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Original Article

Investigation of the relationship between motor performance and sensory processing skills and quality of life in preschool children with type 1 diabetes

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ABSTRACT

Objective: The aim of this study was to examine the relationship between motor performance and sensory processing skills and quality of life in preschool children with type 1 diabetes (T1DM).

Materials and Methods: The study included children with T1DM aged between 60 and 78 months. Sociodemographic information of the children was recorded. Motor performance were assessed using the "Bruininks-Oseretsky Motor Competency Test 2 (BOT 2)," sensory processing skills using the "Sensory Processing Scale (SPM) House Form," and quality of life using the "Children's Quality of Life Scale (CQL).

Results: A total of 20 children with T1DM were included in the study. In the relationship between BOT 2 and CQL, the following BOT 2 parameters were found to be associated with CQL; fine motor sensitivity [physical functioning (r=-0.510, p=0.020), school functioning (r=-0.580, p=0.010), and total CQL score (r=-0.550, p=0.010)], fine motor integration [emotional functioning (r=-0.450, p=0.040), psychosocial health (r=-0.570, p=0.010), and total CQL score (r=-0.520, p=0.010)], hand dexterity [school functioning (r=-0.480, p=0.020)], and bidirectional coordination [physical functioning (r=-0.450, p=0.040)]. A moderately positive correlation was found between physical functionality and the SPM parameters body awareness (r=0.049, p=0.020), planning and ideation (r=0.047, p=0.030), and total SPM score (r=0.450, p=0.040). A moderately positive correlation was found between planning and ideation and the total CQL score (r= 0.440, p= 0.040).

Conclusion: In preschool children with T1DM, impairments in motor skills and sensory processing abilities are associated with quality of life. It is recommended to assess motor performance and sensory processing skills in early childhood.

Keywords: Diabetes mellitus type 1, motor skills, sensation disorders

Introduction

Diabetes mellitus is a metabolic disorder characterized by impaired insulin secretion and high blood sugar levels, leading to significant long-term complications (1). According to etiological classification, there are four distinct types. One of these, Type 1 Diabetes Mellitus (T1DM), is a disease frequently seen in children and adolescents, caused by the destruction of β cells in the islets of Langerhans of the pancreas, and manifesting itself as a lack of or insufficient insulin production in the body (2).

Children with T1DM may experience skeletal muscle disorders and myopathies. Skeletal muscle disorders are characterized by decreased muscle mass in the lower extremities, general weakness, loss of functional skills, and reduced physical capacity. Muscle weakness increases the risk of diabetes-related physical disability in children (3, 4). Studies have shown that fine motor skills are particularly affected, and this impact is more pronounced in early-onset T1DM (5). Interactive coordination of fine motor and visual perceptual skills constitutes visual-motor integration. (6). Children with T1DM are also at risk of developing neurocognitive dysfunction in the area of visual-motor integration (7, 8).

Skill development and the application of skills in children depend on the processing of information from primary sensory systems. It is stated that impairments in processing sensory stimuli can affect children's learning capacity and social relationships (9). Goldberg et al. (10) reported that sensory processing impairments are more common in individuals with T1DM compared to other individuals.

Impairments in motor and sensory functions can negatively affect the quality of life in children. It has been noted that factors such as limitations in daily activities, weakness, disease symptoms, repeated hospitalizations/frequent check-ups, dependence on a medical device, daily insulin injections, and blood sugar monitoring in children with T1DM can lead to deterioration in their physical well-being and a decrease in their quality of life (11-13).

Since factors such as writing and physical education classes can cause changes in motor and sensory skills in children starting primary school, this study will evaluate preschool children. Furthermore, no studies were found that examined motor performance, sensory processing skills, and quality of life in preschool children with T1DM. The aim of this study was to examine the relationship between motor performance and sensory processing skills and quality of life in preschool children with T1DM.

Material and Methods

Children aged 60-78 months who presented to the Pediatric Endocrinology Outpatient Clinic of Ankara Bilkent City Hospital between September 2024 and April 2025 and who had been diagnosed with T1DM at least 6 months prior were included in the study. Those with diabetes, any neurodevelopmental disorder, and those starting first grade were excluded from the study.

The study included 20 children with T1DM, and their sociodemographic information was recorded. Motor performance was assessed using the "Bruininks-Oseretsky Motor Proficiency Test 2 (BOT 2)", sensory processing skills using the "Sensory Processing Scale (SPM) House Form", and quality of life using the "Children's Quality of Life Scale (CQL)".

The Bruininks-Oseretsky Motor Skills Test 2 (BOT 2) is a scale developed to assess motor skills in children aged 4-21 years. The test consists of 8 subtests and 53 items and takes approximately 40-60 minutes to complete. The maximum possible score on the test is 243 points. Higher scores indicate better motor skills. The subtests are: fine motor sensitivity (7 items), fine motor skill integration (8 items), dexterity (5 items), bilateral coordination (7 items), balance (9 items), speed and agility of movement (5 items), upper extremity coordination (7 items), and strength (5 items). The total engine composite score is obtained by summing all subcategories (14). A validity and reliability study was conducted in Turkish (15).

The Sensory Processing Scale (SPM) House Form is a 75-item scale developed to assess sensory processing skills in children aged 5-12 years. Social Participation is assessed using eight subscales: Vision, Hearing, Touch, Body Awareness, Balance and Movement, Planning and Ideas, and Total Sensory Systems. Total Sensory Systems refers to the sum of scores obtained from the subscales of Vision, Hearing, Touch, Body Awareness, Balance and Movement, as well as Taste and Smell, which are not subscales in themselves. Each item is scored according to its frequency of occurrence: Never (1 point), Sometimes (2 points), Frequently (3 points), and Always (4 points). Completing the scale takes approximately 15-20 minutes. High scores indicate poorer sensory processing skills. Turkish adaptation has been made (16, 17).

The Children's Quality of Life Scale (CQL) was developed to measure the health-related quality of life of children and adolescents aged 2-18 years. The 23-item scale assesses physical health, emotional functioning, and social functioning characteristics of well-being as defined by the World Health Organization. School functioning is also evaluated. The scoring is done in three areas: total score (TS), total physical health score (PHS), and total psychosocial health score (PSHS), which consists of calculating item scores that assess emotional, social, and school functioning. As the score increases, the quality of life decreases (18). A validity and reliability study has been conducted in Turkish (19).

Statistical analysis:

Statistical analyses were performed using IBM SPSS Statistics 26.0 (SPSS Inc, Chicago, IL, USA) software package. Descriptive statistics were presented as frequency and percentage values for nominal and ordinal variables, and as mean, standard deviation or median, minimum-maximum values for numerical variables. The normality of the distribution of numerical variables was examined using visual (histograms and probability plots) and analytical methods (Shapiro–Wilk test, skewness and kurtosis values, coefficient of variation). The relationships between the parameters were examined using Spearman correlation analysis (20, 21). For all analyses, cases where the type 1 error level was below 5% were considered statistically significant. Correlation coefficients were interpreted as follows: 0.9-1 indicates very high correlation, 0.70-0.89 indicates high correlation, 0.40-0.69 indicates moderate correlation, and 0.20-0.39 indicates low correlation (22).

Results

The study, conducted with children aged 60-78 months with T1DM, was completed with 20 children. Demographic characteristics including age, Body Mass Index (BMI), gender, duration of diabetes, and educational status of the children are presented in Table I.

In preschool children with T1DM, a moderately negative correlation was found between fine motor sensitivity and physical functioning (r=-0.510, p=0.020), school functioning (r=-0.580, p=0.010), and the total CQL (r=-0.550, p=0.010)

Table I: Demographic characteristics of the patients

Number of patients	20
Age (months)*	71 (60-78)
Body Mass Index (kg/m^2)*	16.41 (11.53-18.75)
Gender†	
Female	5 (25)
Male	15 (75)
Duration of diabetes (months)*	11 (6-57)
Educational background†	
Absent	2 (10)
Kindergarten	2 (10)
Preschool	16 (80)

**: median (min-max), †: n(%)*

Table II: Correlation between motor performance and quality of life

	Values	Quality of Life Scale for Children					
		Physical Functioning	Emotional Functioning	Social Functioning	School Functionality	Psychosocial Health	Total score
Bruininks-Oseretsky Motor Proficiency Test 2							
Fine Motor Sensitivity*	19.2±8.54	-0.51 / 0.02	-0.15 / 0.52	-0.09 / 0.69	-0.58 / 0.01	-0.41 / 0.06	-0.55 / 0.01
Fine Motor Consolidation*	13.5±8.34	-0.33 / 0.15	-0.45 / 0.04	-0.21 / 0.36	-0.39 / 0.08	-0.57 / 0.01	-0.52 / 0.01
Manual Dexterity*	15.9±6.73	-0.32 / 0.15	-0.25 / 0.28	-0.05 / 0.81	-0.48 / 0.02	-0.36 / 0.11	-0.41 / 0.07
Bilateral coordination †	17.5 (0-24)	-0.45 / 0.04	-0.09 / 0.69	-0.07 / 0.76	-0.36 / 0.11	-0.21 / 0.37	-0.38 / 0.09
Balance*	23.25±5.91	-0.23 / 0.32	-0.14 / 0.53	0.05 / 0.83	-0.16 / 0.47	-0.05 / 0.82	-0.16 / 0.49
Speed of movement and agility*	20.85±7.03	-0.27 / 0.23	-0.37 / 0.10	-0.04 / 0.84	-0.18 / 0.44	-0.40 / 0.07	-0.35 / 0.12
Upper extremity coordination*	13.95±8.72	-0.35 / 0.13	-0.34 / 0.14	-0.03 / 0.87	-0.23 / 0.33	-0.33 / 0.15	-0.35 / 0.12
Strength †	22.5 (9-38)	-0.30 / 0.18	-0.02 / 0.93	0.02 / 0.90	-0.19 / 0.40	-0.07 / 0.73	-0.19 / 0.40
Total score*	145.9±51.16	-0.37 / 0.10	-0.29 / 0.20	-0.12 / 0.61	-0.38 / 0.09	-0.41 / 0.07	-0.43 / 0.05

***:** *mean±SD; rho/p* **†:** *median (min-max); rho/p*

Table III: Correlation between sensory processing and quality of life

	Values	Quality of Life Scale for Children					
		Physical Functioning	Emotional Functioning	Social Functioning	School Functionality	Psychosocial Health	Total score
Sensory Processing Scale Home Form*							
Social Participation†	34.1±4.35	-0.24/0.29	-0.02/0.90	-0.30/0.18	-0.34/0.14	-0.28/0.22	-0.33/0.14
Visual†	14 (11/25)	0.42/0.06	-0.22/0.33	0.10/0.67	0.37/0.10	0.07/0.75	0.27/0.25
Auditory†	10 (8/20)	0.13/0.57	-0.01/0.99	0.04/0.83	0.44/0.05	0.17/0.47	0.16/0.49
Tactile†	15 (11/27)	0.26/0.26	-0.15/0.51	-0.07/0.75	0.28/0.21	-0.04/0.84	0.13/0.58
Taste and smell†	5.5 (5/10)	0.07/0.76	0.03/0.87	-0.16/0.49	-0.12/0.61	-0.15/0.51	-0.07/0.75
Body awareness†	13 (10/20)	0.49/0.02	0.19/0.41	0.13/0.57	0.21/0.36	0.20/0.38	0.36/0.10
Balance and movement*	16 (13/21)	-0.06/0.78	-0.30/0.18	-0.09/0.70	0.05/0.80	-0.26/0.26	-0.19/0.41
Planning and thought*	13±3.08	0.47/0.03	0.13/0.58	0.32/0.16	0.29/0.20	0.25/0.28	0.44/0.04
Sensory systems*	75.5±12.03	0.42/0.06	-0.14/0.53	0.16/0.49	0.32/0.16	0.07/0.76	0.27/0.24
Total*	122.6±11.59	0.45/0.04	-0.11/0.63	0.14/0.53	0.23/0.31	0.04/0.84	0.26/0.25

***:** *mean±SD; rho/p* **†:** *median (min-max); rho/p*

score. A moderately negative correlation was found between fine motor integration and emotional functioning (r=-0.450, p=0.040), psychosocial health (r=-0.570, p=0.010), and total CQL (r=-0.520, p=0.010). A moderate negative correlation was found between manuel dexterity and school functioning (r=-0.480, p=0.020), and between bilateral coordination and physical functioning (r=-0.450, p=0.040). No correlation was found between other BOT 2 parameters and the CQL parameters (Table II). When the relationship between sensory processing and quality of life was examined in children with T1DM, no relationship was found between social participation, visual, auditory, tactile, taste and smell, balance and movement, sensory systems and quality of life. A moderately positive correlation was found between body awareness (r=0.049, p=0.020), planning and ideation (r=0.047, p=0.030), and the total SPM score (r=0.450, p=0.040) and physical functioning. A moderately positive correlation was also found between planning and ideas and the total score of the CQL (r=0.440, p=0.040) (Table III).

Discussion

This study, which examined the relationship between motor performance, sensory processing skills, and quality of life in preschool children with type 1 diabetes, concluded that motor performance and sensory processing skills are associated with quality of life. In preschool children with type 1 diabetes, impairments in sub-parameters of motor performance, such as fine motor sensitivity, fine motor integration, dexterity, and bilateral coordination, have been observed to be associated with the children's quality of life.When examining the effects of sensory processing on quality of life in children with type 1 diabetes, the relationship between sensory processing impairments, particularly in the areas of body awareness, planning, and idea generation, and quality of life stands out.It is known that the metabolic changes occurring in individuals with T1DM lead to a number of different problems. One of these is that hyperglycemia seen in T1DM causes damage, particularly to peripheral motor neurons, resulting in a loss of motor performance (23). Children with T1DM may experience musculoskeletal disorders and myopathies (3). It has been reported that there are particular effects on fine motor skills (4). Problems with motor skills can also affect individuals' quality of life. A systematic review published in 2023 reported that motor impairments in children negatively affect their quality of life (24). We concluded fine motor sensitivity, fine motor integration, dexterity, and bilateral coordination were associated with quality of life parameters. Fine motor sensitivity was found to be associated with physical functioning, and fine motor sensitivity and dexterity were found to be associated with school functioning. Since a large proportion of the children attended daycare and preschool, the impairments in fine motor sensitivity and hand dexterity may have led to their inability to perform necessary functions at school and to physical deficiencies.

Fine motor coordination skills were found to be associated with emotional functioning, psychosocial health, and overall quality of life scores. Children with inadequate fine motor skills may feel inadequate compared to their peers, potentially lowering their psychosocial quality of life. In children with T1DM, impairments in fine motor skills have been shown to negatively affect their quality of life. Rehabilitation programs that focus on fine motor skills, especially in the preschool years, can improve children's quality of life. Bilateral coordination skills were found to be associated with physical functionality. A review of the literature indicates that studies in different patient groups have shown that as children's bilateral coordination skills improve, their quality of life also improves (25). Based on this, rehabilitation programs aimed at improving bilateral coordination skills can be used to enhance the quality of life for children with T1DM. In children with T1DM, other motor parameters such as strength, speed and agility, and balance may also be affected, but the impact may not be severe enough to affect quality of life and therefore may not be reflected in the results. Further studies comparing motor skills in healthy children and children with T1DM may be important. The results of this study are consistent with the literature, showing that fine motor skills are affected and that this impact negatively affects the quality of life of children.

In individuals with T1DM, the insulin-producing beta cells of the pancreas are destroyed autoimmuneally. Insulin deficiency in the body leads to uncontrolled blood sugar levels. Therefore, there is a need to take insulin from an external source (26). Studies on the effects of insulin on the brain suggest that insulin has a regulatory effect on sensory processing. Kern et al. (27) suggest that insulin has a direct effect on the modulation of brain functions. Goldberg et al. (10), in their study examining sensory processing in individuals with T1DM, concluded that these individuals have sensory processing disorders. Sensory processing has been defined as the ability to analyze, modulate, and organize incoming sensory information in order to respond to environmental stimuli (28). Therefore, low or high sensitivity in sensory processing can make it difficult to cope with environmental factors, affecting individuals' quality of life. (29,30). In this study, which examined the relationship between sensory processing and quality of life in children with T1DM, we concluded that sensory processing disorders affect quality of life. In children with T1DM, effects on body awareness and planning and thought skills were found to be related to the physical functioning parameter of quality of life. Pfeiffer et al. (31) also reported in their studies that sensory modulation problems affect the physical aspect of quality of life. They noted that hypersensitive individuals, in particular, may experience physical fatigue and a decrease in their physical quality of life as a result of high arousal levels.

Healthy body awareness is crucial for coordinating movements, maintaining posture and balance, and performing holistic physical functions (32). Studies examining the relationship between body awareness and quality of life have shown that individuals with higher body awareness have a higher quality of life (33). Our study also shows that impaired body awareness in individuals with T1DM is associated with their quality of life. In particular, impairments in physical function may result in children with type 1 diabetes having reduced body awareness, which can lead to difficulties in demonstrating physical skills and consequently a decreased quality of life.Motor planning and conception is the process of preparing and organizing motor behaviors to perform specific, goal-oriented actions. It involves integrating intrinsic motor knowledge with sensory information to design, plan, and execute movements. Deficiencies in motor planning can affect a child's independence and social participation because they can impact daily living activities such as dressing and writing (34). Although no studies examining planning and ideation skills in children with T1DM were found, our study concluded that impairments in these skills negatively affect physical functionality and overall quality of life. This may be because children with T1DM have difficulties performing physical skills due to deficits in motor planning Further studies examining the motor planning and decision-making skills of children with T1DM and healthy control groups may be important.

Limitations

Limitations of the study include the lack of a healthy control group and the failure to assess the children's physical activity levels. Further studies comparing motor performance, sensory processing, and quality of life in healthy children and children with T1DM will contribute to the literature. Furthermore, the inclusion and exclusion criteria limited the sample size of the study. The small number of participants is among the limitations. This study included children diagnosed with T1DM for at least 6 months due to the limited age range. Further studies with children diagnosed with T1DM for longer periods may benefit the literature. Another limitation of the study is that metabolic control parameters (HbA1c, etc.) were not included in the analyses. The relationship between these variables and functional outcomes should be investigated in future studies.

Conclusion

In conclusion, motor performance and sensory processing skills are associated with quality of life in children with T1DM. Rehabilitation approaches that improve motor skills and sensory processing abilities in children with T1DM can be important in improving their quality of life.

Ethics committee approval

This study was conducted in accordance with the Helsinki Declaration Principles. The study was approved by Ankara Bilkent City Hospital (05.06.2024, reference numbe:1-24-295).

Contribution of the authors

Idea/Concept: AAB, BE; Design: AAB, BE; Supervision: FG, MB, BE; Funding and Resource Provision: AAB; Materials: AAB, FG, MB, BE; Data Collection and/or Processing: AAB, FG, MB; Analysis/ Interpretation: AAB, BE; Literature Review: AAB, FG, MB, BE; Article Writing: AAB, BE; Critical Review: AAB, FG, MB, BE.

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Conflict of interest

The authors declare that there is no conflict of interest.

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