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Evaluation of Gravitational Insecurity in School-Age Children Diagnosed with Learning Disorder

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Abstract
Aim: This study was conducted to determine the incidence of Gravitational Insecurity in individuals with Specific Learning Disorder.

Material and Methods: We included 99 children, 65 boys and 34 girls, diagnosed with Specific Learning Disorder in our study. All children participating in the study were attending a special education and rehabilitation center. Physically independent individuals without any orthopedic or neurological diagnosis other than Specific Learning Disorder were included in the study. 99 children were evaluated with the Gravitational Insecurity Assessment and the data obtained were statistically analyzed.

Results: Gravitational Insecurity is commonly seen in individuals diagnosed with Specific Learning Disorder. In individuals diagnosed with Specific Learning Disorder, the severity and incidence of Gravitational Insecurity increase with age, there is no significant difference between genders, and these individuals react to different movement patterns at different levels. In individuals diagnosed with Specific Learning Disorder with Gravitational Insecurity, postural symptoms of Gravity Insecurity are observed at higher rates than emotional symptoms. The incidence of both postural and emotional symptoms increases with age.

Keywords: Gravitational Insecurity, Learning Disorders, Sensory Integration, Neuroscience, School-age, Sensory Integration Disorder

Correctly receiving and processing sensory stimuli is fundamental for learning to take place correctly, and what is required for this is rich sensory experiences. Learning is a natural process; it starts with birth and continues throughout life, but some individuals experience problems in the learning process, these problems are called Specific Learning Disorders (Specific Learning Disabilities) (Karaca et al. 2019). Many studies have revealed that individuals with learning disorders experience vestibular system-based problems. Gravitational insecurity, a sensory integration dysfunction described by Ayres in 1972, is frequently seen in individuals with learning disorders and makes their lives complicated.

Specific Learning Disorder
Individuals with a Specific Learning Disorder (SLD) have normal or above-normal intelligence. Depending on their age and education, they are below normal in literacy skills and learning mathematics. Many problems such as difficulty in remembering events and names, forgetting learned facts and information quickly, balance disorder, difficulty in playing games that require balance coordination such as jumping rope and hopscotch, difficulty in using hands and fingers can also be seen. (Karaca et al. 2019).

The first known studies on Specific Learning Disorder were carried out in the medical field. In 1877, neurologist Adolf Kussmaul described word blindness in an adult patient. In an article published in 1896, British ophthalmologist W. Pringle Morgan described a childhood learning disorder in a 14-year-old boy who was successful in playing games with his friends and in mathematics but had difficulties in reading and writing. He used the definition of congenital word blindness in this case, as the child's obvious problem was the confusion of letters and words. The first person to define SLD in the field of special education was Samuel Kirk in 1962. Kirk defined SLD as a neurologically based negative condition in which the intelligence level is normal, but difficulties in learning and social processes may affect the person's future life (Karaca et al. 2019). At the beginning of the 20th century, the first person to use the term 'Dyslexia', a subtype of SLD, was Adolf Berlin, an educationist. (Karaca et al. 2019). The first person to mention 'dyscalculia', another subtype of SLD, was Czechoslovakian researcher Ladislav Kosc in 1974. SLD was defined as 'minimal brain damage' and then 'minimal brain dysfunction' in the 20th century. (Demir, 2005). Specific Learning Disorder, defined under the heading Neurodevelopmental Disorders in DSM 5 (2013), is characterized by deficiencies in an individual's ability to correctly perceive or process information; persistent and disruptive difficulties with basic skills in reading, writing, and math.

According to DSM 5 (2013), the incidence of SLD is between 5-15% in school-aged children. Although it is not known exactly, the incidence is thought to be 4% in adults. According to DSM 5 (2013), the incidence of SLD in boys is 1.5 times higher than in girls. According to a study conducted in 28 countries around the world, the highest incidence of SLD is in Venezuela with 33% and the lowest incidence is in Japan and China with 1%. In the United States, 5-15% of school-age children have Specific Learning Disorder (Harwell, 2008). Premature birth or low birth weight and prenatal exposure to nicotine increase the risk of SLD. People with a first-degree relative with SLD have a much higher risk of developing SLD. 23-65% of children with a dyslexic parent have dyslexia. The incidence of dyslexia in the sibling of an individual with dyslexia is 40% (Shaywitz & Shaywitz, 2005).

Specific Learning Disorder Subtypes and Differences in Neural Structure and Functioning

Dyslexia: Dyslexia is a type of Specific Learning Disorder characterized by problems with word reading accuracy, reading speed or fluency in reading, reading comprehension, recognizing words correctly, poor decoding and poor writing skills. In various neuroimaging studies, it has been shown that the right planum temporale is wider than normal in dyslexic children (Kushch et al., 1993). In neuroimaging studies, it was found that these individuals had low activation in the left temporoparietal and frontal regions, and the right brain language region was larger than the left brain language region, while it should normally be the opposite, additionally low activation was detected in the connection between the temporal and occipital regions in the left hemisphere. The incidence of left hand dominance is also high in dyslexic individuals (Tanrıdağ, 2018).

Dyscalculia: Dyscalculia is a subtype of SLD characterized by difficulties in processing numerical information, learning arithmetic facts and making accurate and fluent calculations (DSM 5, 2013). Neuroimaging studies with children with dyscalculia have revealed that the gray matter volume in the left intraparietal sulcus region is lower than typically achieving children (Isaacs et al., 2001). In another study, it was found that the gray matter density was lower in the right intraparietal sulcus, the anterior sinulum, the left lower frontal gyrus and bilateral middle frontal gyrus regions in children with dyscalculia, and the white matter density was lower in some frontal and parahippocampal regions (Rotzer et al., 2008). In another study conducted in 2013, the increase in white matter volume with age was found to be much less especially in the left frontal cortex and in the lower parietal region where the angular and supramarginal gyrus are located, it was determined that white matter in the corpus callosum, which should be reduced by axonal pruning, also decreased less than in children with typical development. (Ranpura et al., 2013). Functional neuroimaging studies have generally revealed that frontal (superior and medial frontal gyri) – temporal – parietal (inferior parietal lobe and precuneus) connections are important for mathematical thinking and learning (Arsalidou et al., 2018).

Dysgraphia: Dysgraphia is difficulty in writing. Children with dysgraphia write without leaving any spaces between words, with distorted letters and shapes and without using the page properly. Some of them can complete the word by using mixed upper and lower case letters, while others can only write with capital letters.

There are two effective processes in writing, one is the cognitive processes related to writing and the other is the motor coordination required in writing. In an fMRI study conducted in 2013, hypoperfusion was detected in both the cerebellar hemispheres and the medial prefrontal left hemisphere in children with dysgraphia (Van Hoom et al., 2013).

Dyspraxia: The term 'apraxia' in adult neurology literature is used to describe an acquired brain damage that results in impaired ability to perform the learned skill in the absence of underlying motor, sensorimotor, or cognitive deficits. In the pediatric neurology literature, however, the term "apraxia" is somewhat confusing and often describes a less serious form of developmental disorder as ‘Dyspraxia’ (Miller et al., 2014). A study conducted in 2008 with children with dyspraxia found that left-handedness was more common. The result of this study was interpreted as cerebral lateralization may play some role in the development of motor coordination problems in individuals with dyspraxia (Cairney et al., 2008). In an EEG study conducted in 2013, it was found that children with dyspraxia exhibited less engagement of motor cortical brain areas after movement started (Pangelinan et al., 2013). In a 2011 fMRl study, it was shown that children with dyspraxia have insufficient activation in the cerebellar-parietal and cerebellar-prefrontal networks and in brain regions associated with visual-spatial learning (Zwicker et al., 2011).

Subtypes of SLD can be diagnosed alone, or two or three of them can be diagnosed together. The most common form is dyslexia, dyscalculia and dysgraphia seen together with a rate of 40%, followed by dyslexia and dysgraphia seen together with a rate of 25%, and subtypes seen individually with a rate of 5% (Karaca et al., 2019).

Sensory Integration Dysfunction

Sensory Integration Theory, originated by A. Jean Ayres, is a theory that accepts learning as a function of the brain and is shaped on the basis of this argument (Schaaf and Mailloux, 2019). Ayres not only presented the theory, but also defined, classified and evaluated sensory integration deficits, and developed the basic therapy materials and intervention program. Sensory integration; to obtain information about the individual's body, environment and the interaction between them, is the reception, processing and combination of sensory stimuli. As a result of sensory integration; the individual, together with the adequate organization against the external stimuli, creates the correct answers and adapts to the environment in which he lives (Ayres, 1972).

Gravitational Insecurity

Ayres (1979) defined excessive emotional reactions to change in head position as a subgroup of Sensory Integration Dysfunction and named it Gravitational Insecurity. Fear of falling, fear of changing head positions, inability to jump or not wanting to leave feet from the ground, unwillingness to roll over and lie on back are symptoms of Gravitational Insecurity (May – Benson and Koomar, 2007). These are children who dislike daily activities such as walking on uneven ground, climbing a ladder, climbing on objects, leaning back or getting into a car (Lee, 1987).

Ayres (1979) distinguished Gravitational Insecurity from intolerance to movement and postural instability. Intolerance to movement includes autonomic reactions such as dizziness, headache and nausea and occurs as a result of stimulation of the semicircular canals, postural instability is the inability to take different positions in activities that require physical strength and postural imbalance. Fear is the main component of gravitational insecurity.

Gravitational Insecurity is believed to be characterized by limbic system-based fear responses as a result of decreased vestibulocerebellar function and decreased vestibuloocular integration, resulting in excessive stimulation to sudden and confusing movements. (Ayres, 1979), (Fisher and Bundy, 1989). Ayres (1979) hypothesized that GI is a deficiency in the modulation of the perception of gravity that contributes to the fear of movement. Fisher and Bundy (1989) suggested that deficiencies in otolith functioning serve as the underlying mechanism of GI. Lee (1987) also cited poor depth perception, lack of visual input during motor tasks and difficulty integrating vestibular, visual and proprioceptive inputs as features of Gravitational Insecurity. It is thought that these sensory inputs, which help an individual to feel his position in space, are not reliably interpreted by the central nervous system (CNS) (May – Benson & Koomar, 2007). Potegal

(2015) stated that Gravitational Insecurity may result from neural integrator dysfunction related to velocity storage of vestibular inputs.

Even daily activities that cause a head position change, such as bending over and picking up an object from the ground, and turning the head in that direction when called, can contribute to this excessive stimulation (May – Benson & Koomar, 2007). Gravitational Insecurity reactions are more severe when the source of the action is unknown or when someone else is in control of the action (May – Benson & Koomar, 2007). This problem prevents children from participating in daily life activities such as going down stairs, exploring playgrounds, doing sports, cycling, and skating (Ayres, 2005). In adults, these problems restricts daily activities such as driving a car, getting on an airplane, climbing on chairs or stairs, taking an elevator or escalator (May - Benson, 2015). Adults with GI are alert about where and how they walk. Adult GI is associated with self-reported difficulty in motor planning and visual-spatial skills. Gravitational Insecurity is a disorder that affects the social and emotional development of children with sensory integration dysfunction (May-Benson et al., 2015). In addition, it has been found that individuals with GI have a higher sympathetic resting state (high cortisol level, high heart rate) than individuals without GI (Weisberg 1982, Koomar 1996, Gerard 1991). It has been determined that GI is related to motor skill performance and the more severe the GI, the less participation in brisk physical activities (May-Benson et al., 2020). Women and individuals over 65 years old have more severe GI and GI problems associated with driving a car, motor planning, anxiety and visual-spatial skills. (May-Benson, Faria and Teasdale, 2015).

The incidence of Gravitational Insecurity in children with sensory integration dysfunction is 15-21% (May – Benson et al., 2020). The incidence in adults is 19.1% as mild Gravitational Insecurity, and 2.2% as severe Gravitational Insecurity in general population (May – Benson et al., 2016).

Many studies in human and animal models; shows that the vestibular and cerebellar systems are not only effective on motor coordination, but are highly effective in both cognitive and emotional regulation. The fact that these systems contain intense connections with areas of emotional regulation and expression supports this idea. In addition, we can predict that anxiety and depression tendencies will increase in individuals as a result of vestibular and cerebellar dysfunctions (Hilber et al., 2019). Steinberg and Rendle–Short (1977) observed extreme fear responses during the nystagmus test in a group of children with hyponystagmus. Levinson (1988) stated that all adults with anxiety disorders exhibit vestibulocerebellar dysfunction, whereas more than half of the adults with vestibular dysfunction exhibit fears and phobias such as fear of heights, elevators, crowds, amusement parks, escalators and airplanes. Vestibular dysfunction is associated with anxiety (Coelho & Balaban 2014). Koomar (1996) conducted a study revealing that Gravitational Insecurity is associated with anxiety rather than behavioral inhibition and avoidance. Another study revealing its relationship with anxiety in adolescents and adults was conducted in 2015 (May - Benson, Faria, & Teasdale, 2015). In a study conducted in 2016 to determine the prevalence of Gravitational Insecurity in adults diagnosed with anxiety the incidence of mild Gravitational Insecurity was found to be 32.7%, and the incidence of severe Gravitational Insecurity was found to be 4.7% (May-Benson et al, 2016). As a result of a survey conducted with 109 occupational therapists in 2018, it was found that 0-5% of the pediatric occupational therapy population had Gravitational Insecurity (Potegal et al., 2018).

The most common GI comorbidities are developmental coordination disorder and anxiety. A study on the relationship of Gravitational Insecurity and postrotary nystagmus with central vestibular function was initiated by May-Benson and Potegal in 2018, and the researchers continue their studies (Potegal and May - Benson, 2018).

Activities that created fear-inducing conditions in Gravitational Insecurity include the following movements; Movement on an unstable surface, unexpected of quick movement which given another person, change of head position, change of head position with feet leaved off a stable surface, static position or movement on a high surface, disorienting to lack of visual input. (May – Benson and Koomar, 2007).

Literature

There are many studies in the literature that learning disorders may originate from the vestibular system. Frank and Levinson defined dysmetric dyslexia as a subtype of Specific Learning Disorder in 1975 and conducted a study on the cerebellar-vestibular origin of dysmetric dyslexia and dyspraxia. The same researchers recommended various eye exercises (Levinson and Frank, 1975) and medical therapy (Frank and Levinson, 1977), (Frank and Levinson, 1976), (Levinson and Frank, 1977) for the treatment of dysmetric dyslexia and dyspraxia. In the study published by Quirds in 1976, which lasted between 1958 and 1967, and in which a total of 1902 children were examined, including the evaluation of vestibular-proprioceptive mechanisms; children with vestibular disorders and related postural disorders, have been identified for the majority of learning disabilities. (Quirds, 1976). In 1978, Dr. Jean Ayres published a study on the relationship between learning disorders and the vestibular system with 128 children aged 6 to 10 years. As a result of this study, it was concluded that vestibular disorder can prevent academic success and Sensory Integration Therapy can increase academic success (Ayres, 1978). In 1979, two researchers, Pirozzolo and Rayner, suggested that it is the spatial mechanisms guide the eye , rather than the oculomotor mechanisms in developmental dyslexia (Pirozzolo and Rayner, 1979). In a study conducted with kindergarten students in Texas in 1980, activities involving intense vestibular stimuli such as turning, rolling, somersaulting, crawling and jumping on the trampoline were performed for 20 minutes a day for 5 months. At the and of season children have completed their kindergarten education with much higher reading preparation scores than expected (Palmer, 1980). In a study carried out with 113 children aged 4 years in 1983, it was suggested that preterm children are prone to learning disorders in pre-school and school periods and this is related to vestibular system problems (Stevens, 1983). A 1989 study of 30 schoolboys aged 7 to 12 with learning, reading, and attention problems compared the effects of vestibular stimulation and aerobic exercise. As a result, significant changes were recorded only in children included in the vestibular program (Byl et al., 1989).

In 1991, a study was conducted between 52 children with dyslexia with a mean age of 10.5 years and 41 children with typical development as a control group with a mean age of 10 years, to examine the place of vestibular and oculomotor pathology in developmental dyslexia. Participants were first subjected to text-reading and non-verbal testing, and then verbally tested and eye movements were examined. Abnormal eye movements were observed at a rate of 90% in the verbal test in dyslexic individuals, while the abnormality rate in the nonverbal test was found to be 61%. Normal responses were found in only 44% of caloric tests (Jerabek and Krejcova, 1991). In a study carried out in 1996 with 28 adults aged between 23 and 50 with severe learning disorders, individuals with sensory integration dysfunctions, including Gravitational Insecurity, were treated with therapy and significant changes were noted (Soper and Thorley, 1996). Between 2004 and 2006, 88 children aged between 7 and 12 were subjected to Ear - Nose -Throat examination, hearing tests and vestibular examination. 49% of the participants were underperforming in school. Unilateral and bilateral irritative peripheral vestibular changes were detected in 67.4% of the underperformers and in 26.7% of the children who did not have difficulty in school. (Franco and Panhoca, 2008).

In 2012, the relationship between self-motion perception and number processing was examined, and as a result of this study, researchers found that leftward self-motion causes transitions in spatial attention and therefore facilitates the processing of small numbers, while self-motion to the right facilitates the processing of large numbers (Hartmann et al., 2012). In 2016, the incidence of Gravitational Insecurity was found to be 12.3% in children with sensory integration dysfunction, while it was 21.4% in individuals diagnosed with Autism Spectrum Disorder (May – Benson et al., 2016). In a study published in 2020; 689 children aged 4 to 12 with a diagnosis of Learning Disorder, autism, ADHD and anxiety, Gravitational Insecurity was found to be 15-21%. The distribution between age, gender or diagnoses was not significantly different (May - Benson, 2020).

Hypothesis

Gravitational Insecurity is commonly seen in individuals diagnosed with Specific Learning Disorder. With this study, it is aimed to bring a different perspective to the problems experienced by individuals with SLD in the processing of vestibular stimuli and to guide future studies in this field.

Method

We included 99 children, 65 boys and 34 girls, diagnosed with Specific Learning Disorder in our study. All children participating in the study were attending a special education and rehabilitation center. Physically independent individuals without any orthopedic or neurological diagnosis other than Specific Learning Disorder were included in the study. 99 children were evaluated with the Gravitational Insecurity Assessment and the data obtained were statistically analyzed. Gravitational Insecurity (GI) Assessment (revised version) is an observational and individually administered scale developed by Koomar and May Benson in 2007. The administration time is approximately 10 minutes. Revised GI Assessment has a three-point scoring system with two behavioral categories. The behavioral categories include Emotional response and Postural response.
Assessment consists of six items: stand on the chair, jump off the chair (eyes closed), backward somersault, tilt board step, supine on ball (active), supine on ball (passive).

Results and Discussion

1. Prevalence of Gravitational Insecurity in Children with Specific Learning Disorder

Table 1 contains descriptive information about the sociodemographic variables of the participants. It was determined that 65.7% (n=65) of the participants were male and 34.3% (n=34) were female. When Gravitational Insecurity was analyzed according to the assessment scores of the participants, it was found that 76.8% (n=76) of the participants had Gravitational Insecurity while 23.2% (n=23) did not have.

Table1. *Sociodemographic variables of the participants* **(N=99)**

Demographic variables	**n**	**%**
Gender		
Male	65	65,7
Female	34	34,3
Total	**99**	**100,0**
Assessment Group		
Do Not Have Gravitational Insecurity	23	23,2
Have Gravitational Insecurity	76	76,8
Total	**99**	**100,0**

2. The Status of Participant Responses by Mean Values of Emotional-Postural Responses and Total Scores of GI Assessment

In Table 2, minimum, maximum, mean and standard deviation values of age, emotional response, postural response and total scores are given. 44.4% of the participants scored below the emotional category response average. 54.5% of the participants scored below the postural category response average. 47.5% of the participants scored below the total mean value of the assessment.

Table 2: *Descriptive Statistics of the GI Assessment Total Score and Subcategories*

Variables		Min.	Max.	Mean	SD
Age	9	7,00	17,00	11,31	2,41
Emotional Response	9	8,00	18,00	14,67	2,66
Postural Response	9	8,00	18,00	14,08	2,67
Total Score	9	16,00	36,00	28,75	5,219

3. The Relationship Between Gravitational Insecurity Severity and Prevalence with Age in Children with Specific Learning Disorder

In table 3, the relationship between the total and subcategory scores of the assessment applied to the participants and age is given using the Spearman Correlation Analysis. A statistically significant weak negative correlation was found between age and total score (r = - 0.295, p = 0.003). A significant weak negative correlation was found between age and total score (r = - 0.295, p = 0.003), a significant weak negative correlation was found between age and emotional response (r = - 0.243, p = 0.015) and a significant weak negative correlation was found between age and postural response (r = - 0.317, p = 0.001). This indicates that the incidence of GI increases with age.

Table 3: *Correlation Results of GI Assessment Total Score and Subcategories*

Q		1	2	3	4
Age	r	1			
	p				
Total Score	r	-,295**	1		
	p	**0,003**			
Emotional Response	r	-,243*	,969**	1	
	p	**0,015**	<0.001		
Postural Response	r	-,317**	,981**	,906**	1
	p	**0,001**	<0.001	<0.001	

*Correlation is significant at < 0.05 level (Spearman Correlation test), ** Correlation is significant at < 0.001 level (Spearman Correlation test)

4. Variation of Gravitational Insecurity Response in Children with Specific Learning Disorder According to Activities Involving Different Movements

In Tables 4 and 5, the relationships between the scores obtained from the postural and emotional responses of the participants are shown with Spearman Correlation Analysis. According to this analysis; a moderately positive correlation between 1st step 'stand on the chair' (the child was asked to get up on the chair and stand

without holding on) and the 2nd step 'jump off the chair' (the child was asked to jump on the floor with eyes closed) and emotional and postural responses were found. Both steps involve a static position or movement at an elevated place and a change of head position as the feet leave the stable floor.
There was also a weak positive correlation between step 1 and other steps.
A moderately positive correlation was found between both emotional and postural responses in the 2nd step 'jump off the chair' and the 4th step 'tilt board step' (the child was asked to get on the tilt board and swing back and forth). Both steps involve a static position or movement at an elevated place.
There was a weak positive correlation between step 2 and other steps.
There was a moderately positive correlation between the emotional responses of the 3rd step 'backward somersault' (the child was asked to sit on the floor and swing backwards as if to do a backward somersault) and the 5th and 6th steps ‘Supine on ball (active) and (passive)’ (The child was asked to lie on the exercise ball, get up, lie down again, and let the therapist move the ball suddenly backwards twice, respectively.). All three steps here involve changing the head position and changing the head position as the feet leave the stable floor.
A moderately positive correlation was observed between postural responses of step 3 and step 6.
There was a moderately positive correlation between the emotional responses of step 4 'tilt board step' and step 5 ‘supine on ball (active)'.
A moderately positive correlation was observed between step 4 and step 6 'supine on ball (passive)' postural responses. All three steps involve movement on an uneven surface, a change in head position as the feet leave the stable floor, a static position or movement on an elevated place.
A strong positive correlation was found between both emotional and postural responses of the 5th step 'supine on ball (active)' and the step 6 'supine on ball (passive)'. Both steps involve movement on an uneven surface, change of head position, change of head position as feet leave stable ground, static position or movement on an elevated place.

Table 4: *Correlation Results of Emotional Responses*

Q		1	2	3	4	5	6
1)Stand on chair directions - Emotional response 1	r	1					
	p	.					
2)Jump off chair- Emotional response 2	r	,569**	1				
	p	**<0.001**	.				
3)Backward somersault directions - Emotional response 3	r	0,136	,269**	1			
	p	0,18	**0,007**	.			
4)Tilt board step directions - Emotional response 4	r	,344**	,578**	,339**	1		
	p	**<0.001**	**<0.001**	**0,001**	.		
5)Supine on ball (active) - Emotional response 5	r	,248*	,368**	,410**	,403**	1	
	p	**0,013**	**<0.001**	**<0.001**	**<0.001**	.	
6)Supine on ball (passive) - Emotional l response 6	r	,300**	,362**	,411**	,399**	,893**	1
	p	**0,003**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	.

*Correlation is significant at < 0.05 level (Spearman Correlation test), ** Correlation is significant at < 0.001 level (Spearman Correlation test)

Table 5: *Correlation Results of Postural Responses*

Q		1	2	3	4	5	6
Stand on chair directions – Postural response 1	r	1					
	p						
Jump off chair - Postural response 2	r	,456**	1				
	p	**<0.001**					
Backward somersault directions - Postural response 3	r	0,18	,318**	1			
	p	0,07	**<0.001**				
Tilt board step directions - Postural response 4	r	,419**	,482**	,354**	1		
	p	**<0.001**	**<0.001**	**<0.001**			
Supine on ball active - Postural response 5	r	,216*	,346**	,398**	,378**	1	
	p	**0,03**	**<0.001**	**<0.001**	**<0.001**		
Supine on ball passive - Postural response 6	r	,261**	,340**	,407**	,408**	,889**	1
	p	**0,01**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	

*Correlation is significant at < 0.05 level (Spearman Correlation test), ** Correlation is significant at < 0.001 level (Spearman Correlation test)

5. In Children with Specific Learning Disorder; Gender Relationship with Emotional-Postural Responses and Total Scores in Gravitational Insecurity Assessment

As shown in Table 6, the relationship between the total and subcategory scores of the assessment and gender of the participants were compared and no statistically significant difference was found between them.

Table 6: *Comparison of Participants' GI Assessment Total Score and Subcategories and Gender*

	Gender	**n**	**Mean**	**z**	**p**
Total Score	Boy	65	28,95	-0,577	0.564
	Girl	34	28,38		
Emotional Response	Boy	65	14,81	-0.859	0.390
	Girl	34	14,41		
Postural Response	Boy	65	14,13	-0.423	0.672
	Girl	34	13,97		

Mann Whitney U test; *: p<0.05 is statistically significant

6. The Relationship of Gravitational Insecurity with Age in Children with Specific Learning Disorder

As shown in Table 7, the scale groups of the participants were compared according to age. When those with and without Gravitational Insecurity were compared according to their age, a statistically significant difference was found. Those with Gravitational Insecurity had a higher mean age than those without (Z = -3.144, p = 0.002).

Table 7: *Comparison of Assessment Groups and Age*

		n	Mean	z	p
Assessment Group	Do Not Have Gravitational Insecurity	23	10,00	-3,144	**0.002 ***
	Have Gravitational Insecurity	76	11,71		

Mann Whitney U test; *: p < 0.05 is statistically significant

7. The Relationship Between the Prevalence of Gravitational Insecurity and Gender in Children with Specific Learning Disorder

The gender distribution of 99 children was 65 boys and 34 girls. GI was detected in 75.4% (n=49) of 65 boys and 79.4% (n=27) of 34 girls. The incidence of GI in boys and girls was found to be similar to each other.

8. Prevalence of Gravitational Insecurity in Children with Specific Learning Disorder According to Emotional and Postural Responses

The percentage of low scores in postural responses at each assessment step was found to be higher than that of emotional responses. This may indicate that children are less able to control their postural responses, even if they are emotionally self-controlled. On the other hand, it was determined that both emotional and postural GI symptoms increased as the vestibular stimulus increased in activity. This shows that children's emotional control decreases as the intensity of vestibular stimuli in the activity increases.

9. Distribution of Gravitational Insecurity Prevalence by Age Groups in Children with Specific Learning Disorder

In 1 out of 4 participants aged 7 (25%), in 5 out of 8 participants aged 8 (62.5%), in 9 out of 14 participants aged 9 (64.3%), in 11 of 14 participants aged 10 (78.6%), in 9 out of 13 participants aged 11(69.2%), in 11 of 14 participants aged 12 (78.6%), 14 out of 15 participants aged 13 (93.3%), in 7 out of 7 participants aged 14(100%), in 5 out of 5 participants aged 15 (100%), in 2 out of 2 participants aged 16 (100%), in 2 out of 3 participants aged 17 (66.7%), Gravitational Insecurity was observed.

In general, the incidence of GI increases with age. However, there is a decrease in the incidence in the 11-year-old and 17-year-old age group. Designing another study with a larger sample for children in this group will provide us with stronger information on the subject.

Conclusion

Gravitational Insecurity is common in individuals diagnosed with Specific Learning Disorder. In individuals diagnosed with Specific Learning Disorder, the severity and incidence of Gravitational Insecurity increase with age. The incidence of Gravitational Insecurity in individuals diagnosed with Specific Learning Disorder does not have a significant difference between genders. Individuals diagnosed with Specific Learning Disorder with Gravitational Insecurity react different to different movement patterns at different levels. In individuals diagnosed with Specific Learning Disorder with Gravitational Insecurity, postural symptoms of Gravity Insecurity are observed at higher rates than emotional symptoms. The incidence of both postural and emotional symptoms increases with age.

Suggestions

For future studies, the determination of the neural mechanisms of Gravitational Insecurity will provide useful information for the reasons and solutions of this problem. Also, investigating Gravitational Insecurity in the subtypes of Specific Learning Disorder will yield useful results for the solution of this problem. Studies on the prevalence of Gravitational Insecurity in different cultures are recommended for future studies. The data obtained as a result of our study is hoped to be a guide for individuals diagnosed with Specific Learning Disorder, their families and professionals working with these individuals.

References

1. Arsalidou, M., Pawliw-Levac, M., Sadeghi, M., & Pascual-Leone, J. (2018). Brain areas associated with numbers and calculations in children: Meta-analyses of fMRI studies. Developmental Cognitive Neuroscience, 30, 239-250.
2. Ayres A. J., Learning Disabilities and the Vestibular System, University of South California, 1978
3. Ayres AJ. Sensory integration and learning disorders. Los Angeles, CA; 1972
4. Ayres, A. J. (1979). Sensory Integration and the Child, Los Angeles. Western Psychological Services.
5. Ayres, A. J., & Network, P. T. (2005). Sensory integration and the child: 25th anniversary edition.
6. Byl, N. N., Byl, F. M., & Rosenthal, J. H. (1989). Interaction of Spatial Perception, Vestibular Function, and Exercise in Young School Age Boys with Learning Disabilities. Perceptual and Motor Skills, 68(3), 727–738. https://doi.org/10.2466/pms.1989.68.3.727
7. Cairney, J., Schmidt, L. A., Veldhuizen, S., Kurdyak, P., Hay, J., & Faught, B. E. (2008). Left-handedness and developmental coordination disorder. The Canadian Journal of Psychiatry, 53(10), 696-699.
8. Coelho, C. M., & Balaban, D. (2014). Visuo-vestibular contributions to anxiety and fear. Neuroscience & Biobehavioral Reviews.
9. Demir, B. (2005). Okulöncesi ve ilköğretim birinci sınıfa devam eden öğrencilerde özel öğrenme güçlüğünün belirlenmesi. (Published master's thesis). Marmara University, Istanbul.
10. DSM V, Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. Arlington, VA, American Psychiatric Association, 2013, Special Learning Disorder.
11. Fisher, A., & Bundy, A. (1989). Vestibular stimulation in the treatment of postural and related disorders. In O. D. Payton, R. P. DiFabio, S. V. Paris, E. J. Protas, & A. F. Van Sant (Eds.), Manual of physical therapy techniques (pp. 239–258). New York: Churchill Livingstone.
12. Franco, E. S., & Panhoca, I. (2008). Vestibular function in children underperforming at school. *Brazilian Journal of Otorhinolaryngology*, 74(6), 815-825.
13. Frank, J., & Levinson, H. N. Anti-motion sickness medications in dysmetric dyslexia and dyspraxia. *Academic Therapy*, 12(4), 411-424., (1977).
14. Frank, J., & Levinson, H. N. Seasickness mechanisms and medications in dysmetric dyslexia and dyspraxia. *Academic Therapy*, 12(2), 133-153. , (1976).
15. Frank, J., & Levinson, H. N., Dysmetric dyslexia and dyspraxia: Synopsis of a continuing research project. *Academic Therapy*, 11(2), 133-143., 1975
16. Gerard, L. V. D. (1991). An investigation of gravitational insecurity with behaviorally inhibited children (Doctoral dissertation, Boston University).
17. Hartmann, M., Farkas, R., & Mast, F. W. (2012). Self-motion perception influences number processing: evidence from a parity task. Cognitive Processing, 13(1), 189-192.
18. Harwell, J. M., & Jackson, R. W. (2008). The complete learning disabilities handbook: Ready-to-use strategies and activities for teaching students with learning disabilities. John Wiley & Sons.
19. Hilber, P., Cendelin, J., Le Gall, A., Machado, M. L., Tuma, J., & Besnard, S. (2019). Cooperation of the vestibular and cerebellar networks in anxiety disorders and depression. Progress in Neuro-Psychopharmacology and Biological Psychiatry, 89, 310-321.
20. Isaacs, E. B., Edmonds, C. J., Lucas, A., Gadian, D. G. (2001). Calculation difficulties in children of very low birthweight: a neural correlate. Brain, 124(9), 1701-1707.
21. Jerˆábek, J., Krejĉová, H. (1991). Oculomotor and vestibular findings in developmental dyslexia. *Acta Oto-Laryngologica*, 111(sup481), 513-514.
22. Karaca ,O.,Karaca, D.,Çalış, S.,Yiğit,G. (2019) . Disleksi – Özgül Öğrenme Güçlüğü.

23. Koomar J. , Vestibular dysfunction is associated with anxiety rather than behavioral inhibition or shyness, Boston University, *ProQuest Dissertations Publishing*, 1996. 9530623.
24. Kushch, A. , Gross-Glenn, K. , Jallad, B. , Lubs, H. , Rabin, M., Feldman, E., & Duara, R. (1993). Temporal lobe surface area measurements on MRI in normal and dyslexic readers. Neuropsychologia, 31(8), 811-821. 20.
25. Lee, L. (1987). Domain specification of gravitational insecurity for school aged children. Unpublished master's thesis, Boston University.
26. Levinson, H. N. (1988). The cerebellar-vestibular basis of learning disabilities in children, adolescents and adults: hypothesis and study. Perceptual and Motor Skills, 67(3), 983-1006E.
27. May - Benson T., Performance of Typical Adults With and Without Self-Reported Fearfulness to Movement on the Gravitational Insecurity Assessment—Revised, *American Journal of Occupational Therapy*, August 2020, Vol. 74, 7411500028.
28. May-Benson, T. A. (2015). Adult/Adolescent Sensory History Manual. Newton: Spiral Foundation.
29. May-Benson, T. A., & Koomar, J. A. (2007). Identifying gravitational insecurity in children: A pilot study. American Journal of Occupational Therapy, 61(2), 142-147.
30. May-Benson, T. A., de Mello Gentil, J. L., & Teasdale, A. (2020). Characteristics and Prevalence of Gravitational Insecurity in Children with Sensory Processing Dysfunction. Research in developmental disabilities, 101, 103640.
31. May-Benson, T. A., Teasdale, A., & Gentil, J. L. D. M. (2016). Gravitational Insecurity in Children With Sensory Integration and Processing Problems. *American Journal of Occupational Therapy*, *70*(4_Supplement_1), 7011500020p1-7011500020p1.
32. May-Benson, T., Teasdale, A., & Faria, W. J. S. (2016). Incidence and patterns of gravitational insecurity in adults and adolescents. *American Journal of Occupational Therapy*.
33. Miller, M., Chukoskie, L., Zinni, M., Townsend, J., & Trauner, D. (2014). Dyspraxia, motor function and visual–motor integration in autism. Behavioural brain research, 269, 95-102.
34. Palmer, L. L. (1980). Auditory discrimination development through vestibulo-cochlear stimulation. *Academic therapy*, 16(1), 53-68.
35. Pangelinan, M. M., Hatfield, B. D., Clark, J. E. (2013). Differences in movement-related cortical activation patterns underlying motor performance in children with and without developmental coordination disorder. Journal of neurophysiology, 109(12), 3041-3050.
36. Pirozzolo, F. J., Rayner, K. (1979). The neural control of eye movements in acquired and developmental reading disorders. In Studies in neurolinguistics (pp. 97-123). *Academic Press*.
37. Potegal, M. (2015). Is gravitational insecurity a unicorn. *Physical Medicine and Rehabilitation International*, 2(10), 1071.
38. Potegal, M. May- Benson, T. (2018). University of Minnesota, Minneapolis, MN; 2Spiral Foundation, Watertown, MA AOTA Annual Conference, Salt Lake City, UT.
39. Potegal, M., Pfaff, W.O., and Kroker E. (2018) Gravitational insecurity in children: A survey of occupational therapists' observations. Indian Journal of Physiotherapy & Occupational Therapy, 12, 30-37
40. Quirds, J.B. : Diagnosis of vestibular disorders in the learning disabled. *Journal of Learning Disabilities*, 1976, 9, 39-47
41. Ranpura, A., Isaacs, E., Edmonds, C., Rogers, M., Lanigan, J., Singhal, A., Butterworth, B. (2013). Developmental trajectories of grey and white matter in dyscalculia. Trends in neuroscience and education, 2(2), 56-64.
42. Rotzer, S., Kucian, K., Martin, E., von Aster, M., Klaver, P., & Loenneker, T. (2008). Optimized voxel-based morphometry in children with developmental dyscalculia. Neuroimage, 39(1), 417-422.
43. Schaaf R., Mailloux Z., (2019). Ayres Duyu Bütünleme için Klinisyenin Uygulama Rehberi (translation editor Dr. Fzt. Aymen Balıkçı), SenseON.
44. Shaywitz, S. E., Shaywitz, B. A. (2005). Dyslexia (specific reading disability). Biological psychiatry, 57(11), 1301-1309.

45. Soper G., Thorley C., Effectiveness of an Occupational Therapy Programme Based on Sensory Integration Theory for Adults with Severe Learning Disabilities, First Published October 1, 1996 Research Article .
46. Steinberg, M., & Rendle-Short, J. (1977). Vestibular dysfunction in young children with minor neurological impairment. Developmental Medicine & Child Neurology, 19(5), 639-651.
47. Stevens M. L., The status of vestibular-related parameters in relationship to learning ability in four-year old children born prematurely, University of Southern California, *ProQuest Dissertations Publishing*, 1983. EP62507.
48. Tanrıdağ O., (2018), Çocuk Beyninin Gelişimi, Uskudar University Publications, s: 48.
49. Van Hoorn, J. F., Maathuis, C. G., Hadders-Algra, M. (2013). Neural correlates of paediatric dysgraphia. Developmental Medicine & Child Neurology, 55, 65-68.
50. Weisberg, A. (1982). The comparison of autonomic nervous system responses in normal children and developmentally delayed, gravitationally insecure children between one and three years of age: A pilot study. Master's Thesis. University of Southern California.
51. Zwicker, J. G., Missiuna, C., Harris, S. R., Boyd, L. A. (2011). Brain activation associated with motor skill practice in children with developmental coordination disorder: an fMRI study. International Journal of Developmental Neuroscience, 29(2), 145-152.