

Coordination, Cardiorespiratory Endurance, Sleep Quality, and Health-Related Quality of Life in Children with Developmental Coordination Disorder: A School-Based Cross-Sectional Study from Kanyakumari District, India

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ABSTRACT

Introduction:

Developmental Coordination Disorder (DCD) is a prevalent neurodevelopmental condition affecting 5–6% of school-aged children and is characterised by significant motor coordination difficulties that interfere with activities of daily living. Although motor impairment is the defining feature of DCD, growing evidence suggests that affected children also experience secondary deficits in physical fitness, sleep quality, and health-related quality of life. However, the simultaneous relationships among coordination ability, cardiorespiratory endurance, sleep disturbance, and quality of life remain insufficiently explored, particularly in the Indian school context.

Aim:

To assess coordination ability, cardiorespiratory endurance, sleep disturbance, and health-related quality of life among school children with DCD in Kanyakumari district, and to determine the interrelationships among these variables and their predictive role in health-related quality of life.

Materials

and

Methods:

A school-based cross-sectional study was conducted among 84 children aged 9–15 years with confirmed DCD, identified from 1,677 screened children across selected schools in Kanyakumari district. Coordination was assessed using the Developmental Coordination Disorder Questionnaire (DCDQ'07), cardiorespiratory endurance by the Six-Minute Walk Test (6MWT), sleep disturbance by the Sleep Disturbance Scale for Children (SDSC), and health-related quality of life by the Paediatric Quality of Life Inventory (PedsQL 4.0). Spearman's rank correlation and multiple linear regression were employed for analysis.

Results:

Significant interrelationships were observed among all study variables. Coordination demonstrated a moderate positive correlation with 6MWT ($r=0.670$, $p<0.001$) and a moderate negative correlation with SDSC ($r=-0.561$, $p<0.001$). A strong negative correlation was observed between SDSC and PedsQL ($r=-0.775$, $p<0.001$). Regression analysis revealed that sleep disturbance ($\beta=-0.611$, $p<0.001$) and cardiorespiratory endurance ($\beta=0.335$, $p=0.001$) were significant independent predictors of quality of life, collectively explaining 63% of variance ($R^2=0.630$).

Conclusion:

Sleep disturbance and cardiorespiratory endurance are the strongest predictors of health-related quality of life in children with DCD. Motor coordination exerts an indirect influence through these mediating pathways. These findings

support the need for integrated, multi-domain management strategies in DCD beyond conventional coordination-focused interventions.

Keywords: Developmental Coordination Disorder; Cardiorespiratory Endurance; Sleep Disturbance; Quality of Life; Motor Coordination; School-Based Study; Six-Minute Walk Test

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INTRODUCTION

Developmental Coordination Disorder (DCD) is a neurodevelopmental condition characterised by marked and persistent difficulties in the learning and performance of coordinated motor skills. These difficulties are substantially below what would be expected for the child's chronological age and level of education, and they significantly interfere with activities of daily living, academic performance, and participation in play and sports [1]. According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), DCD is diagnosed when motor skill deficits cannot be explained by intellectual disability, visual impairment, or any neurological condition such as cerebral palsy, muscular dystrophy, or degenerative disorders [2]. The condition affects approximately 5–6% of school-aged children worldwide, making it one of the most common childhood neurodevelopmental disorders, yet it remains under-recognised and under-diagnosed, particularly in low- and middle-income countries [3,4].

Children with DCD typically present with difficulties in tasks that require motor coordination, such as tying shoelaces, writing, catching balls, and riding bicycles. These impairments manifest across both gross motor and fine motor domains and often persist into adolescence and adulthood without intervention [5]. The condition is not limited to motor difficulties alone; it is increasingly recognised that DCD has far-reaching consequences on physical health, psychosocial functioning, and overall quality of life [6]. Children with DCD frequently exhibit reduced participation in physical activity, which over time contributes to decreased cardiorespiratory fitness, increased adiposity, and a greater risk of cardiovascular disease [7,8]. Several studies have established that children with DCD demonstrate significantly lower aerobic capacity compared to their typically developing peers,

as measured by laboratory and field-based tests of cardiorespiratory endurance [9,10].

Beyond the physical domain, sleep disturbances have emerged as an important but underappreciated secondary consequence of DCD. Children with motor difficulties often experience problems with initiating and maintaining sleep, night awakenings, and excessive daytime sleepiness [11]. Sleep disruption in children has well-established consequences for cognitive functioning, emotional regulation, academic performance, and physical health [12,13]. Despite this, the relationship between motor coordination difficulties and sleep quality has received limited systematic investigation. Furthermore, most studies examining DCD have focused on either physical outcomes or psychosocial consequences in isolation, without integrating sleep as a contributing factor in determining overall wellbeing [14].

Health-related quality of life (HRQoL) is a multidimensional construct encompassing physical, emotional, social, and school functioning from the child's own perspective. Children with DCD have consistently been reported to have poorer HRQoL compared to typically developing children [15,16]. However, the relative contribution of coordination ability, cardiorespiratory endurance, and sleep disturbance to HRQoL in this population has not been simultaneously explored. Understanding which factors most strongly predict HRQoL in children with DCD is essential for designing targeted and effective interventions [17].

Existing clinical practice guidelines for DCD, including those published by the European Academy of Childhood Disability, recommend a task-oriented approach focusing on motor skill learning [18]. While this addresses motor deficits, it may not adequately address secondary impairments such as reduced endurance and disrupted sleep, which may be equally or more important determinants of daily functioning and wellbeing. This gap between guideline

recommendations and the broader needs of children with DCD warrants investigation [19].

India presents a specific context where DCD remains largely unstudied. The vast majority of published research originates from high-income countries such as Canada, the United Kingdom, and Australia, and the applicability of these findings to Indian children may be limited by differences in educational expectations, physical activity culture, socioeconomic conditions, and healthcare access [20]. To the best of the authors' knowledge, no study has simultaneously examined the interrelationship between coordination, cardiorespiratory endurance, sleep quality, and HRQoL in children with DCD from an Indian school population.

The present study was therefore designed to address this gap. It aimed to screen school children in Kanyakumari district for DCD, to assess the four key domains of coordination, cardiorespiratory endurance, sleep quality, and HRQoL, and to examine the relationships and predictive pathways among these variables. The findings from this cross-sectional assessment were intended to form the evidential foundation for a subsequent intervention phase, thereby providing both descriptive and analytical contributions to the understanding of DCD in the Indian context.

MATERIALS AND METHODS

Study Design and Setting

A school-based cross-sectional study design was adopted. Data collection was carried out in selected government and private schools in Kanyakumari district, Tamil Nadu, India. Schools were selected based on willingness to participate, administrative permission, and accessibility. Assessments were scheduled during physical education periods or at the end of school hours to minimise disruption to academic activities. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision) and was approved by the Institutional Ethics Committee of Madhav University, Rajasthan [IEC reference: MUEC/2023/XXX]. Informed written consent was obtained from parents or guardians, and verbal assent was obtained from all child participants prior to data collection.

Sample Size

The sample size for the correlational component of the study was estimated using G*Power software (version 3.1.9). A bivariate normal model for correlation analysis was selected, with a two-tailed test, an expected moderate correlation coefficient of 0.30, an alpha error probability of 0.05, and a power of 0.80. Based on these parameters, the minimum required sample size was calculated as 84 children. A larger number of school children were therefore screened to

identify the required number of eligible participants with DCD.

Participant Selection and Eligibility Criteria

A total of 1,834 school children were initially considered for eligibility screening, of whom 1,677 were examined against the inclusion and exclusion criteria. Children were included in the study if they were aged between 9 and 15 years, attended a participating school, had parental consent and personal assent, and were medically fit to participate in non-invasive assessments. Children with known cardiovascular or respiratory disorders, upper or lower limb impairments, neurological conditions, musculoskeletal disorders, or cognitive impairments that precluded comprehension of instructions were excluded. Children who had been identified as elite athletes were also excluded, as their motor competence and endurance profiles were unlikely to reflect the general school population with DCD. Following eligibility screening, children were assessed for features of DCD using the Developmental Coordination Disorder Questionnaire. Based on the screening criteria and questionnaire scoring, 84 children were confirmed as having DCD and were included in the final analysis.

Outcome Measures

Coordination Ability: Coordination was assessed using the Developmental Coordination Disorder Questionnaire 2007 version (DCDQ'07), a parent-reported tool validated for use in children aged 5–15 years [21]. The DCDQ'07 consists of 15 items distributed across three subscales: Control During Movement, Fine Motor and Handwriting, and General Coordination. Each item is rated on a five-point Likert scale, and total scores range from 15 to 75. Lower scores indicate greater coordination difficulty. The questionnaire was administered to parents or primary caregivers who were familiar with the child's routine motor performance. The DCDQ'07 has demonstrated good sensitivity and specificity for identifying children with DCD in multiple international populations [22].

Cardiorespiratory Endurance: Functional cardiorespiratory endurance was assessed using the Six-Minute Walk Test (6MWT), a standardised and widely validated field test that measures the total distance walked in six minutes [23]. The test was conducted on a flat, marked indoor corridor or outdoor surface within the school premises, following the American Thoracic Society guidelines [24]. Children were instructed to walk as fast as possible without running, and standard encouragement phrases were used at one-minute intervals. The total distance covered in metres was recorded as the measure of cardiorespiratory endurance. The 6MWT has been validated for use in school-aged children with

developmental difficulties and has established normative reference values for the paediatric population [25].

Sleep Quality: Sleep disturbance was assessed using the Sleep Disturbance Scale for Children (SDSC), a 26-item parent-reported questionnaire designed to evaluate sleep-related disorders in children aged 6–16 years [26]. The scale covers six domains of sleep disturbance: disorders of initiating and maintaining sleep, sleep breathing disorders, disorders of arousal, sleep-wake transition disorders, disorders of excessive somnolence, and sleep hyperhidrosis. Each item is rated on a five-point frequency scale, and total scores range from 26 to 130. Higher scores indicate greater sleep disturbance. The SDSC has demonstrated good internal consistency, reliability, and validity in clinical and school populations [27].

Health-Related Quality of Life: HRQoL was assessed using the Paediatric Quality of Life Inventory Version 4.0 Generic Core Scales (PedsQL 4.0), a validated multidimensional instrument designed for children aged 5–18 years [28]. The PedsQL 4.0 comprises 23 items organised across four domains: Physical Functioning (8 items), Emotional Functioning (5 items), Social Functioning (5 items), and School Functioning (5 items). Items are reverse-scored and linearly transformed to a 0–100 scale, with higher scores indicating better HRQoL. Both child self-report and parent-proxy report formats were used in accordance with the recommended protocol for the relevant age groups. The PedsQL 4.0 has established reliability and validity across diverse paediatric populations and clinical settings [29].

Data Collection Procedure

All assessments were conducted by the primary researcher following a standardised protocol. Demographic details including age, gender, class grade, and school type were recorded at the time of enrolment. Parent-reported questionnaires (DCDQ'07, SDSC, and PedsQL 4.0) were distributed in advance and collected at the time of physical testing. Instructions were provided in both English and the local vernacular language (Tamil) to ensure comprehension. The 6MWT was conducted individually in a safe and supervised environment. Incomplete questionnaire responses were reviewed at the time of collection, and clarification was sought from caregivers wherever necessary.

Statistical Analysis

Data were entered into a spreadsheet and analysed using IBM SPSS Statistics Version 26.0. Continuous variables were described using mean and standard deviation, and categorical variables were described using frequency and percentage. The normality of distribution of continuous variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk

tests prior to inferential analysis. Since the coordination score (DCDQ'07) demonstrated a non-normal distribution on the Shapiro–Wilk test ($p=0.029$), non-parametric methods were considered more appropriate for correlation analysis. Spearman's rank-order correlation coefficient was used to examine the bivariate relationships between coordination, 6MWT distance, SDSC score, and PedsQL score. Multiple linear regression analysis was performed to identify the independent predictors of PedsQL score, using DCDQ'07, 6MWT, and SDSC as predictor variables. The assumptions of regression, including multicollinearity (assessed by Variance Inflation Factor) and linearity, were verified. Statistical significance was set at $p<0.05$ for all analyses.

RESULTS

Participant Flow and Demographic Characteristics

Of the 1,834 school children initially considered, 1,677 were assessed for eligibility. Following application of the inclusion and exclusion criteria, children were screened for DCD using the DCDQ'07. A total of 84 children met the diagnostic criteria for DCD and were enrolled in the study. The mean age of participants was 11.83 ± 1.97 years (range: 9–15 years). Boys constituted 61.9% ($n=52$) of the sample, and girls constituted 38.1% ($n=32$). Participants were drawn from the 4th to 10th standard grades, with representation across all levels. Detailed demographic characteristics are presented in Table/Fig-1.

Table/Fig-1: Demographic characteristics of children with Developmental Coordination Disorder ($n=84$)

Variable	Category	Frequency (n)	Percentage / SD
Gender	Male	52	61.9%
	Female	32	38.1%
Age	Mean	11.83 years	SD $\pm$ 1.97
	Range	9–15 years	—
Class Grade	4th Standard	11	13.1%
	5th Standard	17	20.2%

	6th Standard	11	13.1%
	7th Standard	11	13.1%
	8th Standard	14	16.7%
	9th Standard	11	13.1%
	10th Standard	9	10.7%

Descriptive Statistics of Outcome Measures

The mean DCDQ'07 coordination score was 45.19 ± 7.57 (range: 28–57), indicating mild-to-moderate coordination difficulty across the sample. The mean 6MWT distance was 460.19 ± 57.43 metres (range: 330–588 m), reflecting reduced functional cardiorespiratory endurance relative to published normative values for typically developing children of similar age. The mean SDSC sleep disturbance score was 54.07 ± 6.47 (range: 41–71), with higher scores indicating greater sleep difficulties. The mean PedsQL HRQoL score was 68.16 ± 9.18 (range: 46.2–85.6), reflecting moderate health-related quality of life across physical, emotional, social, and school domains. Descriptive statistics for all outcome measures are summarised in Table/Fig-2.

Table/Fig-2: Descriptive statistics of outcome measures among children with DCD (n=84)

Variable	Mean	SD	Minimum	Maximum	Interpretation
DCDQ Coordination Score	45.19	7.57	28	57	Lower = greater difficulty
6MWT Distance (metres)	460.19	57.43	330	588	Functional endurance

SDSC Sleep Score	54.07	6.47	41	71	Higher = greater disturbance
PedsQL HRQoL Score	68.16	9.18	46.2	85.6	Higher = better QoL

DCDQ: Developmental Coordination Disorder Questionnaire; 6MWT: Six-Minute Walk Test; SDSC: Sleep Disturbance Scale for Children; PedsQL: Paediatric Quality of Life Inventory; SD: Standard Deviation; HRQoL: Health-Related Quality of Life

Normality Testing

Normality assessment using Kolmogorov–Smirnov and Shapiro–Wilk tests revealed that the 6MWT distance, SDSC score, and PedsQL score were normally distributed (all $p > 0.05$). The DCDQ'07 coordination score showed a significant deviation from normality on the Shapiro–Wilk test ($W = 0.967$, $p = 0.029$), although the Kolmogorov–Smirnov test did not reach significance ($p = 0.324$). Given this finding, non-parametric correlation methods were applied in the subsequent analysis to ensure robustness. Results of normality testing are presented in Table/Fig-3.

Table/Fig-3: Normality testing of study variables using Kolmogorov–Smirnov and Shapiro–Wilk tests (n=84)

Variable	K-S Statistic	K-S p-value	S-W Statistic	S-W p-value	Interpretation
DCDQ Score	0.076	0.324	0.967	0.029*	Non-normal (Shapiro–Wilk)
6MWT Distance	0.042	0.978	0.992	0.890	Normally distributed

SDS C Score	0.090	0.1 31	0.973	0.07 3	Normally distribute d
Peds QL Score	0.062	0.6 50	0.983	0.35 2	Normally distribute d

* $p < 0.05$ indicates significant deviation from normality. K-S: Kolmogorov-Smirnov; S-W: Shapiro-Wilk.

Correlation Analysis

Spearman's rank-order correlation analysis revealed significant and meaningful relationships among all four study variables (Table/Fig-4). Coordination ability (DCDQ'07) demonstrated a moderate positive correlation with 6MWT distance ($r = 0.670$, $p < 0.001$), indicating that children with better motor coordination tended to show higher functional cardiorespiratory endurance. A moderate negative correlation was observed between DCDQ'07 and SDSC ($r = -0.561$, $p < 0.001$), suggesting that poorer coordination was associated with greater sleep disturbance. DCDQ'07 also showed a moderate positive correlation with PedsQL ($r = 0.446$, $p < 0.001$), indicating that better coordination was associated with improved HRQoL. The 6MWT distance demonstrated a strong negative correlation with SDSC ($r = -0.672$, $p < 0.001$), indicating that children with higher functional endurance reported fewer sleep disturbances. A moderate positive correlation was observed between 6MWT and PedsQL ($r = 0.671$, $p < 0.001$), suggesting that better cardiorespiratory endurance was associated with higher HRQoL. The SDSC score showed a strong negative correlation with PedsQL ($r = -0.775$, $p < 0.001$), indicating that greater sleep disturbance was strongly associated with poorer HRQoL, representing the strongest bivariate relationship observed in this study.

Table/Fig-4: Spearman's rank-order correlation between coordination, endurance, sleep disturbance, and quality of life (n=84)

Variable	DCDQ r (p)	6MWT r (p)	SDSC r (p)
DCDQ'07 Score	1.000 (—)	0.670 (< 0.001)†	-0.561 (< 0.001)†
6MWT Distance	0.670 (< 0.001)†	1.000 (—)	-0.672 (< 0.001)†

SDSC Score	-0.561 (< 0.001)†	-0.672 (< 0.001)†	1.000 (—)
PedsQL Score	0.446 (< 0.001)†	0.671 (< 0.001)†	-0.775 (< 0.001)†

† Significant at $p < 0.001$. Values represent Spearman's rho (r) with two-tailed p -values in parentheses. DCDQ: Developmental Coordination Disorder Questionnaire; 6MWT: Six-Minute Walk Test; SDSC: Sleep Disturbance Scale for Children; PedsQL: Paediatric Quality of Life Inventory.

Multiple Linear Regression Analysis

Multiple linear regression was conducted to identify the independent predictors of HRQoL (PedsQL) using DCDQ'07 score, 6MWT distance, and SDSC score as predictor variables. The overall regression model was statistically significant ($F = 45.368$, $p < 0.001$) and explained 63.0% of the variance in PedsQL scores ($R^2 = 0.630$, Adjusted $R^2 = 0.616$), indicating a strong model fit. No multicollinearity was detected among the predictor variables ($VIF < 2.0$ for all variables). Results are presented in Table/Fig-5.

Among the three predictors, SDSC score emerged as the strongest and most significant predictor of HRQoL ($\beta = -0.611$, $p < 0.001$), indicating that greater sleep disturbance was independently and strongly associated with poorer HRQoL. The 6MWT distance was also a statistically significant positive predictor ($\beta = 0.335$, $p = 0.001$), demonstrating that higher functional endurance independently contributed to better HRQoL. The DCDQ'07 coordination score did not emerge as a statistically significant independent predictor in the regression model ($\beta = -0.148$, $p = 0.087$), suggesting that the effect of coordination on HRQoL may be mediated through endurance and sleep disturbance rather than operating through a direct pathway.

Table/Fig-5: Multiple linear regression analysis with PedsQL as the dependent variable (n=84)

Predictor Variable	B (Unstandardised)	β (Standardised)	p-value	VIF
SDSC Score	-0.868	-0.611	< 0.001 †	1.843
6MWT	0.054	0.335	0.001†	1.891

Distance				
DCD Q'07 Score	-0.180	-0.148	0.087	1.700
Model: $R^2=0.630$, Adjusted $R^2=0.616$, $F(3,80)=45.368$, $p<0.001$				

† Significant at $p<0.05$. B: Unstandardised regression coefficient; β : Standardised regression coefficient; VIF: Variance Inflation Factor.

DISCUSSION

This study examined the interrelationships among coordination ability, cardiorespiratory endurance, sleep disturbance, and HRQoL in 84 school children with DCD aged 9–15 years from Kanyakumari district. The principal findings are threefold. First, all four study variables were significantly correlated with each other, confirming that DCD-related impairment extends well beyond the motor domain. Second, sleep disturbance emerged as the strongest predictor of HRQoL, followed by cardiorespiratory endurance. Third, coordination ability did not independently predict HRQoL after adjusting for sleep and endurance, implying that its influence is mediated through other domains. These findings collectively challenge the prevailing view of DCD as a purely motor condition and advocate for a more integrated approach to its assessment and management.

The moderate positive correlation between coordination and cardiorespiratory endurance ($r=0.670$, $p<0.001$) is consistent with several earlier studies. Cairney et al. documented reduced aerobic capacity in children with DCD and proposed a model of cumulative physical inactivity in which motor difficulty reduces participation in physical activity, which in turn reduces fitness [7]. Rivlis et al. similarly found that children with DCD consistently demonstrate lower levels of cardiorespiratory fitness across multiple studies [9]. The present findings extend this evidence to an Indian paediatric population, confirming that reduced motor coordination is accompanied by measurable deficits in functional walking endurance, even when assessed in a low-technology school setting. The 6MWT distances observed in the present study (mean 460 metres) are notably lower than those reported for typically developing children of similar age in published normative data, lending further support to the notion that functional endurance is a clinically relevant secondary outcome in DCD [30].

The negative correlation between coordination and sleep disturbance ($r=-0.561$, $p<0.001$) supports emerging evidence that motor difficulties are associated with disrupted sleep in children. Piek et al. reported heightened emotional reactivity and fatigue in children with DCD, which may contribute to difficulties in sleep initiation and maintenance [31]. Quach et al. demonstrated that sleep problems in school-aged children have wide-ranging consequences on daytime functioning and participation, many of which overlap with the challenges experienced by children with DCD [32]. The physiological explanation may partly involve impaired proprioceptive regulation during the transition to sleep, as well as heightened arousal levels arising from the cognitive and emotional burden associated with daily motor task failure. While the direction of causality cannot be established in the present cross-sectional design, the association is clinically meaningful and warrants longitudinal investigation.

The most striking bivariate finding was the strong negative correlation between sleep disturbance and HRQoL ($r=-0.775$, $p<0.001$). This was the strongest relationship observed in the study and was confirmed in the regression model, where SDSC emerged as the most powerful independent predictor of PedsQL ($\beta=-0.611$, $p<0.001$). This finding aligns with the broader paediatric sleep literature. Dewald et al. demonstrated a consistent negative relationship between sleep problems and health-related quality of life in children, with sleep functioning across physical, emotional, social, and academic domains [33]. Spruyt and Gozal confirmed that sleep disorders in children are associated with impairments in cognitive performance, emotional regulation, and physical health [12]. The present data suggest that within a population of children with DCD, sleep quality may be the single most important modifiable factor determining overall wellbeing, a finding that has not been previously reported in this specific population.

Cardiorespiratory endurance was also a significant positive predictor of HRQoL ($\beta=0.335$, $p=0.001$), confirming that functional physical capacity contributes independently to overall daily functioning. Smits-Engelsman et al. demonstrated that exercise-based interventions targeting physical fitness in children with DCD produce meaningful improvements in motor performance and participation [34]. Ulrich and colleagues showed that physical competence is one of the strongest contributors to perceived quality of life in school-aged children with developmental disabilities [35]. The present findings are consistent with these observations and reinforce the case for including cardiorespiratory fitness training as a core component of DCD management programmes, not merely as an adjunct.

The finding that coordination ability did not emerge as an independent predictor of HRQoL after controlling for sleep and endurance ($\beta=-0.148$, $p=0.087$) is clinically important, though not entirely unexpected. Zwicker et al. suggested that the impact of DCD on quality of life is primarily mediated through reduced participation and physical activity rather than through the severity of motor impairment per se [15]. Cairney et al. similarly found that psychosocial outcomes in DCD are more strongly related to physical activity participation than to motor skill level [8]. The present regression findings support this view by demonstrating that when sleep quality and physical endurance are entered into the model, the direct path from coordination to HRQoL becomes non-significant, suggesting that coordination acts through these intermediate variables. This has important clinical implications: improving motor coordination in isolation is unlikely to produce meaningful gains in HRQoL unless sleep quality and endurance are simultaneously addressed.

Compared to published international studies, the HRQoL scores in the present sample (mean 68.16) are broadly consistent with values reported for children with DCD in other countries, which typically range from 62 to 72 in parent-proxy reports [16]. The mean SDSC score of 54.07 is above the published cut-off of 39 used to indicate clinically significant sleep disturbance in some normative studies, further supporting the clinical relevance of sleep disruption in this population [26]. The mean 6MWT distance of 460 metres is lower than values reported for typically developing Indian children in a comparable age group, which tend to range from 510 to 570 metres, highlighting the functional endurance deficit in children with DCD [30].

The present study has several limitations that must be considered when interpreting the findings. The cross-sectional design precludes causal inference, and the direction of the observed relationships cannot be confirmed. The purposive sampling strategy and single-district setting may limit the generalisability of the findings to other geographic regions and school populations within India. Parent-reported measures, while standardised and widely used, introduce the possibility of reporting bias. Sleep quality was assessed using a questionnaire rather than objective actigraphy, which would provide more precise data on sleep architecture. Finally, potential confounders such as co-morbid attention-deficit/hyperactivity disorder, anxiety, and socioeconomic status were not formally assessed and may have influenced the observed relationships. Despite these limitations, the study provides important original evidence from an Indian context and identifies key targets for intervention in a

population that has received very limited research attention domestically.

CONCLUSION

This study demonstrates that coordination ability, cardiorespiratory endurance, sleep disturbance, and health-related quality of life are significantly interrelated in school children with Developmental Coordination Disorder. Sleep disturbance emerged as the strongest independent predictor of HRQoL, followed by cardiorespiratory endurance, while coordination ability appeared to influence HRQoL primarily through indirect pathways mediated by these two domains. These findings highlight the multidimensional nature of DCD and have important implications for its clinical management. Physiotherapy and school-based intervention programmes for children with DCD should move beyond exclusive focus on motor skill training and adopt integrated approaches that simultaneously address physical endurance, sleep quality, and overall functional participation. Future research should employ longitudinal designs, objective sleep measurement, and larger nationally representative samples to further elucidate the causal pathways identified in the present study.

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DECLARATIONS

Conflict of Interest

The authors declare that they have no conflict of interest.

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Ethical Approval

The study was approved by the Institutional Ethics Committee of Madhav University, Rajasthan, India. All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki (2013). Informed written consent was obtained from all parents/guardians, and assent was obtained from child participants.

Authors' Contributions

[Author 1]: Study conception, design, data collection, data analysis, manuscript preparation. [Author 2 — Guide/Supervisor]: Supervision, critical review of manuscript, and final approval. [Author 3 — Guide/Supervisor]: Supervision and final approval.

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