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THE RELATIONSHIP OF DYNAMIC BODY BALANCE WITH LOCOMOTOR ABILITY AND ENDURANCE OF CORE MUSCLES IN CHILDREN WITH DOWN SYNDROME

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Authors' contribution:

A. Study design/planning
B. Data collection/entry
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Abstract:

Background: The scarcity of research results related to the relationship of dynamic body balance with locomotor ability and core muscle endurance makes it difficult to compile a physical exercise program for children with Down syndrome, even though the preparation of the form and duration of exercises that adjust the level of dynamic body balance will minimize the occurrence of more severe injuries and musculoskeletal problems. This study aims to find out, prove, and examine the relationship between dynamic body balance and locomotor ability, and core muscle endurance in children with Down syndrome.

Material and Methods: This study included 30 children with Down syndrome who were chosen using a purposive sampling technique. All samples followed the research procedure by measuring dynamic body balance using a functional reach test, assessing locomotor ability with a test of gross motor development (2nd edition), and measuring core muscle endurance using a plank test. The statistical analysis technique uses the Pearson correlation test at a significance level of $\alpha = 0.05$, which is carried out in SPSS software version 22.

Results: There is a significant positive relationship between dynamic body balance and locomotor ability with a significance value of 0.000 (Sig. < 0.05) and a positive Pearson correlation value of 0.821. In addition, there was a positive significant relationship between dynamic body balance and the endurance of the core muscles of the children with Down syndrome at a significance level set at 0.000 (Sig. < 0.05) and a positive Pearson correlation of 0.710.

Conclusions: The dynamic body balance of children with Down syndrome is significantly positively related to locomotor abilities at a perfect level and the endurance of the core muscles at a strong level.

Introduction

Posture is a dynamic action as a strategy for maintaining an upright body position against the force of gravity, with a spatial system of segments as its outer manifestation [1]. Body balance is the ability to react to any changes in postural position that keep the body stable and under control. The right balance will maximize a person's ability to perform activities and movements efficiently with minimal risk of falling [2]. Body balance is a very influential fac-

tor in the realization of motor abilities [3]. Efforts to achieve body balance rely on the combined performance of the somatosensory system and motor system coordinated by the brain to create postural reactions. Information from the vestibular receptors, visual system, and somatosensory system will be sent to the central nervous system, which plays a role in activating the musculoskeletal system [4].

Dynamic body balance is associated with the ability to perform basic movements because it balances the body dynamically as an initial ability or foundation to achieve physical development [5]. Dynamic body balance plays an important role in completing daily tasks, even as an important element to produce more complex movements and improve sports performance [6]. In everyday life, children with Down syndrome must perform locomotor movements to complete their tasks, such as walking up stairs, hopping or jumping to pick up items that are higher than their reach, running while exercising, and others.

Children with Down syndrome experience dynamic body balance problems that cause difficulties meeting the need for movement to complete various daily tasks. Motor and cognitive disorders are the causes of body balance problems in children with Down syndrome. Motor disorders that are usually experienced by children with Down syndrome include muscle hypotonia, weakness of ligaments, weak muscles, inadequate muscle contraction, inadequate postural control when moving, and dysfunction of proprioceptive components [7, 8]. On the other hand, children with Down syndrome experience cognitive impairment in the form of not maximal integration processes in the nervous system, decision-making that takes longer, not the maximal ability to integrate multi-sensory information, and simple reaction times that occur more slowly [9].

The ability to balance the body dynamically is a foundation for achieving various motion abilities, ranging from very simple to very complex movements [10], but there is a scarcity of published research related to the relationship of dynamic body balance problems with the locomotor ability of children with Down syndrome so that the direction and degree of the relationship between dynamic body balance and locomotor ability are unknown. Knowing the level of dynamic body balance will make it easier for teachers, trainers, therapists, or parents to choose and compile an exercise or therapy program that is suitable for children with Down syndrome based on the level of body balance. It is very important to choose a form of training based on the level of body balance in children with Down syndrome because if the wrong form of exercise or therapy is chosen, it will have an impact on the emergence of even greater problems in the joint and muscle areas of the child, especially in the core part of the body.

The core parts of the body (muscles and joints) play a role in achieving body balance [11, 12]. However, it is not yet known how much of a role they play in helping children with Down syndrome achieve dynamic body balance because the core parts of the body are not the only components that contribute to achieving dynamic body balance, and because of the scarcity of research evaluating the relationship between dynamic body balance and the performance of the core muscles of the body in children with Down syndrome. Research related to the relationship between body balance and the strength or endurance of core muscles shows different results. A weak positive significant correlation between core muscle strength and dynamic equilibrium was shown in health staff in hospitals [13]. There is a moderately negative significant association between dynamic balance and muscle static and dynamic endurance in individuals with chronic low back pain [14]. There was no significant correlation between core strength and stability with dynamic equilibrium in young adult individuals [15].

Weak core parts of the body are believed to cause changes in energy transfer that result in decreased sports performance and an increased risk of injury to weak or poorly developed muscle groups [16]. Knowing the relationship between dynamic body balance and the endurance of the core muscles of children with Down syndrome is important because the ability to balance the body dynamically will be useful to avoid premature fatigue during activities with a long duration. Better muscular endurance of the core parts of the body will contribute to performance and technical development and allow athletes to perform technical movements with less effort to prevent the athlete from experiencing early fatigue when participating in long competitions [17]. Premature fatigue that occurs in the extensor part of the body will affect the ability to balance the body through increased postural tremor [18]. The longer the duration of the exercise of a child with Down syndrome during physical training, the longer the postural tremor will occur. Therefore, the duration of training must be adjusted to the dynamic body balance of the child with Down syndrome to avoid problems that can occur as a result of the prolonged postural tremor.

It is important to know, prove, and study the relationship of dynamic body balance with the locomotor ability and core muscle endurance of children with Down syndrome because it will be useful to determine the shape and duration of exercise to minimize the occurrence of injuries or more severe joint and muscle problems. Therefore, this study aims to find out, prove, and examine the relationship of dynamic body balance with locomotor abilities (running, hopping, jumping) and the relationship of dynamic body balance with the endurance of the core muscles

in children with Down syndrome. Based on the objectives of the study, the hypothesis was proposed that there is a positive relationship between dynamic body balance and locomotor ability and core muscle endurance in children with Down syndrome.

Material and Methods

This study used a sample of 30 children with Down syndrome whose parents were members of the Pusat Informasi dan Komunikasi (PIK) Persatuan Orang Tua Anak Down Syndrome (POTADS) of the Yogyakarta Special Region selected using purposive sampling techniques based on the following inclusion criteria: children with Down syndrome, aged 8 to 13 years, able to hear and understand the instructions given, and able to stand and walk independently. Furthermore, in the selection of the study sample, the following exclusion criteria were used: not undergoing routine treatment or therapy, not experiencing heart problems, not experiencing atlanto-occipital or spinal stability disorders, and not experiencing joint dislocation in the limbs. Dynamic body balance measurements, locomotor ability assessment (running, hopping, jumping), and core muscle endurance measurements were performed for all study samples.

Dynamic body balance data were collected using functional reach test instruments that had within-session reliability of ICC = 0.98, interrater reliability values of ICC = 0.99, test-retest reliability values of ICC = 0.95, and validity values (ρ) of BBS = 0.7 [19]. Data on the ability to run, hop, and jump were measured using a test of gross motor development (2nd edition, TGMD-2) with specific intra-class correlation coefficients for Run (ICC = 0.68), Hop (ICC = 0.96), and Jump (ICC = 0.90), while the raw score of intra-class locomotor correlation coefficients was 0.94 [20]. The plank test is used to measure the endurance of core muscles and it is a feasible, valid, and reliable tool for the assessment of the endurance of torso muscles in children. Interrater (ICC = 0.62), intrarater (ICC = 0.83), and test-retest (ICC = 0.63) reliability is acceptable for plank [21].

Data on dynamic body balance, locomotor ability, and core muscle endurance were collected from each sample, and then statistical analysis was carried out. The first step of the analysis is to verify the normality of the data using Z-score data. If the data is normally distributed, statistical analysis is carried out using Pearson correlation test at the significance level of $\alpha = 0.05$ in SPSS software version 22.

Results

Data from dynamic body balance measurements, locomotor ability assessment, and core muscle endurance measurement can be considered normally distributed if the significance level is greater than 0.05 (Sig > 0.05). The results of the Z-score data normality test for dynamic body balance, locomotor ability, and core muscle endurance are shown in Table 1.

Table 1. Data Normality Test Results

	Data Shapiro-Wilk			
	Statistic	Df	Sig.	Information
Z-score: Dynamic Body Balance	0.975	30	0.695	Normal
Z-score: Locomotor Abilities	0.965	30	0.412	Normal
Z-score: Core Muscle Endurance	0.952	30	0.191	Normal

Table 1 shows a significance value of 0.695 for the dynamic body balance Z-score, 0.412 for the locomotor ability Z-score, and 0.191 for the core muscle endurance Z-score. The three data have a significance level greater than 0.05 (Sig. > 0.05) so it can be said that the three data are normally distributed. The results of the Pearson correlation test between dynamic body balance and locomotor ability data can be seen in Table 2 and Pearson correlation test results between dynamic body balance and core muscle endurance data can be seen in Table 3.

The Pearson correlation test results presented in Table 2 show a significance level of 0.000, which means it is smaller than 0.05 (Sig. < 0.05), so it can be concluded that there is a relationship between dynamic body balance and locomotor ability. Furthermore, the results of the Pearson correlation test also show a positive Pearson correlation of 0.821 so it can be interpreted that the relationship between dynamic body balance and locomotor ability is in a positive direction with a perfect degree or degree of relationship.

Table 2. The Relationship of Dynamic Body Balance with Locomotor Ability

		Z-score: Dynamic Body Balance	Z-score: Locomotor Abilities
Z-score: Dynamic Body Balance	Pearson Correlation	1	0.821
	Sig. (2-tailed)		0.000
	N	30	30
Z-score: Locomotor Abilities	Pearson Correlation	0.821	1
	Sig. (2-tailed)	0.000	
	N	30	30

Table 3. The Relationship of Dynamic Body Balance with Core Muscle Endurance

		Z-score: Dynamic Body Balance	Z-score: Core Muscle Endurance
Z-score: Dynamic Body Balance	Pearson Correlation	1	0.710
	Sig. (2-tailed)		0.000
	N	30	30
Z-score: Core Muscle Endurance	Pearson Correlation	0.710	1
	Sig. (2-tailed)	0.000	
	N	30	30

Table 3 shows a significance level of the relationship of dynamic body balance with core muscle endurance of 0.000, which can be interpreted as smaller than 0.05 (Sig. $<$ 0.05) so it can be concluded that there is a relationship between dynamic body balance and the endurance of the core muscles in children with Down syndrome. The Pearson correlation test results presented in Table 3 also show a positive Pearson correlation of 0.710 so it can be said that the dynamic body balance and endurance of the core muscles are positively related to a strong degree.

Discussion

The Relationship of Dynamic Body Balance with Locomotor Ability

The purpose of this study is to find out, prove, and examine the relationship of dynamic body balance with the locomotor ability of children with Down syndrome. Statistical analysis shows there is a significantly positive relationship with a perfect degree between dynamic body balance and the locomotor ability of children with Down syndrome, which means that the hypothesis is supported. It provides knowledge that the better the dynamic body balance of a child with Down syndrome, the better his or her locomotor abilities (running, hopping, and jumping). In line with the results of this study, Malak et al., 2013; Capio et al., 2017 [22,23] also proved a significant positive relationship between body balance and locomotor skills of children with Down syndrome. A positively significant relationship between dynamic body balance and gross motor development was also shown in children aged 3 to 6 years [24]. Furthermore, a positive relationship between body balance and locomotor skills was also found in children with CHARGE syndrome [25].

Motion activities such as running, hopping, and jumping require good body balance. Poor balance of the body leads to a large postural sway. Studies show that the worse the ability to balance the body, the greater the postural sway experienced by children with intellectual disabilities [26]. In dynamic conditions, postural performance relies on the ability to maintain body balance in altered postural conditions (pedal support displacement and support base displacement), and at times, in external mechanical changes, postural performance helps avoid falling [27]. When a person performs movements such as running, hopping, and jumping in an uneven environment or on an uneven surface, the components (visual and vestibular) that are responsible for maintaining dynamic body balance will actively send information to the brain and then the feedback will be sent by the brain to the muscles and the proprioceptive system to produce postural control.

The success of the performance of body movements depends on the quality of postural control that serves to establish and maintain the proper postural orientation of the body segments relative to each other and to the environment, and to ensure the dynamic stability of the moving body [28]. Maintaining and controlling body balance is necessary to prevent falls [29,30]. The better the dynamic body balance, the smaller the postural sway that occurs when doing dynamic activities, and it is easier to achieve better locomotor abilities. It was shown that dynamic body balance affects the level of development of locomotor abilities in children aged 5 to 6 years [31].

Body balance is part of the components of locomotor performance, which is one of the special (psychomotor) coordination abilities that shows readiness to control and regulate motor actions optimally [32]. Dynamic balance is necessary for activities of daily living, such as walking, running, and climbing stairs [33]. It promotes the improvement of dynamic proprioceptive body balance abilities and provides more opportunities to practice as an important task to be performed by children who are in the golden age for developing locomotor skills [24]. If the exercise program is expected to focus on improving locomotor ability, it must prioritize body balance exercises in the training process [34,10]. To develop various locomotor abilities, children with Down syndrome who are in the golden age should be given a variety of physical activities that will improve their dynamic body balance performance so that the body will respond and adapt to produce locomotor abilities which will ultimately help the child with Down syndrome avoid a period of delay in acquiring locomotor abilities compared to children without disabilities.

The Relationship of Dynamic Body Balance with Core Muscle Endurance

This study also aims to find out, prove, and examine the relationship of dynamic body balance with the endurance of the core muscles of children with Down syndrome. Statistical analysis revealed that the hypothesis was supported, as the results of the study showed a significant relationship in a positive direction with a strong degree between dynamic body balance and the muscular endurance of the core muscles of children with Down syndrome. The results of this study provide knowledge that the better the dynamic body balance of children with Down syndrome, the more developed endurance of the core muscles. Similar to the results of the present study, a significant relationship between dynamic body balance and high core muscle endurance was also found in professional basketball players [35,16]. Furthermore, a weak to moderate relationship was found between core endurance and dynamic body balance in men and women with knee osteoarthritis aged more than 40 years.

The endurance of the core muscles plays a very important role in producing efficient movements [36]. There is a significant relationship between core muscle endurance and dynamic balance [37]. A dynamic balance control system creates, transfers, and maintains the strength of distal kinetic chain segments specifically through core stability [38]. Core muscles are consistently activated before any limb movement [39]. The muscles of the core part of the body will contract before body movement occurs during activities to maintain and control the balance of the body during movement.

The core muscles transfer forces between the upper and lower extremities of the postural control system that are necessary to maintain or move the center of mass over the base of support and thus maintain balance [40]. Increased balance can decrease the number of muscles involved in stabilization, allowing more muscles to contribute to generating forces needed for certain movements [16]. The core of the body is very important in ensuring local strength and balance as the center of almost all kinetic chains when on the move [41]. Core muscle activity precedes the integrated work of one or many joints to maintain stability and movement [2].

Physical activity requires great body dynamic stability [42]. The constantly contracting core muscles perform their functions in coordination with other musculoskeletal components during prolonged physical exercise, leading to fatigue due to energy reduced by the continuous core muscle contractions in children with Down syndrome who experience body balance problems. The weak muscles of the core part of the body used to control the dynamic balance of the body have an impact on the onset of early fatigue during physical activities because it requires the core muscles to work hard in transferring forces between the upper and lower body.

Research Contributions and Limitations

The results of this study can be a guide for adaptive physical education teachers, therapists, trainers, and parents in compiling physical training programs based on the level of dynamic body balance of children with Down syndrome to maximize physical training outcomes and avoid the occurrence of injuries or severe musculoskeletal problems. This study has limitations, such as assessing only the ability to run, hop, and jump as the locomotor abilities of children with Down syndrome. Therefore, it is hoped that future research will also assess the ability to sprint, leap, slide, and object control as locomotor skills of children with Down syndrome linked to dynamic body balance.

Conclusions

Dynamic body balance is significantly positively related to perfect degrees with the locomotor abilities of children with Down syndrome, whereas significant dynamic body balance is also positively related to strong degrees with the endurance of their core muscles. In children with Down syndrome, the forms and duration of physical exercise should be adjusted to the level of dynamic body balance of the child.

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Informed consent statement: Informed consent was obtained from all subjects involved in the study. In addition, all parents and legal guardians gave written consent to participate in the study.

Data Availability Statement: All data are presented in the study.

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