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ASSOCIATION BETWEEN IDIOPATHIC TOE WALKING AND GROSS MOTOR SKILL DEVELOPMENT IN EARLY CHILDHOOD

Asharib Rathore, Maryam Shabbir, Rabia Majeed, Aqsa Majeed, Aqsa Abid, Qurat-Ul-Ain, Hafiza Amna Akram, Sadaf Anjum

Department of Physical Therapy and Rehabilitation, University of Lahore Teaching Hospital, Lahore, Pakistan. Physical Therapy Department, Sehat Medical Complex, Hanjarwal, Lahore, Pakistan.

Correspondence:
Maryam Shabbir,
Head of Department, University Institute of Physical Therapy, Faculty of Allied Health Sciences, The University of Lahore. Pakistan.
Email:
maryam.shabbir@uipt.uol.edu.pk

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ABSTRACT:

The objective of this cross-sectional study was to establish the association between idiopathic toe walking and gross motor skill acquisition among children aged 4 to 10 years. Data were collected between July 2025 and January 2026 from the Physical Therapy and Rehabilitation Department at the University of Lahore Teaching Hospital (ULTH) and the Physical Therapy Department at Sehat Medical Complex (SMC), Hanjarwal, Lahore, Pakistan, after obtaining informed written consent. Children with idiopathic toe walking (ITW) were recruited through non-probability convenience sampling (n = 29). ITW characteristics were assessed using the Toe Walking Tool (TWT), while gross motor performance was measured using the locomotor subtest of the Test of Gross Motor Development, Third Edition (TGMD-3). Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 26, applying descriptive statistics and the Spearman rank correlation. A statistically significant moderate negative correlation was found between toe-walking frequency and gross motor development scores ($r = -0.529$, $p = 0.003$). Children with higher severity of toe walking demonstrated lower gross motor performance, and significant differences in motor scores were observed across severity groups. Idiopathic toe walking is significantly associated with reduced gross motor skill development; increased frequency and severity of toe walking are linked with poorer motor performance, highlighting the importance of early identification and physiotherapy intervention.

Keywords: Early childhood, Gait, Motor skills, Movement, Physical performance

INTRODUCTION

Toe walking is a gait pattern in which children walk on their forefeet without heel contact (1). A certain amount of toe walking in very young children is generally interpreted as part of normal motor exploration during development; however, when the pattern persists beyond the age at which it is expected to resolve, it becomes a cause for clinical concern (2). Persistent toe walking may become fixed and can lead to pain, movement impairment, restriction in school and play activities, and reduced emotional wellbeing (3). Idiopathic toe walking (ITW) is regarded as a diagnosis of exclusion and may continue into later childhood, potentially affecting lower-limb biomechanics and the functional development of motor activity. The reported prevalence of idiopathic toe walking ranges from 2% to 5% among otherwise healthy children below ten years of age (4) a developmental window during which basic motor skills and habitual physical activity are established. Because motor competence, social participation, and psychosocial wellbeing are closely tied to physical activity, the early appearance of ITW raises the need to understand its wider impact, particularly on the acquisition of gross motor skills and on everyday functional activities (5). ITW is observed in both sexes, indicating that it reflects neuromuscular control rather than a sex-linked characteristic (6). It is commonly associated with ankle equinus (7) and is thought to be an important

contributor to foot pain, poor motor skills, and low participation in sport and leisure activity, with only limited guidelines available to support consistent treatment recommendations (8). This study was conducted to determine the association between idiopathic toe walking and gross motor skill development in children. It was hypothesised that increased frequency and severity of toe walking are associated with poorer gross motor performance.

METHODS

This cross-sectional study was conducted at the Physical Therapy and Rehabilitation Department of the University of Lahore Teaching Hospital (ULTH) and the Physical Therapy Department of Sehat Medical Complex (SMC), Hanjarwal, Lahore, Pakistan, following informed written consent and approval from the Research Ethics Committee (REC), University Institute of Physical Therapy, University of Lahore (REC No. REC-UIPT-29-08926/DPT-Aug-2025, dated 29 August 2025). Using convenience sampling, 29 participants were recruited with the aid of Epi Tool (9).

Inclusion criteria: Children aged 4 to 10 years at the time of enrolment, of either sex, who demonstrated a stable pattern of ITW gait with a Gross Motor Quotient below 90 were included.

Exclusion criteria: Children with a diagnosed neurological, neuromuscular, cognitive, or genetic disorder were excluded, as were those with any acute lower-limb injury or fracture, or emotional or psychological stress within the preceding six months. Written informed consent was obtained from the parents or guardians of all participating children prior to data collection, and the study was conducted in accordance with ethical standards for research involving human participants.

Data were collected using questionnaires and standardised assessment instruments, namely the Toe Walking Tool (TWT) and the Test of Gross Motor Development, Third Edition (TGMD-3), which were used to record demographic details, gait characteristics, and gross motor skills. Only the locomotor subtest of the TGMD-3 was administered, as the study was concerned with gait-based gross motor performance. All children were assessed in a relaxed, distraction-free setting, with their caregivers present to help them cooperate during the assessment.

Statistical Analysis

Data were analysed using SPSS version 26. Demographic variables and gross motor development categories were summarised using descriptive statistics. The Shapiro–Wilk test indicated that the data were not normally distributed; the Spearman rank correlation coefficient was therefore used to determine the strength and direction of the relationship between the variables. Gross motor development scores across the toe-walking severity groups were compared using the Kruskal–Wallis H test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics of Participants

A total of 29 children with toe walking were included in the final analysis. As shown in Table 1, most children had an idiopathic presentation, with no reported medical condition (79.3%) and no family history of toe walking (86.2%). Toe-walking frequency varied, with nearly half of the children walking on their toes only occasionally (48.3%). A functional impact was reported for 48.3% of children, while 89.7% had received no prior intervention. Most children (82.8%) had achieved their gross motor milestones, and the sample was almost evenly distributed by sex.

Association Between Toe-Walking Frequency and Gross Motor Development

As shown in Table 2, the analysis revealed a statistically significant moderate negative correlation between toe-walking frequency and gross motor development scores (Spearman's rho = -0.529, p = 0.003). This indicates that a higher reported frequency of toe walking was associated with poorer standardised gross motor performance in this sample. To examine differences in gross motor development across the mild, moderate, and severe toe-walking groups, a Kruskal–Wallis H test was applied because of the non-normal distribution of the data. As shown in Table 3, the mean rank was highest in the mild group, followed by the moderate group, and was lowest in the severe group, indicating a graded relationship in which greater toe-walking severity is associated with poorer gross motor performance.

Table 1. Demographic characteristics of participants (n = 29).

Variable	Frequency (n)	Percent (%)
Child Gender		
Male	15	51.7
Female	14	48.3
Total	29	100.0
Birth History		
Full term	25	86.2
Pre term	4	13.8
Total	29	100.0
Toe-Walking Frequency		
Always	8	27.6
Sometimes	14	48.3
Rarely	7	24.1
Total	29	100.0
Reported Medical Condition		
No	23	79.3
Yes	6	20.7
Total	29	100.0
Previous Interventions for Toe Walking		
No	26	89.7
Yes	3	10.3
Total	29	100.0
Gross Motor Milestone Achievement		
No	5	17.2
Yes	24	82.8
Total	29	100.0
Family History of Toe Walking		
No	25	86.2
Yes	4	13.8
Total	29	100.0
Functional Impact of Toe Walking		
No	15	51.7
Yes	14	48.3
Total	29	100.0

Table 2. Spearman correlation between idiopathic toe-walking frequency and gross motor development.

Variables	Spearman's rho (r)	Sig. (2-tailed)	N
Toe-walking frequency vs. gross motor development scores	-0.529**	0.003	29

***Correlation is significant at the 0.01 level (2-tailed).*

DISCUSSION

The present study set out to determine the relationship between idiopathic toe walking and gross motor skill development in children. Although persistent toe walking has traditionally been regarded as a benign developmental variation, accumulating evidence suggests that it may be linked to measurable differences in functional and motor performance.

Table 3. Comparison of gross motor development scores across toe-walking severity groups (Kruskal–Wallis test).

Toe-walking severity	N	Mean rank
Mild	7	20.57
Moderate	14	16.39
Severe	8	7.69
Total	**29**	

The findings of this study are, in part, consistent with the existing literature. Several studies have reported that idiopathic toe walking is associated with deficits in balance, coordination, posture, and motor planning. The negative correlation observed here between toe-walking frequency and gross motor development supports earlier work indicating that continuous toe walking can disrupt efficient movement patterns and functional motor activity.

The present study examined the relationship between ITW severity and gross motor skill development, whereas Morrow et al. focused on quality of life in children with ITW. Their findings pointed to reduced physical functioning, particularly in persistent cases. In a similar vein, the present results show that greater ITW severity is associated with poorer gross motor performance. Although most children in this sample achieved their early milestones, their motor scores varied widely, suggesting subtle impairments. In contrast to the largely subjective focus of that earlier work, the present study provides objective evidence of declining motor performance with increasing ITW severity (10).

Compared with the cross-sectional survey by Harris et al. on ITW management in the United Kingdom, the present study focuses on the functional relationship between ITW and gross motor development in early childhood. Harris et al. described differences in treatment approaches between physiotherapists and surgeons based on perceived severity. By contrast, the present study offers objective evidence of a strong negative relationship between toe-walking frequency and motor performance, showing a decline in motor skill with increasing ITW severity. Whereas their work emphasised clinical decision-making, these findings support early, targeted physiotherapy by demonstrating measurable motor impairment in severe and persistent ITW (11).

Unlike the review by Freiman et al., which examined the diagnosis, progression, and treatment of ITW, the present study concentrates on the link between ITW severity and gross motor skill in young children. While Freiman et al. noted that many children show normal early development and may improve spontaneously — consistent with the present finding that most children reached their early milestones — this study identifies a strong negative relationship between toe-walking frequency and motor performance. It demonstrates that gross motor skill declines as ITW severity increases, suggesting that chronic ITW may contribute to functional impairment and underlining the need for timely assessment and targeted physiotherapy (12).

Compared with Gray et al., who sought to standardise outcome measures for assessing ITW severity, the present study examines the functional relationship between ITW severity and gross motor development in early childhood. Gray et al. highlighted inconsistencies in assessment and the importance of parental input; the present study adds empirical evidence of a significant negative correlation between toe-walking frequency and motor performance (Spearman's rho = -0.529, p = 0.003), showing that gross motor skill declines as ITW severity increases. Rather than focusing on measurement standardisation, these findings emphasise the clinical value of early detection and targeted physiotherapy in addressing potential motor impairment (13).

Bauer et al. suggested that most children with ITW achieve their early motor milestones and follow a benign course. The present study echoes this in part — 82.8% of children in the sample reached their milestones on time — but also reveals notable functional variability, with a moderate negative correlation between toe-walking frequency and gross motor development. Unlike the diagnostic and treatment focus of Bauer et al., the present study demonstrates a gradual decline in motor performance with increasing ITW severity, suggesting an underlying functional impairment rather than a simple gait variation (14).

Other work has explored sensory processing differences in children with idiopathic toe walking, reporting that altered sensory modulation — particularly tactile and proprioceptive processing — may contribute to persistent toe-walking behaviour. The present study, by contrast, focused on functional outcomes and demonstrated a significant negative association between toe-walking severity and gross motor skill development. Taken together, these lines of evidence indicate that idiopathic toe walking is multifactorial, involving both sensory processing differences and measurable deficits in gross motor performance, and reinforce the need for comprehensive assessment and early intervention (15).

Studies of the prevalence and natural history of idiopathic toe walking have reported that many children outgrow the condition spontaneously without significant long-term consequences. The present findings, however, show a significant negative association between toe-walking frequency and gross motor skill development, particularly in children with persistent and severe patterns. While Engström and Tedroff emphasised the generally benign, self-limiting nature of idiopathic toe walking, the present results suggest that persistent cases may be associated with functional motor impairment, highlighting the importance of early assessment and targeted intervention (16).

Work assessing dynamic stability in children with idiopathic toe walking has reported that altered gait mechanics and reduced stability may contribute to inefficient walking patterns. The present study extends these biomechanical observations by demonstrating a significant negative association between toe-walking severity and gross motor skill development. Whereas that earlier work concentrated on gait-stability deficits, the present results point to a broader functional impact on locomotor performance, suggesting that impaired dynamic stability may underlie the reduced gross motor outcomes seen in children with persistent idiopathic toe walking (17).

Finally, research using wearable sensors and machine learning to classify gait patterns in children with ITW has identified measurable variations in movement. The present study, in contrast, focuses on functional outcomes, showing a significant negative relationship between ITW severity and gross motor skill. While that earlier research emphasised technological assessment, the present study highlights clinical relevance by linking greater severity with poorer motor performance. Together, these approaches underline the value of combining gait analysis with functional evaluation for a comprehensive understanding of ITW (18). There are a few limitations of the study need to be considered when interpreting these findings. First, the small sample size and the restriction to two Lahore-based rehabilitation centres limit the generalisability of the results. Second, the use of only the locomotor subtest of the TGMD-3 provides a narrow picture of gross motor skill, as ball skills were not assessed. Finally, the short study duration precluded long-term follow-up, limiting insight into how motor development changes over time.

CONCLUSION

This study concludes that idiopathic toe walking is significantly associated with reduced gross motor skill development. Increased frequency and severity of toe walking are linked with poorer motor performance. Early identification and targeted physiotherapy intervention are recommended to improve functional outcomes. Future research should recruit a larger and more geographically diverse sample to strengthen statistical power and external validity, as the present work was confined to an urban population. The administration of the full Test of Gross Motor Development, Third Edition (TGMD-3), rather than the locomotor subtest alone, is strongly advised so that both locomotor and object-control abilities can be evaluated and the influence of ITW on gross motor proficiency more fully described. Longitudinal studies following children with ITW over time are also needed to clarify developmental trajectories and establish causal relationships.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

ETHICAL APPROVAL

The study was approved by the local Research Ethics Committee.

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