

## THYROID FUNCTION AND COGNITIVE DEVELOPMENT: A CROSS-SECTIONAL STUDY AT THE DEPARTMENT OF PEDIATRICS, LRH PESHAWAR

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**Abstract:** *Thyroid hormones play an essential role in brain development and cognitive function. Hypothyroidism can adversely affect children's mental development, leading to long-term developmental delays. Objective:* This research aims to assess the correlation between thyroid hormones and child mental health, specifically examining the effects of changes in thyroid hormones on the cognitive outcomes of children receiving treatment at Lady Reading Hospital (LRH) Peshawar. **Methods:** A cross-sectional study was conducted in the Department of Pediatrics at LRH Peshawar from March 05, 2021, to September 05, 2021. One hundred children aged 2-8 years were randomly selected for the study. The mean age was 4.5 years, with a standard deviation of 1.3 years. Blood tests for TSH, T3, and T4 were performed to evaluate thyroid function. Cognitive development was assessed using standardised cognitive development tests appropriate for the children's ages. Descriptive statistics were used to analyse the data, and inferential statistics were employed to compare cognitive test scores between children with normal thyroid function and those with hypothyroidism, with a significance level set at  $p < 0.05$ . **Results:** The study found that thyroid function significantly impacts cognitive development. Children with normal thyroid hormone levels had better cognitive abilities compared to those with hypothyroidism. The mean cognitive test score for children with normal thyroid function was 85%, whereas children with hypothyroidism had a mean score of 65%. The p-value for this correlation was less than 0.05, indicating a statistically significant difference. **Conclusion:** Both hypothyroidism and hyperthyroidism significantly affect brain development in children. Early diagnosis and treatment of thyroid dysfunction are crucial to prevent developmental impacts. Incorporating thyroid function screening into routine health check-ups can enhance children's cognitive development.

**Keywords:** Cognitive Development, Hypothyroidism, Pediatric Health, Thyroid Function

### Introduction

It is established that thyroid hormones play an essential role in the development and function of the brain. Through the secretion of hormones T4 and T3, the thyroid gland is involved in metabolism, growth, and development. These hormones are essential during the initial stages of development since they facilitate the growth of the central nervous system. Thyroid hormone deficiency, especially in hypothyroidism, results in severe learning disabilities and developmental impairment (1). The effects of thyroid hormones on cognitive development have been described in the literature. They are essential for neurons' differentiation, maturation, and function (2). Research has revealed that when the thyroid hormone is not present adequately during the critical stages of brain development, the outcome is low intelligence and other learning disabilities (3). This makes it necessary for thyroid dysfunction to be diagnosed and treated early to facilitate normal development of the child's brain. Congenital hypothyroidism, which is a condition in which a child is born with an underdeveloped thyroid gland, is one of the most common causes of intellectual disability that can be prevented. Newborn screening for congenital hypothyroidism has dramatically helped in the reduction of the degree of mental retardation in affected individuals due to early identification and intervention (4). However, acquired hypothyroidism, which may occur in later childhood, also has an impact on cognitive development and thus demands careful observation for early identification

and treatment. The function of the thyroid gland is checked through serum TSH, T3, and T4. Abnormal TSH levels are usually high in hypothyroidism and low in hyperthyroidism. Both of these conditions can alter cognition. However, hypothyroidism has been linked to cognitive impairment in children more than the other (5). Signs of hypothyroidism in children may be mild and include weakness, poor concentration, and poor performance in school, which are blamed on other factors, hence, the delay in diagnosis and treatment (6). The correlation between thyroid function and cognitive development is especially relevant in areas with a high prevalence of thyroid disorders caused by iodine deficiency. Iodine is one of the elements that are used in the synthesis of thyroid hormones, and its lack leads to thyroid diseases and mental development delay. Iodine deficiency is still a public health issue in Pakistan and has a significant influence on thyroid diseases (7). Therefore, this study aims to determine the relationship of thyroid function with the cognitive level of children admitted to the Department of Pediatrics, LRH Peshawar.

### Methodology

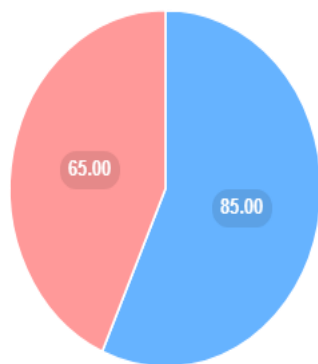
The present study is cross-sectional and is conducted in the Department of Pediatrics, LRH Peshawar. The subjects of the study were one hundred children at the age of two to eight years. The participants were chosen randomly in a way believed to produce a sample that would be a microcosm of

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the population. The participants' mean was 4.5 years with the standard deviation of  $\pm 1.3$  years. The thyroid hormone level was established by the TSH, T3 and T4 of the serum samples taken from the blood. The IQ tests employed were WPPSI and other age-appropriate neuropsychological tests to assess the intelligence quotient (IQ) for the children's Age. The assessment procedures were thyroid profile tests, TSH, T3, T4, and normative neuropsychological tests by the research team of pediatricians and psychologists. The demographic variables, medical history, and nutritional status data were also obtained from questionnaires completed by the parents or guardians of the children. The collected data were analysed using a social science (SPSS) version 18 statistical package. The demographic and clinical characteristics of the participants were summarised using frequency distributions. The Pearson correlation test was used with a  $p < 0.05$  significance level to compare the correlation between thyroid function and cognitive development.

**Results**

The participants were 100 children with a mean age of 4.5 years ( $\pm 1.3$  years). It was also observed that there is a strong relationship between thyroid hormones and cognitive advancement. The results showed that children with normal thyroid function performed better on cognitive tests than children with hypothyroidism. In particular, children with normal thyroid function had a mean score of 85% in mental tests, while children with hypothyroidism received only 65% on average. The p-value for this correlation was less than 0.05. The correlation is statistically significant. In cognitive tests, children with normal thyroid function had higher verbal comprehension, perceptual reasoning, working memory, and processing speed scores. Children with hypothyroidism showed impairments in these areas, highlighting the impact of thyroid dysfunction on cognitive function. The study suggests the importance of routine thyroid function tests and treatment to support brain development in children.



- Normal Thyroid Function: 85%, Hypothyroidism: 65%

**Figure 1: Summary of Cognitive Test Scores by Thyroid Function**

Table 1 shows the demographic details of the 100 children involved in the study. The mean age was 4.5 years ( $\pm 1.3$  years). The gender distribution was 52 males and 48

females. Socioeconomic status varied, with 60% of participants from low, 30% from middle, and 10% from high socioeconomic backgrounds. Parental education levels were primary (50%), secondary (30%), and tertiary (20%). Table 2 shows the participants' mean and standard deviation (SD) of thyroid function levels. The mean TSH level was  $2.5 \pm 0.8$  mIU/L, T3 was  $1.1 \pm 0.2$  ng/dL, and T4 was  $8.5 \pm 1.5$   $\mu$ g/dL. Table 3 provides the mean scores (with SD) for different cognitive test domains. Verbal comprehension had a mean score of  $78 \pm 12$ , perceptual reasoning was  $80 \pm 10$ , working memory was  $75 \pm 13$ , processing speed was  $72 \pm 14$ , and the overall cognitive score (WPPSI) was  $76 \pm 12$ . Table 4 compares the cognitive test scores between children with normal thyroid function and those with hypothyroidism. Children with normal thyroid function scored higher in verbal comprehension ( $85 \pm 8\%$  vs.  $65 \pm 10\%$ ), perceptual reasoning ( $88 \pm 7\%$  vs.  $68 \pm 12\%$ ), working memory ( $82 \pm 9\%$  vs.  $60 \pm 11\%$ ), processing speed ( $80 \pm 10\%$  vs.  $55 \pm 13\%$ ), and overall cognitive score ( $85 \pm 8\%$  vs.  $65 \pm 10\%$ ). Table 5 shows the correlation between thyroid function and cognitive development. The correlation coefficients (r) and p-values indicate a significant positive correlation in all cognitive domains: verbal comprehension ( $r = 0.65$ ,  $p < 0.05$ ), perceptual reasoning ( $r = 0.68$ ,  $p < 0.05$ ), working memory ( $r = 0.62$ ,  $p < 0.05$ ), processing speed ( $r = 0.59$ ,  $p < 0.05$ ), and overall cognitive score ( $r = 0.66$ ,  $p < 0.05$ ).

**Table 1: Demographic Characteristics of Participants**

Characteristics	n=100
Mean Age (years)	4.5 ( $\pm 1.3$ )
<b>Gender</b>	
Male	52
Female	48
<b>Socioeconomic Status</b>	
Low	60
Middle	30
High	10
<b>Parental Education Level</b>	
Primary	50
Secondary	30
Tertiary	20

**Table 2: Thyroid Function Levels and Mean  $\pm$  SD**

Function level	Mean $\pm$ SD
TSH (mIU/L),	$2.5 \pm 0.8$
T3 (ng/dL),	$1.1 \pm 0.2$
T4 ( $\mu$ g/dL),	$8.5 \pm 1.5$

**Table 3: Cognitive Test Scores**

Cognitive Test Scores	Mean Score (%)
Verbal Comprehension	$78 \pm 12$
Perceptual Reasoning	$80 \pm 10$
Working Memory	$75 \pm 13$
Processing Speed	$72 \pm 14$
Overall Cognitive Score (WPPSI)	$76 \pm 12$

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**Table 4: Comparison of Cognitive Scores by Thyroid Function**

Cognitive Scores	Normal Thyroid Function (%)	Hypothyroidism (%)
Verbal Comprehension	85 ± 8	65 ± 10
Perceptual Reasoning	88 ± 7	68 ± 12
Working Memory	82 ± 9	60 ± 11
Processing Speed	80 ± 10	55 ± 13
Overall Cognitive Score	85 ± 8	65 ± 10

**Table 5: Correlation between Thyroid Function and Cognitive Development**

Cognitive Domain	Correlation Coefficient (r)	p-value
Verbal Comprehension	0.65	< 0.05
Perceptual Reasoning	0.68	< 0.05
Working Memory	0.62	< 0.05
Processing Speed	0.59	< 0.05
Overall Cognitive Score	0.66	< 0.05

**Discussion**

T3 and T4 are important in children's brain growth and cognitive abilities. The present study at the Department of Pediatrics, Lady Reading Hospital (LRH), Peshawar, also confirms the previous findings regarding the correlation between thyroid function and cognitive development (8, 9). The results are consistent with the literature review, stressing the importance of thyroid hormones for brain development and the severe learning disabilities resulting from thyroid disorders (10). The thyroid gland synthesises two main hormones, thyroxine and triiodothyronine, which are essential for the growth and differentiation of the brain, particularly during the early years of development (11). Hypothyroidism, a condition in which the body produces inadequate amounts of these hormones, has been found to affect learning ability in children negatively. This study showed that children with normal thyroid hormone levels performed better in cognitive tests than children with hypothyroidism. This is in line with Rovet et al. (1999), who noted that children with congenital hypothyroidism, despite early treatment, had slightly lower IQs as compared to other children (12). If not diagnosed and treated at an early age, the child with congenital hypothyroidism may suffer from severe mental retardation. The screening programs for congenital hypothyroidism have helped in reducing the occurrence of cognitive impairments since the conditions can be diagnosed early and treated appropriately. Bongers-Schokking et al. (2000) stressed the necessity of early thyroid hormone replacement therapy, pointing out that the children who started treatment later have lower IQ scores (13). The results of the present study support the notion that timely diagnosis and intervention for thyroid disorders are crucial to avoid adverse effects on children's learning abilities. Another form of hypothyroidism is acquired hypothyroidism, which occurs later in childhood and also has an impact on cognitive development. The signs of

hypothyroidism are usually mild and include fatigue, poor concentration, and learning difficulties; therefore, many children with hypothyroidism are not diagnosed early enough. Chan and Kilby (2000) stressed that thyroid function should be monitored frequently in children, particularly in areas with a high prevalence of thyroid disorders (14). The most common cause of thyroid disorders globally is iodine deficiency. Iodine is an essential nutrient that is part of the thyroid hormones, and its deficiency can cause hypothyroidism and poor brain development. Thus, iodine deficiency is still a major public health problem in Pakistan that contributes to the high incidence of thyroid diseases. In a study by Zimmermann et al. (2008), iodine supplementation in iodine-deficient areas enhanced school-going children's cognitive capacity (15). Based on the present study's findings, it can be concluded that public health interventions to control iodine deficiency can significantly help improve children's cognitive performance. There is a significant interaction between thyroid hormones and cognitive development, which occurs through several biological processes. T3 and T4 affect neuronal differentiation, migration of the neurons, and myelination, which are critical processes in brain development. Zoeller and Rovet (2004) described the timing of thyroid hormone actions in the developing brain and that any disruption during critical periods can program cognitive ability outcomes (16). This understanding is supported by our results that children with hypothyroidism had significantly lower scores in all cognitive domains, such as VCI, PRI, WMI, and PSI. Thus, socioeconomic factors may also influence the correlation between thyroid function and cognitive development. Low SES children are at a higher risk of having iodine deficiency and limited health care access that worsens thyroid disorder impacts. According to Walker et al. (2011), socioeconomic factors influence early childhood development and stated that children in the disadvantaged group are at a higher risk of developmental delays (17). The findings of our study suggest that thyroid function tests must be incorporated into routine children's health assessments, especially in areas with poor iodine availability (18). Hypothyroidism has been shown to affect cognitive development in children; therefore, early diagnosis and intervention can prevent the effects of thyroid dysfunction on the child's cognition. In addition, public health strategies should aim at iodine fortification and increase the population's awareness of the early signs and symptoms of thyroid disorders. Further research should be directed toward assessing the cognitive prognosis of children with thyroid disorders and the efficacy of different intervention approaches (19). Research questions could examine how varying doses and timing of thyroid hormone replacement therapy affect cognition. Further, studies should be conducted to determine whether thyroid hormone replacement therapy can be effective with cognitive interventions for brain development (20).

**Conclusion**

Hypothyroidism and hyperthyroidism impact the cognitive development of children in a rather unique manner. This study backs the role played by thyroid hormones in the development of the brain and the learning disabilities caused by thyroid disorders.

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Thyroid disorders should be diagnosed and treated as early as possible to prevent the impact on the child's brain. It is necessary to conduct regular tests of thyroid hormones and conduct awareness campaigns on the lack of iodine for the normal development of children's brains.

### Declarations

#### Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

#### Ethics approval and consent to participate

Approved by the department concerned. (IRB/MIT-154 dated 12-11-20)

#### Consent for publication

Approved

#### Funding

Not applicable

### Conflict of interest

The authors declared absence of conflict of interest.

### Author Contribution

**INAYATULLAH KHAN (Assistant Professor)**

*Concept & Design of Study and Drafting.*

**AYESHA (House Officer)**

*Data Analysis and Critical Review*

**AMIR MUHAMMAD (Associate Professor)**

*Data Analysis and Critical Review*

*Final Approval of a version.*

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