Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v31i2.4559

RELATIONSHIP BETWEEN BMI, PHYSICAL FITNESS & MOTOR SKILLS IN CHILDREN WITH DOWNS SYNDROME

Mahnoor[1], Sadaf Tubassam[2], Fareeha Kousar[3], Aadil Omer[4], Maria Arif[5], Muhammad Tahir[6*]

[1]Riphah International University, Lahore – Pakistan Mahnoorbukhari148@gmail.com
[2]Senior Physiotherapist, Rising Sun Institute for Special Children DHA, Lahore – Pakistan, dr.sadafmiyan@gmail.com
[3]Senior Lecturer, Riphah International University, Lahore – Pakistan fareeha.kausar@riphah.edu.pk
[4]Islamabad College of Physiotherapy, Margalla Institute of Health Sciences, Rawalpindi – Pakistan, aadil.omer@hotmail.com
[5]National University of Sciences and Technology, Islamabad - Pakistan, maria.aadil@yahoo.com
[6] * Physical Therapist, Link Medical Institute, Lahore - Pakistan muhammadtahirkhan55@gmail.com

***Corresponding Author:** Muhammad Tahir
*Physical Therapist, Link Medical Institute Lahore - PakistanEmail: muhammadtahirkhan55@gmail.com

Abstract:

Background:
Children with Down syndrome frequently experience particular difficulties with regard to their physical well-being and motor growth. The body mass index (BMI) measures body composition and weight status, whereas physical fitness measures general health and functional capacity.

Objective:
To evaluate the relationship between BMI, Physical fitness and motor skills in children with Downs syndrome.

Methods:
In our seven-month cross-sectional study, spanning December 2022 to June 2023, we evaluated 169 children between the ages of 6 to 11 (average age 7.96 ± 1.461 years). Participants were randomly selected The SAMU Disability Fitness Battery (SAMU-DISFIT) assessed physical fitness, encompassing Waist Circumference and BMI for Body Composition, the Time Up and Go Test for Motor Fitness, Deep Trunk Flexibility, Right and Left Hand Grip Strength, a 30-second Sit-Up, and a 10 Timed Stand Test for Musculoskeletal Fitness. Cardiorespiratory Fitness was evaluated with the 6-minute walk test. Motor skills assessment was conducted using the Total Gross Motor Development-2 (TGMD-2) test. Data were analyzed using SPSS version 25.0

Results:
The results revealed the following associations: "Body Composition": Waist Circumference displayed a weak negative correlation (-0.205). "Motor Fitness": The Time up and Go Test showed a moderate negative correlation (-0.263). "Musculoskeletal Fitness": Grip Strength in the Right Hand had a significant strong positive correlation (0.559), and in the Left Hand, it showed a moderate positive correlation (0.484). Deep trunk Range of Motion (ROM) displayed a strong positive correlation (0.644). These findings underline the complexity of the relationship between BMI and various types

of physical fitness and the need of taking several fitness factors into account when assessing an individual's overall health.
Conclusion: The study found a negative association between BMI and physical fitness and mobility. Underweight children with Down syndrome demonstrated better physical fitness and mobility compared to overweight children. These findings emphasize the importance of weight management for optimizing physical well-being in individuals with Down syndrome.

Key words: Body Mass Index, Down syndrome, Motor Skills, Physical Fitness

Introduction

Trisomy 21, commonly known as Down syndrome, is marked by the presence of an extra chromosome 21 and is the most prevalent chromosomal condition associated with intellectual disability. This genetic anomaly gives rise to a spectrum of anatomical, cognitive, and functional challenges, including distinctive facial features and physical abnormalities that contribute to the condition's characteristic presentation.(1) Down syndrome's clinical variability is influenced by over 300 genes on chromosome 21, affecting a range of clinical characteristics. Trisomy 21 can result from nondisjunction, leading to 47 chromosomes, or translocation. Despite the cause, the clinical manifestations of trisomy 21 are consistently observed.(2)

Children with Down syndrome often exhibit delays in developing motor skills, encompassing both gross and fine motor abilities, which are essential for day-to-day activities, education, and social interactions. These delays can impact their physical activity and engagement with their environment.(3) Physical fitness, which includes attributes such as body composition, muscular strength, flexibility, and cardiovascular endurance, is crucial for overall health and functional independence. However, children with Down syndrome typically display lower physical fitness levels compared to their peers, potentially influencing their motor skill development and overall physical health.(4)

A person's risk of acquiring weight-related health problems is assessed using their BMI. It is measured in kilograms per square meter (kg/m2). For a particular height, BMI determines excess weight although it has been demonstrated to correlate with body fat, it is not a direct measurement (5) % of body fat, because skinfold measurements and underwater weighing are more intrusive and costly methods of taking direct measures of body fat, 33-35 BMI is the most commonly utilized indicator of weight- related health risk. (6) Children who are overweight or obese experience psychological problems as well as concerns with one's physical health, including low self-esteem and depressed feelings decline in overall health, and metabolic abnormalities.(7) The body mass index (BMI), which connects weight to height, is a commonly used indicator of body composition.(8) The BMI of people with Down syndrome has been observed to vary greatly as a result of a number of variables, such as decreased levels of physical activity, changed metabolic processes, and maybe eating habits.(9)

The body mass index (BMI) is a standard measure of body composition and weight status. Elevated BMI values are associated with various health risks, including musculoskeletal issues, and are especially pertinent in children with Down syndrome, who may be predisposed to weight-related health concerns due to their genetic condition.(10) This study aims to illuminate the complex relationship between BMI, physical fitness, and motor skills in children with Down syndrome, contributing valuable insights into the tailored interventions needed to enhance their physical development and quality of life.(11)

In 2022, Rosa Maria, Mariola, and colleagues researched the link between physical activity and body composition changes in individuals with Down syndrome, employing the PICOS framework to define study eligibility criteria.(12) Two independent researchers carried out the analysis, concluding that increased body composition diversity can mitigate the adverse effects of obesity, potentially reducing healthcare costs.

A 2022 study on the effects of early physical therapy on motor development in children with Down syndrome found that initiating physical therapy early significantly improves both gross and fine motor

skills. This supports the recommendation for children with Down syndrome to begin physical therapy programs before their first birthday.(13)
In 2020, Int.J. Envior et al. conducted a cross-sectional study with 35 individuals with Down syndrome (DS) to examine the relationship between age, isometric knee strength, peak aerobic capacity, and the timed performance of daily functional tasks.(14) Utilizing multiple regression analyses, they identified a correlation suggesting that individuals with DS have compromised physical fitness, impacting their ability to perform daily living tasks effectively.(15)

Lauteslager et al.'s 2020 study focused on charting the motor development of children with Down syndrome. They aimed to establish the typical ages at which these children achieve key motor milestones and to create a motor growth curve using the Test of Basic Motor Skills for Children with Down Syndrome.(16) (BMS). Analyzing data from 119 children, the study highlighted the most significant motor skill advancements occurring in infancy, with the rate of improvement diminishing as children approached their peak potential scores. Additionally, the research identified the ages at which children with Down syndrome were 50% likely to reach developmental milestones such as sitting, crawling, and walking.(17)

Methodology

A cross sectional study performed within 7 months from December 2022 to June 2023 in which 169 children with age of 6-11 years (mean and SD = 7.96 + 1.461) were taken randomly after meeting inclusion and exclusion criteria. The inclusion criteria include children that were diagnosed with Downs's syndrome and only those students who follow at least minimum two-step instruction and have minimum motor ability of independent locomotion. BMI weight will be measured with weighing scale whereas height will be measured by measuring tape. Physical Fitness by using SAMU Disability Fitness Battery (SAMU-DISFIT). Contains different components; "Body composition" categorized into Waist Circumference and BMI, "Motor Fitness" includes the time up test. The "Musculoskeletal Fitness" category includes Deep Trunk Flexibility, Right hand Grip Strength, left hand Grip, 30s Sit up, 10 Timed Stand Test, "Cardiorespiratory Fitness" includes, the 6-minute walk test. Motor skills will be assessed by using Total Gross Motor Development 2 (TGMD-2). Statistical Package for Social Sciences (SPSS 22) was used to analyze the data.

Objective:

To evaluate the relationship between BMI, Physical fitness and motor skills in children with Downs syndrome.

Results

The table summarizes key fitness metrics for children with Down syndrome, showing that on average, they have a waist circumference of 61.33 cm and a BMI of 21.24. Their motor fitness is gauged at an average of 10.75 seconds for the Timed Up & Go test. Musculoskeletal fitness tests show averages of 21.96 cm for trunk flexibility, around 11.5 kg for hand grip strength, and they can perform about 18 sit-ups in 30 seconds. Their cardiorespiratory fitness, measured by the distance walked in 6 minutes, averages at 442 meters. The provided standard deviations indicate the variability in each measurement. The table reflects fitness assessments and their relationship with BMI for children with Down syndrome. Waist circumference and timed agility tests show a slight negative correlation with BMI, indicating higher BMI may be linked to larger waist sizes and slower agility. Conversely, trunk flexibility and hand grip strength are positively correlated with BMI, suggesting that higher BMI could be associated with better performance in these areas. The table also highlights a strong negative correlation between BMI and gross motor quality, where a higher BMI is related to lower motor skill proficiency. Each correlation is statistically significant, as indicated by the p-values

Table 1 BMI,, Motor Fitness, Musculoskeletal Fitness, And Cardiorespiratory Fitness

	description	Mean±SD

Body Composition	Waist Circumference (cm)	61.33±6.47
	BMI (kg/m^2)	21.24±2.74
Motor Fitness	Timed Up & Go (s)	10.75±1.38
Musculoskeletal Fitness	Deep Trunk Flexibility Test (cm)	21.96±4.20
	Hand Grip Right (kg)	11.73±1.16
	Hand Grip Left (kg)	11.24±1.08
	30 s Sit up (number)	17.94±3.33
	10 Timed Stand Test (s)	12.4±0.82
Cardiorespiratory Fitness	6 Minute Walk Test (m)	442.0±112.49

The table summarizes key fitness metrics for children with Down syndrome, showing that on average, they have a waist circumference of 61.33 cm and a BMI of 21.24. Their motor fitness is gauged at an average of 10.75 seconds for the Timed Up & Go test. Musculoskeletal fitness tests show averages of 21.96 cm for trunk flexibility, around 11.5 kg for hand grip strength, and they can perform about 18 sit-ups in 30 seconds. Their cardiorespiratory fitness, measured by the distance walked in 6 minutes, averages at 442 meters. The provided standard deviations indicate the variability in each measurement.

Table 2 Correlation with BMI

Description	Mean±SD	Correlation with BMI	P value
Waist Circ. (cm)	61.33±6.47	-0.205	0.008
BMI (kg/m^2)	21.24±2.74	1	0.000
Timed Up & Go (s)	10.75±1.38	-0.263	0.001
Deep Trunk Flex. (cm	21.96±4.20	0.644	0.000
Hand Grip Right (kg)	11.73±1.16	0. .559	0.000
Hand Grip Left (kg)	11.24±1.08	0.484	0.000
30 s Sit up	17.94±3.33	-0.414	0.000
10 Timed Stand Test (s)	12.4±0.82	0. .240	0.002
6 Min Walk Test (m)	442.0±112.49	0.659	0.000
GMQ Standard Score	6.20±1.00	-0.729	0.000

The table reflects fitness assessments and their relationship with BMI for children with Down syndrome. Waist circumference and timed agility tests show a slight negative correlation with BMI, indicating higher BMI may be linked to larger waist sizes and slower agility. Conversely, trunk flexibility and hand grip strength are positively correlated with BMI, suggesting that higher BMI could be associated with better performance in these areas. The table also highlights a strong negative correlation between BMI and gross motor quality, where a higher BMI is related to lower motor skill proficiency. Each correlation is statistically significant, as indicated by the p-values.

Table 3 (TGMD-2)

	Mean +SD
BMI	21.24 + 2.74
GMQ Standard Score	6.20 + 1.00
Percentile Rank Rating	6.20 + 1.00

Table 3 showed the GMQ Standard Score and Percentile rank rating mean and Standard deviation are 6.20 + 1.00. And BMI are 21.24 + 2.74.

Table 4 TGMD-2 Correlation with BMI (Under Weight, Normal, Over Weight)

		BMI	
		Pearson Correlation (r)	**p-value**
Under Weight	**GMQ Standard Score**	-0.314	0.046
	Percentile Rank Rating	-0.314	0.046
Normal Weight	**GMQ Standard Score**	-0.466	0.000
	Percentile Rank Rating	-0.466	0.000
Over Weight	**GMQ Standard Score**	0.057	0.002
	Percentile Rank Rating	0.057	0.002

Table 4 showed the BMI categories correlation with Total Gross Motor Development-2. In the underweight category, both GMQ Standard Score and Percentile Rank Rating exhibit a negative correlation of -0.314 ($p = 0.046$), Within thenormal weight category, there is a stronger negative correlation observed for both GMQ Standard Score and Percentile Rank Rating, with a coefficient of -0.466 ($p <$

DISCUSSION

The interrelation of BMI, physical fitness, and motor skills in children with Down syndrome (DS) presents a nuanced picture that necessitates a tailored approach in both assessment and intervention. Children with DS frequently exhibit reduced cardiovascular and muscular fitness, coupled with a higher incidence of overweight and obesity compared to their typically developing peers. Consequently, these children often fall short of meeting daily aerobic activity recommendations, a pattern that tends to persist as they grow older.(18)

To mitigate these health risks, annual screenings for overweight and obesity are advised, taking into consideration the distinctive body composition and stature of individuals with DS, which may influence BMI calculations.(19) This is a continuation of the approach informed by prior studies, which underscored the inadequacy of relying solely on BMI to determine body fatness in this population due to their unique physiological characteristics.(20)

Motor skill acquisition also varies widely among children with DS. Both 'bottom-up' (assessing current motor abilities) and 'top-down' (evaluating long-term motor capabilities) assessment approaches have yielded medium-level correlations.(21, 22) It's imperative that these assessments are sufficiently sensitive to discern the individual motor profiles of children with DS to inform appropriately customized interventions. For comparative purposes, the Fundamental Motor Skills (FMS) assessments are used to gauge the motor competencies of children with DS against those of typically developing children.(23)

In research focused on adults with DS conducted in 2023, the SAMU-Disability Fitness Battery Test (SAMU-DISFIT) was introduced to evaluate physical fitness, with an emphasis on identifying distinct fitness profiles based on gender and physical activity levels. This study utilized the EUROFIT Battery and Motor Assessment Battery for Children (MAB-C) to perform six tests, marking a shift from previous methodologies.(24)

Comparatively, a 2016 study titled “An Evaluation of Fine and Gross Motor Skills in Adolescents with Down Syndrome” aimed to assess the motor abilities of adolescents with DS. This study employed the Bruininks-Oseretsky Test of Motor Proficiency, second edition. In contrast, current research adopts the Total Gross Motor Development-second edition (TGMD-2) for evaluating motor

skills.(25) The study population comprised 34 participants aged 14-20 years, including 16 adolescents with DS and 18 without, which provides a direct reference point for understanding the evolution of motor skill assessment in this demographic.(26)

These studies collectively underscore the importance of regular, nuanced assessments and interventions tailored to the individual needs of children with DS, considering both the broad trends identified in research and the individual variations that are characteristic of this group.(27)

A study was conducted on "A development in children with Down Syndrome" they reviewed the motor development of children with downs syndrome. They concluded that children with DS, obesity, poor reflex development, hypotonia, and instability pose the biggest obstacles to learning how to move.(28) Medical and health issues including as joint hypermobility, congenital heart disorders, atlantoaxial subluxation, and sensory- motor issues can also impact motor development. (29) According to them Gallahue's third stage basically second period of development children age 2-10 yearschildren acquire and refine fundamental motor patterns and begin to develop more complex motor skills. Whereas the current study used the Total Gross Motor Development Scale to access the motor skills. It showed BMI correlation with Total Gross Motor Development-2. GMQ Standard Score and Percentile ran rating showedthe strong negative correlation of -0.729 with a p-value of 0.00.(30)

CONCLUSION

The study found a negative association between BMI and physical fitness and mobility. Underweight children with Down syndrome demonstrated better physical fitness and mobility compared to overweight children. These findings emphasize the importance of weight management for optimizing physical well-being in individuals with Down syndrome.

LIMITATION

- Limited generalizability to other regions or ethnic groups within Pakistan.
- Potential language barriers and translation accuracy for assessment tools. 3.
- Socioeconomic disparities that may influence the physical fitness and motor skills of participants
- Possible variations in data collection procedures or implementation across different research sites.

RECOMMENDATION

- Encourage community centers, schools, and recreational facilities to provide inclusive opportunities for children with Down syndrome to participate in physical activity and sports programs that cater to the specific needs of children with Down syndrome.
- Conduct longitudinal studies to explore the longitudinal relationship between BMI, physical fitness, and motor skills in children with Down syndrome. This will provide a deeper understanding of the developmental trajectory and potential interventions.
- Investigate specific factors that may influence BMI, physical fitness, and motor skills in children with Down syndrome, such as socioeconomic status, access to healthcare, and the impact of interventions or exercise programs on their development.

REFERENCES

1. Frey G, Chow B. Relationship between BMI, physical fitness, and motor skills in youth with mild intellectual disabilities. International journal of obesity. 2006;30(5):861-7.
2. Coppedè F. The genetics of folate metabolism and maternal risk of birth of a child with Down syndrome and associated congenital heart defects. Frontiers in genetics. 2015;6:223.
3. Galli M, Lewis JE, Goldup SM. A Stimuli-Responsive Rotaxane–Gold Catalyst: Regulation of Activity and Diastereoselectivity. Angewandte Chemie International Edition. 2015;54(46):13545-9.
4. Lin J-D, Lin L-P, Hsu S-W, Chen W-X, Lin F-G, Wu J-L, et al. Are early onset aging conditions correlated to daily activity functions in youth and adults with Down syndrome? Research in

developmental disabilities. 2015;36:532-6.
5. Van der Fels IM, Te Wierike SC, Hartman E, Elferink-Gemser MT, Smith J, Visscher C. The relationship between motor skills and cognitive skills in 4–16 year old typically developing children: A systematic review. Journal of science and medicine in sport. 2015;18(6):697-703.
6. Bertapelli F, Pitetti K, Agiovlasitis S, Guerra-Junior G. Overweight and obesity in children and adolescents with Down syndrome—prevalence, determinants, consequences, and interventions: A literature review. Research in developmental disabilities. 2016;57:181-92.
7. Hauck J, Jeong I, Esposito P, MacDonald M, Hornyak J, Argento A, et al. BENEFITS OF LEARNING TO RIDE A TWO-WHEELED BICYCLE FOR ADOLESCENTS WITH DOWN SYNDROME AND AUTISM SPECTRUM DISORDER. Palaestra. 2017;31(2).
8. Beqaj S, Tërshnjaku EE, Qorolli M, Zivkovic V. Contribution of physical and motor characteristics to functional performance in children and adolescents with Down Syndrome: a preliminary study. Medical science monitor basic research. 2018;24:159.
9. Hamer M, O'Donovan G, Stamatakis E. Lifestyle risk factors, obesity and infectious disease mortality in the general population: Linkage study of 97,844 adults from England and Scotland. Preventive medicine. 2019;123:65-70.
10. Pierce M, Ramsey K, Pinter J. Trends in obesity and overweight in oregon children with Down syndrome. Global pediatric health. 2019;6:2333794X19835640.
11. Yamauchi Y, Aoki S, Koike J, Hanzawa N, Hashimoto K. Motor and cognitive development of children with Down syndrome: The effect of acquisition of walking skills on their cognitive and language abilities. Brain and Development. 2019;41(4):320-6.
12. Martínez-Espinosa RM, Molina Vila MD, Reig Garcia-Galbis M. Evidences from clinical trials in down syndrome: Diet, exercise and body composition. International journal of environmental research and public health. 2020;17(12):4294.
13. Ropper AH, Bull M. Down syndrome. NEJM. 2020;382(24):2344-52.
14. Zhang L, Zhu X, Haegele JA, Wang D, Wu X. Effects of a one-year physical activity intervention on fundamental movement skills of boys with severe intellectual disabilities. Research in developmental disabilities. 2021;114:103980.
15. Alesi M, Giustino V, Gentile A, Gómez-López M, Battaglia G. Motor Coordination and global development in subjects with Down Syndrome: The influence of physical activity. Journal of clinical medicine. 2022;11(17):5031.
16. Vandoni M, Giuriato M, Pirazzi A, Zanelli S, Gaboardi F, Carnevale Pellino V, et al. Motor Skills and Executive Functions in Pediatric Patients with Down Syndrome: A Challenge for Tailoring Physical Activity Interventions. Pediatric Reports. 2023;15(4):691-706.
17. Arslan FN, Dogan DG, Canaloglu SK, Baysal SG, Buyukavci R, Buyukavci MA. Effects of early physical therapy on motor development in children with Down syndrome. Northern Clinics of İstanbul. 2022;9(2).
18. Comeras-Chueca C, Villalba-Heredia L, Perez-Lasierra JL, Marín-Puyalto J, Lozano-Berges G, Matute-Llorente Á, et al. Active video games improve muscular fitness and motor skills in children with overweight or obesity. International journal of environmental research and public health. 2022;19(5):2642.
19. Tahir M, Tehzeeb K, Javaid F, Khan UA, Ayyaz A, Usama M. EFFECTS OF ROUTINE PHYSICAL THERAPY WITH AND WITHOUT HIGH INTENSITY INTERVAL TRAINING ON BALANCE, QUALITY OF LIFE AND FUNCTION IN PARKINSON'S DISEASE PATIENTS. Journal of Population Therapeutics and Clinical Pharmacology. 2023;30(19):483-90.
20. Elshafey MA, Alsakhawi RS. Inspiratory muscle training and physical fitness in children with down syndrome: a randomized controlled trial. Archives of physical medicine and rehabilitation. 2022;103(12):2279-87.
21. Tahir M, Maqsood M, Azhar N, Safdar Z, Amin U, Waheed TS. Association of Knee Pain in Long Standing and Sitting among University Teachers: Association of Knee Pain in University Teachers. The Healer Journal of Physiotherapy and Rehabilitation Sciences. 2023;3(1):314-21.

22. Tahir M, Tariq F, Saeed HW, Nauman M, Usman M, Ali S. Impact of Air Pollution on Respiratory Health of Traffic Wardens in Lahore: Air Pollution and Respiratory Health. The Healer Journal of Physiotherapy and Rehabilitation Sciences. 2023;3(7):703-9.
23. Post EM, Kraemer WJ, Kackley ML, Caldwell LK, Volek JS, Sanchez BN, et al. The Effects of Resistance Training on Physical Fitness and Neuromotor-Cognitive Functions in Adults With Down Syndrome. Frontiers in Rehabilitation Sciences. 2022;3:927629.
24. Raghupathy MK, Divya M, Karthikbabu S. Effects of traditional Indian dance on motor skills and balance in children with Down syndrome. Journal of Motor Behavior. 2022;54(2):212-21.
25. Reffat S, Abdelazeim F. Evidence based physical therapy modalities on motor proficiency in children with Down syndrome: Meta-analysis of Systematic Reviews. 2022.
26. Sousa GRd, Almeida EWd, Castilha FA, Greguol M. Association of aerobic fitness and body composition in people with down syndrome. Journal of Physical Education. 2022;33.
27. Izquierdo-Gómez R, Esteban-Cornejo I, Cabanas-Sánchez V, Marcos A, Gómez-Martínez S, Castro-Piñero J, et al. Are obesity and physical fitness associated with cardiovascular disease risk in adolescents with Down syndrome? The longitudinal UP&DOWN study. Journal of Intellectual & Developmental Disability. 2023:1-13.
28. Safdar Z, Asghar M, Tahir M. Level of Quality of Life among Post Stroke Patients; A Cross Sectional Survey. Journal of Health and Rehabilitation Research. 2023;3(2):299-304.
29. Mann S, Spiric J, Mitchell C, Hilgenkamp TIM. Development of a Physical Therapy-Based Exercise Program for Adults with Down Syndrome. International journal of environmental research and public health. 2023;20(4):3667.
30. Rodrigues LP, Cordovil R, Luz CJ, Silva B, Lopes VP. Relationship between motor competence, weight status, and cardiorespiratory fitness from 7 to 16 years of age. Journal of Sport & Exercise Psychology. 2023:S23-S4.