committee at the Directorate of Research and Community Services Yogyakarta State University (approval No. B/50/UN34.9/KP.06.07 /2023).

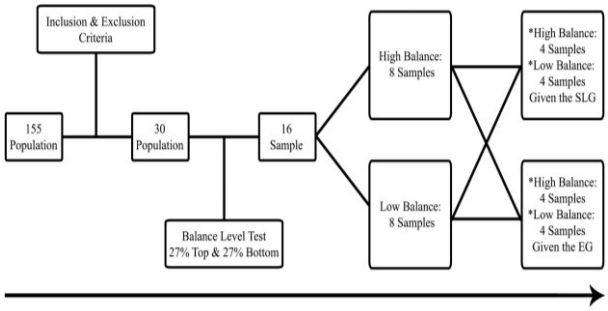

Figure 1. Sample determination

Research design

This research is conducted with the experiment method with the 2x2 factorial design. The entire sample was divided into 4 groups based on dynamic body balance which was the moderator variable and treatment (game-based training) which was given as the independent variable. This study did not have a control group.

Table 1.
2x2 Factorial research design

Dynamic Balance Game	High	Low
Snakes and Ladders (SLG)	SLG-High	SLG-Low
Engklek (EG)	EG-High	EG-Low

Notes:
SLG-High: Groups with the High Balance were given Snakes and Ladders game.
EG-High: Groups with the High Balance were given Engklek game.
SLG-Low: Groups with the Low Balance were given Snakes and Ladders game.
EG-Low: Groups with the Low Balance were given Engklek game.

Operational definition of variables

Manipulative independent variable: Snakes and ladders and Engklek game-based exercise

The Snakes and Ladders game-based exercise is to perform hopping and jumping movements which are carried out separately to move from one box to another according to the order of numbers from smallest to largest or from number one (start) to number 25 (finish). Meanwhile, the Engklek game-based exercise is played with a combination of alternating jumping and hopping movements when moving from the box where the participant is standing to another box. In the Snakes and Ladders game-based exercise, one repetition is counted if the person plays (hops or jumps) from the start (number one) to the finish box (number twenty-five). However, in the Engklek game-based exercise, one repetition is counted if the participant

plays from box number one to box number six and back to box number one four times (back and forth).

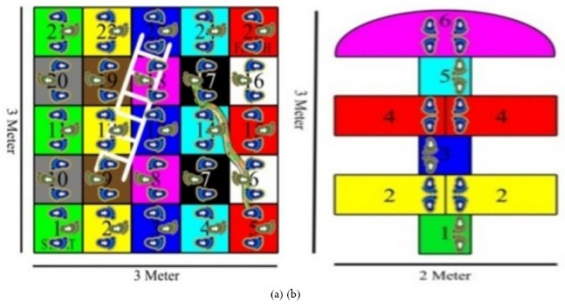

Figure 2. (a) Snakes and Ladders game media; (b) Engklek game media

Attributive independent variable: Dynamic balance

Dynamic body balance is the ability of children with DS which is measured by how far (centimeters) the arms reach straightened forward at shoulder level with the fingers clenched into fists in an effort to maintain the body when moving bent in a standing position without the slightest step.

Dependent variable: Locomotor ability

a. Running is the ability to see how well the anatomical position of a child with DS moves when running a distance of 10 meters on a flat surface as seen from the position of the arms when moving, both legs raised (floating), the position of the feet when landing, and the degree to which the feet are not supported.

b. Jumping is the ability to see how well the anatomical position of a DS child's body movements are in making jumping movements on a flat surface as seen from the position of the feet which are not supported, arm movements, jumping movements and landing three times consecutively with the left foot and the right foot.

c. Hopping is the ability to see how well the anatomical position of a DS child's body movements are in carrying out horizontal hopping movements on a flat surface as seen from the initial preparation movements, arm movements when hopping and landing, and the position of the feet when hopping and landing.

Dependent variable (dependent): Core muscle endurance

Core muscle endurance is the ability of how long (time) a child with DS can maintain or control his body's core so that it remains in a good and correct plank position on a flat surface or floor covered with a mattress.

Test Procedure

After the samples were determined and divided into 4 groups, then all research samples went through a pretest procedure, followed by the giving exercises and the posttest, with a total of 20 meetings. All samples were examined for locomotor abilities using the test of gross motor development-2nd edition (Tun et al., 2021) and core muscle endurance was measured using the plank test (Boyer et al., 2013) at pretest and post-test as the dependent variable.

Exercise Protocols

All samples received bodyweight training in the form of calf raises against the wall, sit-to-stand, squats, and core stability exercises (glute bridge and airplane in four point kneeling). After carrying out bodyweight training, the samples were separated into groups to do hopping and jumping exercises on Snakes and Ladders and Engklek games covered with mats to minimize injury if the samples fell. The training was carried out in 18 meetings over 6 weeks with a frequency of 3 times a week and a training duration of 60 minutes. The intensity of the exercise is determined by the speed of performing hopping and jumping movements from one box to another. Meetings 1 to 6 each sample hopped and jumped from box to box with the pause duration of 6 seconds, meetings 7 to 12 the pause duration was 4 seconds, and Meetings 13 to 18 have a pause duration of 2 seconds, but for samples who can already do jumps and jumps, they can do it without a pause. The pause duration is used to provide instructions to the sample.

Table 2.
Training program

Phase Training	Form of Exercise	Repetition	Total Sets per Week (W)						Duration
			W 1	W 2	W 3	W 4	W 5	W 6	
Warmup	Stretching								10 minutes
Core	Bodyweight training	3	1	1	2	2	3	3	40 minutes
	SLG with a jumping motion	4	2	2	2	4	4	4	
	SLG with a hopping motion	4	2	2	2	4	4	4	
	EG	8	4	4	4	8	8	8	
Cooling	Stretching								10 minutes

Statistical Analysis

Analysis of variance (ANOVA) as a data analysis technique in this research, uses a two-way ANOVA technique at a significance level of $\alpha = 0.05$ using the difference between pre and post test data as the dependent variable which is carried out in SPSS version 22 software. Statistical analysis begins by carrying out prerequisite tests consisting of data normality tests and homogeneity of variance test, then a hypothesis test is carried out and if there is an interaction it will be continued with the Tukey test.

Results

Normality and Homogeneity Test

Data normality and homogeneity tests have been carried out, all standardized resedual data from pretest, posttest, and the difference in locomotor ability and core muscle endurance of each group show a significance value greater than 0.05 (Sig.>0.05) so all data are normally distributed and homogeneous.

Hypothesis Test

The hypothesis test was only performed using data on the rise or difference between the pretest and posttest data; data was deemed to have an influence and an interaction if it is less than 0.05. The findings of hypothesis testing were shown in Tables 3 and 4

Table 3.
Result of hypothetical test for the variable of locomotor ability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Game-Based Exercises	10.563	1	10.563	10.347	0.007	0.463
Balance	39.063	1	39.063	38.265	0.000	0.761
Game-Based Exercises*Balance	3.063	1	3.063	3.0	0.109	0.2
Error	12.250	12	1.021			

The results of the study on locomotor ability showed a significant main effect for Game-Based Training, $F(1, 12) = 10.347$, $p = 0.007$, partial $\eta 2 = 0.463$; a significant main effect for Balance, $F(1, 12) = 38.265$, $p = 0.000$, partial $\eta 2 = 0.761$; and no significant interaction between Game-Based Training and Balance, $F(1, 12) = 3.0$, $p = 0.109$, partial $\eta 2 = 0.2$. The graph of the estimated marginal means of the difference in locomotor ability scores is as follows.

Table 4.
Result of hipothetical test for the variable of core muscle endurance

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Game-Based Exercises	23.401	1	23.401	2.690	0.127	0.183
Balance	326.977	1	326.977	37.590	0.000	0.758
Game-Based Exercises*Balance	78.101	1	78.101	8.979	0.011	0.428
Error	104.383	12	8.699			

The results of the study on core muscle endurance showed a significant main effect for Game-Based Exercises, $F(1, 12) = 2.690$, $p = 0.127$, partial $\eta 2 = 0.183$; significant main effect for Balance, $F(1, 12) = 37.590$, $p = 0.000$, partial $\eta 2 = 0.758$; and a significant interaction between Game-Based Exercises and Balance, $F(1, 12) = 8.979$, $p = 0.011$, partial $\eta 2 = 0.428$. The graph of the estimated marginal means of the difference in core muscle endurance scores is as follows.

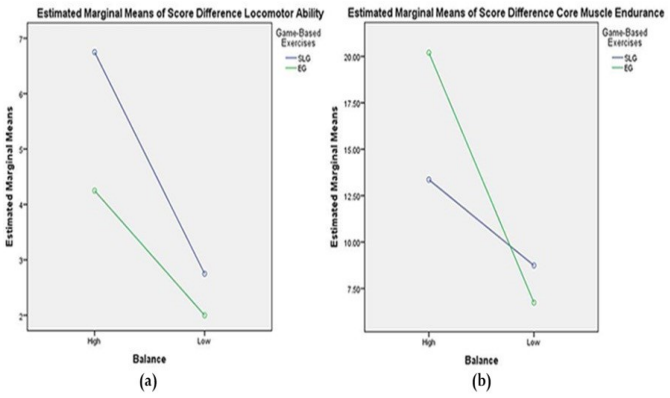

Figure 3. (a) Graph of differences in locomotor ability scores; (b) Differences in core muscle endurance scores

Table 5.
Result of *tukey* test for the interaction between the dynamic body balance and the variable games of core muscle endurance

Group	N	Subset		
		1	2	3
EG-Low	4	6.7400		
SLG-Low	4	8.7400	8.7400	
SLG-High	4		13.3625	
EG-High	4			20.2000
Sig		0.774	0.174	1.000

According to Table 5, group EG-High in subset 3 exhibited a substantial difference from groups SLG-High and SLG-Low in subset 2, and a significant difference from group EG-Low in subset 1. Group SLG-High differed significantly from group EG-Low, but there was no significant difference between groups SLG-High and SLG-Low, nor between groups SLG-Low and EG-Low.

Discussion

Effect of Snakes and Ladders Game and Engklek towards Locomotor Ability

One of the goals of this research was to demonstrate

the impact of the Snakes and Ladders game on locomotor ability. The statistical test findings show that there is a difference between the two games in terms of enhancing the locomotor abilities of children with DS, indicating that the hypothesis is accepted. According to the findings of this study, giving the Snakes and Ladders game to 32 elementary school pupils increased their abilities to sprint, hopp, and jump (Sahudi et al., 2021). Children with autism spectrum disorder (ASD) aged 4 to 5 years old had their locomotor abilities improved by playing the Snakes and Ladders game for one hour per day, three days per week for five weeks (Martseeda et al., 2021). The Engklek game contains a form of training that involves repetitive locomotor motions. Training with the Engklek game has been shown to improve the locomotor abilities of children with mild mental retardation (Paramesthi et al., 2022). Furthermore, there has been a rise in children aged 5 to 6 years (Apriliani et al., 2019; Lorena et al., 2020).

Playing offers youth people pleasure and makes them want to repeat the same activities, so they do not feel they are training muscles to work, which is defined by repetitive muscular actions that enhance muscle strength, speed, agility, and flexibility and effect ability progress motor skills of children (Sutapa et al., 2021; Dimyati, et al. 2022). Jumping and stepping are examples of active foot movements that can be used to train children's balance (Jati et al., 2020).

According to the findings of this study, playing Snakes and Ladders improves locomotor ability more than playing Engklek. According to Martseeda et al., 2021; Sahudi et al., 2021, the Snakes and Ladders game causes an increase in locomotor abilities because it provides many opportunities for teachers or trainers to teach each locomotor skill separately with the right and focus, which causes the reactivation of children repeatedly-repeat by continuing to repeat the movement. The Engklek game, unlike Snakes and Ladders, is played with alternating hopping and jumping movements, and each person gets a turn to play (Apriliani et al., 2019; Sholikan & Sudijandoko, 2019).

The more actions that are performed, the more effective the workout and the better it is for strengthening fast-type muscle fibers, resulting in the ability to handle larger workloads (Astrawan, 2019). Furthermore, the sensorimotor system appears to be influenced by previous movement experience; repeated movements in a specific direction are known to have a dramatic effect on involuntary movements elicited by cortical stimulation, a phenomenon known as plasticity; repetition of movements increases the generation of the same movements in the future by reducing the time required to prepare for repeated movements; the advantage in reaction time is due to the preparation being (Mawase et al., 2018).

The position of the feet when practicing hopping and jumping on the Engklek game differs from the position of the feet during the ability test; the distinction is between the position of the feet (two feet or one foot) when standing at the start of the move and the position of the feet (two feet or one foot) when landing from hopping or jumping. In contrast, the Snakes and Ladders game's hopping and jumping movements correlate to the movements during the locomotor ability exam. According to Eva et al. (2021), a movement that is repeated will become a habit to do it with the same technique, but if you must do a movement with a different technique, kinesthetic perception will take time to adapt. The process of kinesthetic adaptation, which will not have an impact on poor quality of movement when assessing locomotor abilities with new techniques or techniques that are not the same as movement experience, allows for differences in the results of increasing locomotor abilities between groups given the Snakes and Ladders game with a group given a Engklek game.

Effect of Snakes and Ladders and Engklek Game towards Core Muscle Endurance

One of the goals of this study is to demonstrate the difference between Snakes and Ladders and Engklek on the core muscle endurance of children with DS. The statistical test findings revealed that there was no difference between the two games in terms of core muscle endurance in children with DS, hence the hypothesis was rejected. Children with DS who have a high dynamic body balance benefit more from Engklek playing. The Snakes and Ladders game, on the other hand, delivers an average value of developing core muscle endurance that is significantly higher for children with DS who have poor dynamic body balance.

Repetitive hopping and jumping movements are an effective exercise for increasing core muscle endurance in children with DS. It has also been established that it generates considerable gains in explosive action, balance, and intermittent endurance capacity in vertical jumps, horizontal jumps, and a combination of both (Ramrez-Campillo et al., 2015). Plyometric exercise improves dynamic body balance and core muscle

strength (Pal et al., 2021). Plyometric workouts, pilates exercises, and a combination of the two provide significant improvements in vertical jump height and trunk endurance (Chouhan et al., 2022).

Muscles that are exercised will experience myelin thickening, resulting in an increase in muscle endurance if the muscles are trained for a minimum of 12 weeks and three times per week (Sutapa et al., 2021). Continuous repetition exercises induce adaptations to endure muscular fatigue, which are connected with enhanced buffering and oxidative capacity, increased capillaryization and mitochondrial density, and increased metabolic enzyme activity. Repetitive hopping and jumping movements training results in muscle adaptations and muscle endurance (Schoenfeld et al., 2021).

The speed with which hopping and jumping actions are performed is a factor that causes disparities in the achievement of developing core muscle endurance between the groups trained using the Snakes and Ladders game and the group trained using the Engklek game. The group with high dynamic body balance who played the Engklek game appeared to travel faster from one flat surface to another than the group with high dynamic body balance who played the Snakes and Ladders game. In the low dynamic body balance group, the group who received exercises using the Snakes and Ladders game demonstrated faster body motions when hopping than the group that received the Engklek game, which frequently paused.

Core muscular endurance is linked to speed, agility, and aerobic power performance (Boyaci & Tutar, 2018). Muscular endurance is defined as the number of repetitions accomplished in a given amount of time until exhaustion sets in (Thomas et al., 2018). This demonstrates that the faster you repeat an action at a given period, the more repetitions you will complete, resulting in increased muscle endurance. The performance of the core muscles affects the performance of hopping and jumping actions. The strength, stability, and endurance of the core muscles affect jumping performance (Kamdin & Varghese, 2020). Hopping and jumping exercises performed at a faster pace result in more repetitions of the movement in a given time, resulting in higher core muscular endurance.

Effect of Dynamic Body Balance towards Locomotor Ability

One of the goals of this study is to determine the variations in the effects of high and low dynamic body balance on the locomotor abilities of children with DS. This goal has been met by statistical tests that reveal that there are differences in the influence of high and low dynamic balance on the locomotor abilities of children with DS, indicating that the hypothesis is accepted. The group with high body balance improved their locomotor abilities more than the group with low body balance.

Body balance influences the development of children's locomotor abilities (Bakhtiar et al., 2020). According to Hendra et al. (2019), the greater a kid's dynamic body balance, the easier it will be for the youngster to make the numerous movements required in play, resulting in the development of locomotor abilities. The capacity to manage and maintain the body's center of mass or center of gravity during movement with cooperation between the core and extremities to provide stability and reflectivity as a reaction to change is referred to as body balancing (Yanovich & Bar-Shalom, 2022). Body balance refers to the ability to perform motions more efficiently and with greater bodily control (Singh et al., 2022).

The proprioceptive system, which consists of muscles, joints, and tendons, is also involved in the development of movement abilities. These components raise the body's awareness of external situations, regulate balance and posture, and aid in the development of well-coordinated motions (Rachman & Anggita, 2018). The level of gross motor development is highly correlated with dynamic balance and the child's proprioceptive system (Jiang et al., 2018). Appropriate motor skills and nervous system development enable a youngster to effectively coordinate his limbs (Sutapa et al., 2021).

Effect of Dynamic Body Balance on Core Muscle Endurance

One of the goals of this research is to understand and demonstrate the influence of dynamic body balance on core muscle endurance. The hypothesis was accepted when statistical analyses revealed that there were differences in the effect of high and low dynamic balancing on core muscle endurance in children with DS. The difference can be seen in the average value of the rise in core muscle endurance, which reveals that the increase in core muscle endurance of the high-body balance group is much greater than the increase in core muscle endurance of the low-body balance group.

There is a link between balance, core muscle endur-

ance, and functional level (Bezgin et al., 2020). Theoretically, core stability and motor performance are linked (Cengizhan et al., 2019). The core is a complicated anatomical area composed of the lumbar spine, hips, hip joints, and muscles that govern the body's equilibrium when moving (Sannicandro, 2017). Dynamic body balance can have an impact on performance; maintaining proper body balance will minimize premature exhaustion (Baghbaninaghadehi et al., 2013). Dynamic activities necessitate a high level of stability, which causes fatigue in children with DS who have poor dynamic body balance (Schott et al., 2014). This occurs because there is a link between the weakening of the muscles responsible for torso stability and the incapacity to perform adequately at work (Bezgin et al., 2020).

Extensor fatigue influences balance by increasing postural sway (Barati et al., 2013). As postural sway occurs, the neuromuscular kinesthetic senses respond to govern and cope with the rapid changes in body segments supported by the core muscles (Joshi et al., 2019; Reyes-Ferrada et al., 2021). Strong core muscles help to establish optimal mobility, posture, and technique by reducing fatigue during long-duration exercises and the incidence of increased postural sway (Boz & Temur, 2020).

The core muscles of the body will contract prior to the leg movement to give a stable foundation for the leg and muscle activation (Almutairi et al., 2022). Jumping, running, and kicking will activate the core muscles, which will help to support the spine and body during dynamic movements (Akuthota et al., 2008). Furthermore, insufficient core muscular endurance might result in greater knee loads and knee joint contact forces during dynamic activities (Joshi et al., 2019). Poor dynamic body balance affects core muscular endurance because the core muscles of the body are required to work extra hard to create a firm foundation for the joints of the legs, resulting in premature tiredness.

Interaction between Dynamic Body Balance and Play on Locomotor Abilities

One of the goals of this study is to learn how the interplay of dynamic body balance (high and low) and games (Snakes and Ladders and Engklek) impacts the locomotor abilities of children with DS. The statistical test findings revealed no interaction, indicating that the hypothesis was rejected. When compared to the low dynamic body balance group, the group with high dynamic body balance had a significant boost in locomotor ability. These findings support Oktarifaldi et al (2020) assertion that body coordination and balance influence locomotor ability; the better the coordination of movement and body balance, the higher the level of locomotor ability that can be demonstrated.

When compared to the Engklek game, the group that received the Snakes and Ladders game exercise excelled at both the high dynamic body balance level and the low dynamic body balancing level. Children with DS have cognitive impairments, which manifest as a slowed integration process in the neurological system, longer decision-making times, a diminished ability to integrate multisensory information, and slower basic reactions. Delays in the nerve system's multisensory integration process to control body posture are the cause of body balance and poor movement abilities in people with DS (Giustino et al., 2021; García-Fresneda et al., 2022). In principle, attainment of body balance and movement ability is also related with cognitive characteristics, therefore the lower a child's body balance level, the worse the child's cognitive handicap.

Cognitive impairment in children with DS has been linked to changes in how they play the Snakes and Ladders and Engklek games. The Snakes and Ladders game has a defined movement structure, and each move is rehearsed separately from beginning to end. The movement structure of the Engklek game, on the other hand, is done arbitrarily (randomly) or combines hopping and jumping movements when the participants get their chance to play.

The high contextual interference driving learning necessitates more cognitive effort during motor skill execution, and the higher cognitive engagement observed during randomized practice may be due to higher levels of elaboration and differentiation involved in processing, or it may result from forgetting and reconstructing action plans (Lage et al., 2015). Variations in movement structure in play can be linked to the process of correcting movement faults because children with intellectual disabilities have a working memory that is not operating properly and has difficulties following multiple directions (van Abswoude et al., 2015).

The corrective procedure for the group practicing with the Snakes and Ladders game can be repeated for each movement separately, keeping the correction process focused on each movement being performed. In the game of Engklek, on the other hand, the correct-

ing procedure is carried out concurrently between the hopping and jumping actions in one repetition, allowing for more instructions to be received. A child's working memory capacity is positively proportional to the number of instructions received; the more instructions a youngster receives, the more information is stored to be understood and obeyed (Buszard et al., 2017). The number of instructions supplied can affect locomotor ability; the less instructions given, the easier it is to comply swiftly (Chatzopoulos et al., 2020). Because working memory capacity affects the amount of information that must be processed, the number of instructions that can be stored in working memory and processed relies on the demands of the task assigned to the kid (Cowan, 2010). When compared to the Snakes and Ladders game, the Engklek game incorporates hopping and jumping actions, allowing for more motion correction instructions. This may influence memory capacity and the time (sooner or later) required to understand the movement correction instructions.

Interaction between dynamic body balance and play on core endurance

One of the goals of this study is to learn how the interplay of dynamic body balancing (high and low) and games (Snakes and Ladders and Engklek) impacts the core muscular endurance of children with DS. The statistical test findings reveal that there is an interaction, indicating that the hypothesis is correct. Engklek games are a good way to build core muscle endurance in children with DS who have strong dynamic body balance, but Snakes and Ladders games are useful in children with DS who have low dynamic body balance.

The speed of children with DS who have high dynamic body balance when playing the Engklek game outperforms the speed of children with DS who practice with the Snakes and Ladders game, resulting in differences in increased muscle endurance because movement speed is related to intensity. Various intensities differ as indicators of improving motor quality (Kuznetsova et al. 2022). Training the core muscles with dynamic exercises of moderate to high intensity can improve trunk and core muscle endurance (Ylmaz, 2022). The faster you leap and hop, the greater the gain in core muscular endurance.

The combination of hopping and jumping actions in the Engklek game can also be linked to foot agility, because shifting locations necessitates that the position that was previously sustained on one leg be supported on two feet. This maneuver is performed rapidly and without much pause by a DS child with good body balance. According to Cengizhan et al. (2019), agility may carry the body further with more regulated motions and that there is a relationship between postural stability, core muscular endurance, and agility.

Effect of additional visual aspects and bodyweight exercises on locomotor abilities and core muscle endurance

Colors, numbers, shapes, and lines in the Snakes and Ladders and Engklek games can excite children with DS's visual components. In response to this question, digital picture visual stimulation can improve body balance and vestibular rehabilitation, and it can help people with peripheral vestibular disorders improve their postural control (Manso et al., 2015). Intermittent visual occlusion as an easy way to improve dynamic body balance (Symeonidou & Ferris, 2022). In addition, all samples in this study received bodyweight workouts as extra exercises. Locomotor training with bodyweight has been proven to be possible for the rehabilitation of individuals with neurological disease, with the benefits of enhanced muscle strength, bone density, decreased heart rate, and improved physical conditioning (Dutra et al., 2013; Benavides Pando et al., 2023). In this study, additional bodyweight workouts improved locomotor ability and core muscle endurance in children with DS.

The findings of this study have a significant impact on enhancing locomotor abilities and core muscle endurance in children with DS, allowing them to acquire independence and a higher quality of life. The findings of this study can help adaptive physical education teachers, therapists, trainers, and parents choose the best treatment for children with DS based on their level of dynamic body balance in increasing locomotor abilities and core muscular endurance. This study contains drawbacks, such as samples whose moods fluctuate during the exercise procedure, forcing the sample to leave the practice area and halt for a while before returning to complete the activity. Another limitation in this study is the difference in the number of hopping and jumping movements in the Snakes and Ladders game and the Engklek game. In the Snakes and Ladders game, the hopping and jumping movements are carried out 25 times in one repetition, whereas in the Engklek game, the hopping and jumping movements are carried out 24 times in a single repetition. The exercise is re-

peated once. Based on these constraints, we can undertake research in the future by observing the mood of children with DS and equal the number of hopping and jumping movements every repetition in Snakes and Ladders and Engklek games. Also, future research can test and analyze the memory capacity of children with DS using a variety of instructions connected to different game rules to boost the movement abilities of children with DS, based on the discussion.

Research Limitations and Strengths

This research has shortcomings such as differences in the number of hopping and jumping movements in the Snakes and Ladders game and the Engklek game due to differences in the number of boxes that the sample passes through for one repetition of the exercise, and this research has shortcomings control group. In the game Snakes and Ladders the hopping and jumping movements are done 25 times in one repetition, while in the game Engklek the hopping and jumping movements are done 24 times in one repetition. Based on these constraints, further research can be carried out using a control group and an even distribution of the number of jumping and hopping movements for each repetition in the Snakes and Ladders and Engklek games.

Training based on Snakes and Ladders and Engklek games has the advantage that participants have to carry out repetitive movements which can be evaluated directly or with video, there are visual elements and bodyweight training is added as an excellent combination to improve locomotor ability with DS, so that it can enhance locomotor ability in children with DS to gain independence and a better quality of life. Practitioners can apply these exercises by accompanying children with DS through the stages of introducing exercise, introducing exercise rules, practicing with one participant first, and conceptualizing the exercise as a recreational sport that is carried out with clear and few instructions.

Conclusion

The Snakes and Ladders game is a better way to develop the locomotor abilities of children with DS who have high and poor dynamic body balance. Exercises involving the Engklek game are more appropriate for increasing core muscle endurance in children with DS who have high dynamic body balance, whereas exercises involving the Snakes and Ladders game are more appropriate for increasing core muscle endurance in children with DS who have low body balance. The training program will be prepared based on the level of dynamic body balance of children with DS and the game characteristics in order to attain greater locomotor abilities and better core muscle endurance.

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Availability of data and materials

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical reasons.

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Conflicts of Interest

The authors declare no conflict of interest.

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References

Abhilash, P. V., Sudeep, S., & Anjana, K. (2021). Relationship between core endurance and dynamic balance in professional basketball players: A pilot study. *International Journal of Physical Education, Sports and Health, 8*(4), 1–5. Retrieved from https://www.kheljournal.com/archives/2021/vol8issue4/PartA/8-3-74-346.pdf

Ahad, W. A., Ehsan, F., Fatima, N., Yousaf, F., Qamar, R., Sadaf, A., Ashraf, S. (2020). Cognitive impairments in children with Down syndrome. *Journal of Health, Medicine and Nursing, 71*, 96–100. https://doi.org/10.7176/JHMN/71-12

Akuthota, V., Ferreiro, A., Moore, T., & Fredericson, M. (2008). Core stability exercise principles. *Current Sports Medicine Reports, 7*(1), 39–44. https://doi.org/10.1097/01.CSMR.0000308663.13278.69

Almutairi, N., Alanazi, A., Seyam, M., Kashoo, F. Z., Alyahya, D., & Unnikrishnan, R. (2022). Relationship between core muscle strength and dynamic balance among hospital staff. *Bulletin of Faculty of Physical Therapy, 27*(24), 1–8. https://doi.org/10.1186/s43161-022-00082-y

Apriliani, A. M., Yasbiati., & Elan. (2019). Meningkatkan kemampuan gerak lokomotor anak usia 5-6 tahun di kelas B hijau melalui permainan Engklek rintangan di TK Negeri Pembina Kota Tasikmalaya. *Jurnal PAUD Agapedia, 3*(2), 178–190. Retrieved from https://ejournal.upi.edu/index.php/agapedia/article/view/26680

Astrawan, I. T. (2019). Comparison between the effects of 10 repetition 2 sets footwork with 5 repetition 4 sets footwork for improving trainees' agility in badminton training. Proceedings of the 3rd International Conference on Innovative Research Across Disciplines (ICIRAD 2019). *Atlantis Press, 394*, 425–429. https://doi.org/10.2991/assehr.k.200115.070

Atradinal., Vetra, Y., Jonni, Oktarifaldi, Syahputra, R., Mardela, R., & Bakhtiar, S. (2019). Effect of balance on development level of the locomotor capabilities of kindergarten children. Advances in Social Science, Education and Humanities Research. *Atlantis Press, 460*, 263–265. https://doi.org/10.2991/assehr.k.200805.072

Baghbaninaghadehi, F., Ramezani, A. R., & Hatami, F. (2013). The effect of functional fatigue on static and dynamic balance in female athletes. *International SportMed Journal, 14*(2), 77–85. Retrieved from https://www.researchgate.net/publication/269932489

Bakhtiar, S., Khairuddin., Oktarifaldi., Syahputra, R., Putri, L. P., & Asnaldi, A. (2020). Pengaruh keseimbangan terhadap tingkat level perkembangan kemampuan lokomotor siswa paud Kabupaten Padang Pariaman. *Educatio, 15*(1), 12–21. https://doi.org/10.29408/edc.v15i1.1985

Barati, A., Safarcherati, A., Aghayari, A., Azizi, F., Abbasi, H. (2013). Evaluation of relationship between trunk muscle endurance and static balance in male students. *Asian Journal of Sports Medicine, 4*(4), 289–294. https://doi.org/10.5812/asjsm.34250

Benavides Pando, E. V., Delgado Valles, C., Ornelas Contreras, M., & Jiménez Lira, C. (2023). hysical activity in people with Down syndrome. *Retos, 50*, 415–420. Retrieved from https://recyt.fecyt.es/index.php/retos/article/view/94542

Bezgin, S., Arslan, S. A., Sertel, M., Vergili, O., Kocaman, A. A., Oral, M. A., Saham, T, Y., Demirci, C. S., Ugurlu, K., Onal, B., Keskin, E. D. (2020). The relationship between balance, trunk muscular endurance, and functional level in individuals with chronic low back pain. *Annals of Medical Research, 27*(2), 582–587. https://doi.org/10.5455/annalsmedres.2019.11.684

Boyaci, A., & Tutar, M. (2018). The effecet of the quad-core training on core muscle strength and endurance. *International Journal of Sports Science, 8*(2), 50–54. https://doi.org/10.5923/j.sports.20180802

Boyer, C., Tremblay, M., Saunders, T., McFarlane,

A., Borghese, M., Lloyd, M., & Longmuir, P. (2013). Feasibility, validity, and reliability of the plank isometric hold as a field-based assessment of torso muscular endurance for children 8–12 years of age. *Pediatric Exercise Science, 25*(3), 407–422. https://doi.org/10.1123/pes.25.3.407

Boz, H. K., & Temur, H. B. (2020). The relationship between core stability and some performance parameters between fourteen and sixteen year old group male long distance runners and football players. *African Educational Research Journal, 8*(2), 352–356. https://doi.org/10.30918/AERJ.82.20.076

Buszard, T., Farrow, D., Verswijveren, S. J. J. M., Reid, M., Williams, J., Polman, R., Ling, F. C. M., & Masters, R. S. W. (2017). Working memory capacity Limits motor learning when Implementing Multiple instructions. *Frontiers in Psychology, 8*, 1350, 1–12. https://doi.org/10.3389/fpsyg.2017.01350

Cengizhan, P. A., Cobanoglu, G., Gokdogan, C. M., Zorlular, A., Akaras, E., Orer, G. E., Kafa, N., & Guzel, N. A. (2019). The relationship between postural stability, core muscle endurance and agility in professional basketball players. *Annals of Medical Research, 26*(10), 2181–2186. https://doi.org/10.5455/annalsmedres.2019.07.436

Chatzopoulos, D., Foka, E., Doganis, G., Lykesas, G., & Nikodelis, T. (2020). Effects of analogy learning on locomotor skills and balance of preschool children. *Early Child Development and Care, 192*, 1–9. https://doi.org/10.1080/03004430.2020.1739029

Chouhan R, Misra A, Soni R, Joseph, A., & Umate, R. (2022). Effectiveness of plyometrics along with pilates exercises in increasing vertical jump performance among basketball players. *Cureus, 14*(12), 1–6. https://doi.org/10.7759/cureus.32957

Cowan, N. (2010). The Magical Mystery four: How is working memory capacity limited, and Why?. *Current Directions in Psychological Science, 19*(1), 51–57. https://doi.org/10.1177/0963721409359277

Dimyati, A., Setiawan, E., Dewi, R. K., Meirizal, Y., Gani, R. A., Saputro, Y. D., Satrianingsih, B., Winarno, M. E., Németh, Z. (2022). The effect of movement games on the level of physical fitness and mental health of students with disabilities: Mixed method. *Physical Education Theory and Methodology, 22*(4), 466–472. https://doi.org/10.17309/tmfv.2022.4.02

Dutra, C. M. R., Dutra, C. M. R., Moser. A. D. L., & Manffra, E. F. (2013). Locomotor training with partial body weight support in spinal cord injury rehabilitation: Literature review. *Fisioterapia em Movimento, 25*(4), 907–920. Retrieved from https://www.scielo.br/j/fm/a/sgfhtxxzhkCCfxnCJp8cG3r/?format=pdf&lang=en

Eva, J. P., Yusmawati., Widyaningsih, H., & Halim, A. (2021). Quality physical education learning through process modeling based on kinesthetic perception. *International Journal of Human Movement and Sports Sciences, 9*(1), 89–96. https://doi.org/10.13189/saj.2021.090112

Foley, C., & Killeen, O. G. (2018). Musculoskeletal anomalies in children with Down syndrome: An observational study. *Archives of Disease in Childhood, 104*, 482–487. https://doi.org/10.1136/archdischild-2018-315751

García-Fresneda, A., Theodorou, A. S., Panoutsakopoulos, V., Jordán, M. A. T., Padullés, J-M., Padullés, X., & Kotzamanidou, M. C. (2022). Step regulation in Paralympic long jumpers with intellectual impairment. *European Journal of Adapted Physical Activity, 15*(1), 1-15. https://doi.org/10.5507/euj.2022.004

Giustino, V., Messina, G., Alesi, M., Mantia, L. L., Palma, A., & Battaglia, G. (2021). Study of postural control and body balance in subjects with Down syndrome. *Human Movement, 22*(1), 66–71. https://doi.org/10.5114/hm.2021.98466

Hendra, J., Sepdanius, E., & Daya, W. J. (2019). Walking on the board for dynamic balance. Proceedings of the 1st progress in social science, humanities and education research symposium (PSSHERS 2019). *Atlantis Press, 464*, 755–758. https://doi.org/10.2991/assehr.k.200824.168

Jain, P. D., Nayak, A., Karnad, S. D., & Doctor, K. N. (2022). Gross motor dysfunction and balance impairments in children and adolescents with Down syndrome: A systematic review. *Clinical and Experimental Pediatrics, 65*(3), 142–149. https://doi.org/10.3345/cep.2021.00479

Jati, R. K., Suwastika, N. A., & Yasirandi, R. (2020). Hopscotch game to support stimulus in children's gross motor skill using IoT. *Kinetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control, 5*(4), 277–290.

https://doi.org/10.22219/kinetik.v5i4.1090

Jiang, G. P., Jiao, X. B., Wu, S. K., Ji, Z. Q., Liu, W. T., Chen, X., & Wang, H. H. (2018). Balance, proprioception, and gross motor development of chinese children aged 3 to 6 years. *Journal of Motor Behavior, 50*(3), 1–10. https://doi.org/10.1080/00222895.2017.1363694

Joshi, S. M., Sheth, M. S., & Jayswal, M. M. (2019). Correlation of core muscles endurance and balance in subjects with osteoarthritis knee. *International Journal of Medical Science and Public Health, 8*(5), 347–351. https://doi.org/10.5455/ijmsph.2019.01021080320 19

Kamath, T., & Sandesh TS. (2017). The test retest reliability and concurrent validity of functional reach test in 5 to 15 years old children with down's syndrome - A cross sectional study. *International Journal of Physical Education, Sports and Health, 4*(3), 523–529. https://doi.org/10.22271/kheljournal

Kamdin, F., & Varghese, A. (2020). Relationship between core strength and stability, with dynamic balance and jumping performance in young adults. *International Journal of Recent Scientific Research, 11*(06), 38854–38860. http://dx.doi.org/10.24327/ijrsr.2020.1106.5390

Kashi, A., Dawes, H., Mansoubi, M., & Sarlak, Z. (2023). The effect of a physical exercise package on the motor proficiency of students with Down syndrome. *Innovative Journal of Pediatrics, 33*(1). https://doi.org/10.5812/ijp-120408

Kim, H. I., Kim, S. W., Kim, J., Jeon, H. R., & J, D. W. (2017). Motor and cognitive developmental profiles in children with Down syndrome. *Annals of Rehabilitation Medicine, 41*(1), 97–103. https://doi.org/10.5535/arm.2017.41.1.97

Krishna, H. S., Shetty, S., & Raj, A. S. (2020). Relationship between core endurance and dynamic balance in college level football players: A pilot study. *International Journal of Physical Education, Sports and Health,* 7(5), 149–153. Retrieved from https://www.kheljournal.com/archives/2020/vol7issue5/PartC/7-4-81-971.pdf

Kuznetsova, L., Trachuk, S., Semenenko, V., Kholodova, O., Podosinova, L., Brychuk, M., Varenyk, O., & Kedrych, H. (2022). Effect of movement games on physical fitness of children with intellectual disabilities. *Physical Education Theory and Methodology, 22*(2), 158–165. https://doi.org/10.17309/tmfv.2022.2.02

Lage, G. M., Ugrinowitsch, H., Apolinário-Souza, T., Vieira, M. M., Albuquerque, M. R., Benda, R. N. (2015). Repetition and variation in motor practice: A review of neural correlates. *Neuroscience and Biobehavioral Reviews, 57*, 132–141. http://dx.doi.org/10.1016/j.neubiorev.2015.08.012

Lengkana, A. S., Rahman, A. A., Alif, M. N., Mulya, G., Priana, A., & Hermawan, D. B. (2020). Static and dynamic balance learning in primary school students. *International Journal of Human Movement and Sports Sciences, 8*(6), 469–476. https://doi.org/10.13189/saj.2020.080620

Lopes, C. N. J., Alane, S. É., & Silva, G. M. (2023). Analysis of motor learning task in children with intellectual disability. *Retos, 49*, 807–812. https://doi.org/10.47197/retos.v49.98355

Lorena, H., Drupadi, R., & Syafrudin, U. (2020). Pengaruh modifikasi permainan tradisional Engklek terhadap perkembangan motorik kasar anak usia 5-6 tahun. *Jurnal Pendidikan Anak, 6*(2), 68–76. http://dx.doi.org/10.23960/jpa.v6n2.22261

Lourenço, C. C. V., Melo, G. L. R., & Boato, E. M. (2021). Balance assessment in children with Down syndrome who practice dance. *Annals of Applied Sport Science, 9*(4), 1–9. https://doi.org/10.52547/aassjournal.977

Malak, R., Kotwicka, M., Krawczyk-Wasielewska, A., Mojs, E., Samborski, W. (2013). Motor skills, cognitive development and balance functions of children with Down syndrome. *Annals of Agricultural and Environmental Medicine, 20*(4), 803–806. Retrieved from https://pubmed.ncbi.nlm.nih.gov/24364457/

Malak, R., Kostiukow, A., Krawczyk-Wasielewska, A., Mojs, E., & Samborski, W. (2015). Delays in motor development in children with Down syndrome. *Medical Science Monitor, 21*, 1904–1910. https://doi.org/10.12659/MSM.893377

Manso, A., Ganança, M. M., & Caovilla, H. H. (2016). Vestibular rehabilitation with visual stimuli in peripheral vestibular disorders. *Brazilian Journal of Otorhinolaryngology, 82*(2), 232–241. https://doi.org/10.1016/j.bjorl.2015.05.019

Martseeda, P., Srisuruk, P., Aonsri, C., Jumpanon, P., Chaiudomsom, K., & Paholpak, S. (2021). Effects of playing snake ladder game in family to increase

gross motor skills in kindergarten children with autism spectrum disorder: 3 case reports. *Journal of the Psychiatric Association of Thailand, 66*(3), 323–336. Retrieved from https://he01.tci-thaijo.org/index.php/JPAT/article/view/252103

Mawase, F., Lopez, D., Celnik, P. A., Haith, A. M. (2018). Movement repetition facilitates response preparation. *Cell Reports, 24*, 801–808. https://doi.org/10.1016/j.celrep.2018.06.097

Mocanu, G. D., Murariu, G., & Potop, V. (2020). Optimization of body balance indices according to body mass index categories during physical education lessons for university students. *Pedagogy of Physical Culture and Sports, 26*(4), 233–243. https://doi.org/10.15561/26649837.2022.0403

Oktarifaldi., Putri, L. P., Amra, F., Syahputra, R., & Bakhtiar, S. (2020). The effect of coordination and balance toward elementary students' locomotor ability age 7 to 10 in lima puluh kota regency. *International Journal of Research and Innovation in Social Science (IJRISS), 4*(2), 82–86. Retrieved from https://www.rsisinternational.org/journals/ijriss/Digital-Library/volume-4-issue-2/82-86.pdf

Pal, S., Yadav, J., Sindhu, B., & Kalra, S. (2021). Effect of plyometrics and pilates training on dynamic balance and core strength of karate players. *Journal of Clinical and Diagnostic Research, 15*(1), 5–10. https://doi.org/10.7860/JCDR/2021/47171.14473

Padmanabhan, S. B. R., & Anju, R. P. P. (2020). Relationship between dynamic balance and fine motor performance with core endurance in school children. *International Journal of Science and Healthcare Research, 5*(4), 285–291. Retrieved from https://ijshr.com/IJSHR_Vol.5_Issue.4_Oct2020/IJSHR0037.pdf

Paramesthi, R., Soegiyanto., & Pramono, H. (2022). The effect of modifications of challenge board games and traditional Engklek games on the movement of locomotors in mild children. *JUARA: Jurnal Olahraga, 7*(3), 733–740. https://doi.org/10.33222/juara.v7i2.2418

Rachman, H. A., & Anggita, G. M. (2018). The development pattern of early age children's motor skills. *Journal of Physical Education, Sport, Health and Recreation, 7*(2), 104–112. https://doi.org/10.15294/active.v7i2.23652

Ramírez-Campillo, R., Gallardo, F., Henriquez-Olguín, C., Meylan, C. M., Martínez, C., Álvarez, C., et al. (2015). Effect of vertical, horizontal, and combined plyometric training on explosive, balance, and endurance performance of young soccer players. *Journal of Strength and Conditioning Research, 29*(7), 1784–1795. https://doi.org/10.1519/JSC.0000000000000827

Reyes-Ferrada, W., Plaza, P., Jerez-Mayorga, D., Chirosa-Rios, L., & Peñailillo, L. (2021). Effects of slackline training on core endurance and dynamic balance (Efectos del entrenamiento en slackline sobre la resistencia del core y el equilibrio dinámico). *Retos, 41*, 756–763. https://doi.org/10.47197/retos.v41i0.86262

Riskesdas Kementerian Kesehatan RI. (2018). *Key results of basic health research, 44*(8). Retrieved from https://kesmas.kemkes.go.id/assets/upload/dir519d41d8cd98f00/files/Hasil-riskesdas-2018_1274.pdf

Sahudi, U., Priyono, A., Saputra, Y. M. (2021). Effects of ular tangga games on the development of locomotor skills in elementary school. *International Journal of Human Movement and Sports Sciences, 9*(4A), 119–124. https://doi.org/10.13189/saj.2021.091320

Sannicandro, I. (2017). Effects of a core stability program on strength and balance skills in senior over 65. *International Journal of Science and Research (IJSR), 6*(8), 939–943. https://doi.org/10.21275/ART20176091

Schoenfeld, B. J., Grgic, J., Van Every, D. W., & Plotkin, D. L. (2021). Loading recommendations for muscle strength, hypertrophy, and local endurance: A re-examination of the repetition continuum. *Sports, 9*(2), 1–25. https://doi.org/10.3390/sports9020032

Schott, N., Holfelder, B., & Mousouli, O. (2014). Motor skill assessment in children with Down syndrome: Relationship between performance-based and teacher-report measures. *Research in Developmental Disabilities, 35*(12), 3299–3312. https://doi.org/10.1016/j.ridd.2014.08.001

Sholikan, K. F. A., & Sudijandoko, A. (2019). Pengaruh olahraga tradisional sunda manda (Engklek) terhadap motorik kasar gerak lokomotor melompat pada anak difabel (tunagrahita ringan) SLB siswa Budhi Surabaya. *Jurnal Kesehatan Olahraga, 7*(2), 219–224. Retrieved from https://ejournal.unesa.ac.id/index.php/jurnal-kesehatan-olahraga/article/view/28000

Simahate, S., & Munip, A. (2020). Latihan gerak loko-

motor sebagai upaya mengembangkan motorik kasar anak Down syndrome. *ThufuLA: Jurnal Inovasi Pendidikan Guru Raudhatul Athfal, 8*(2), 236–248. https://doi.org/10.21043/thufula.v8i2.7656

Singh, D. K. A., Rahman, N. N. A. A. A., Rajikan, R., Zainudin, A., Nordin, N. A. M., Karim, Z. A., & Y, Y. H. (2015). Balance and motor skills among preschool children aged 3 to 4 years old. *Malaysian Journal of Medicine and Health Sciences, 11*(1), 63–68. Retrieved from https://medic.upm.edu.my/upload/dokumen/FKUSK1_Article_7.pdf

Singh, V., Bhutia, T. N., Singh, M. K., & Krishna, N. R. (2022). Effect of vinyasa training on dynamic body balance of male national level yoga players. *Physical Education Theory and Methodology, 22*(1), 43–47. https://doi.org/10.17309/tmfv.2022.1.06

Sutapa, P., Pratama, K. W., Rosly, M. M., Ali, S. K. S., & Karakauki, M. (2021). Improving motor skills in early childhood through goal-oriented play activity. *Children, 8*(994), 1–11. https://doi.org/10.3390/children8110994

Symeonidou, E. R., & Ferris, D. P. (2022). Intermittent visual occlusions increase balance training effectiveness. *Frontiers in Human Neuroscience, 16*, 1–6. https://doi.org/10.3389/fnhum.2022.748930

Thomas, E., Bianco, A., Raia, T., Messina, G., Tabacchi, G., Bellafiore, M., Paoli, A., & Palma, A. (2018). Relationship between velocity and muscular endurance of the upper body. *Human Movement Science, 60*, 175–182. https://doi.org/10.1016/j.humov.2018.06.008

Tun, M. T., Aye, T., & Khin, M. T. (2021). Inter-rater reliability of the test of gross motor development second edition (TGMD-2) for children with Down syndrome: A pilot study. *The Journal of Asian Rehabilitation Science, 4*(3), 39–46.

Utomo., & Ismail, M. (2019). *Permainan tradisional media stimulasi & intervensi AUDBK (anak usia dini berkebutuhan khusus)*. Kota Banjarbaru: PJ JPOK FKIP ULM Press. Retrieved from http://eprints.ulm.ac.id/6530/

Van Abswoude, F., Santos-Vieira, B., van der Kamp, J., & Steenbergen, B. (2015). The influence of errors during practice on motor learning in young individuals with cerebral palsy. *Research in Developmental Disabilities, 45–46*, 353–364. https://doi.org/10.1016/j.ridd.2015.08.008

Yanovich, E., & Bar-Shalom, S. (2022). Static and dynamic balance indices among kindergarten children: A short-term intervention program during covid-19 lockdowns. *Children, 9*(939), 1–10. https://doi.org/10.3390/children9070939

Yılmaz, N. (2022). Investigation of the effect of isometric core strength training in addition to basic basketball trainings on explosive power in children aged 9-17. *Pedagogy of Physical Culture and Sports, 26*(2), 4–11. https://doi.org/10.15561/26649837.2022.0201

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