

Physical activity as a factor supporting psychomotor development, autonomy, and quality of life in children and adolescents with Down syndrome: a narrative literature review

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Abstract

Physical activity plays a significant role in supporting the psychomotor development, functional independence, and quality of life of children and adolescents with Down syndrome. The aim of this narrative literature review was to assess the effects of various forms of physical activity on psychomotor development, autonomy, and quality of life in children and adolescents with Down syndrome. Publications were searched in PubMed, Scopus, Web of Science, PsycINFO, and SPORTDiscus, focusing on 2023-2026 with supplementary consideration of older works of significant empirical and theoretical importance. A total of 45 publications were included in the narrative synthesis. Findings suggest that aerobic and resistance training, balance and coordination exercises, treadmill training, Pilates, cognitive-motor training, and virtual reality-based interventions may improve motor fitness, balance, coordination, muscle strength, and functional mobility. The most consistent evidence concerns improvements in balance, including dynamic balance, and muscle strength. Evidence regarding executive functions, autonomy, and health-related quality of life remains limited and inconclusive. Interpretation is constrained by small sample sizes, heterogeneous interventions, varied outcome assessment methods, and limited long-term follow-up. Physical activity may therefore be an important component of comprehensive support for the development and everyday functioning of children and adolescents with Down syndrome.

Keywords: Down syndrome, motor skills, physical activity, exercise, child

Introduction

Down syndrome is a genetically determined developmental disorder that most often results from an extra copy of chromosome 21. The clinical presentation includes intellectual disability of varying severity, as well as hypotonia, increased joint and ligamentous laxity, and delayed motor development [1]. Children with Down syndrome also exhibit difficulties with balance, coordination, and postural control [2,3]. Motor proficiency is linked to aspects of cognitive, emotional, and social functioning. Developing motor skills can foster greater independence, mobility, and participation in daily activities. Conversely, difficulties with balance, locomotion, and coordination can limit opportunities for independent action and increase the need for support from parents or caregivers [2,4]. Studies indicate that individuals with Down syndrome engage in more low-intensity activity and tend to participate less in moderate- and high-intensity activities [5].

Research indicates that regular and appropriately designed physical activity may help reduce some motor difficulties and physical fitness deficits in children and adolescents with Down syndrome [4,6]. Furthermore, various exercise programs can improve muscular fitness, cardiorespiratory fitness, dynamic and overall balance, agility, and functional performance, although the results vary depending on the type and duration of the intervention [3,7]. Developing functional motor and recreational skills, which can be utilized outside the therapeutic setting, may be of particular importance. Activities such as cycling, swimming, independent mobility, or participation in adapted sports can expand the range of available leisure options and foster greater social participation [4,8]. Autonomy includes not only independence in daily activities but also the ability to make choices, engage in activities aligned with one's interests, and participate in the local community.

Research findings indicate that appropriately tailored physical activity can support autonomy as well as the physical, psychological, emotional, and social dimensions of quality of life for individuals with Down syndrome [4]. It may also foster competence and self-efficacy; however, evidence on these specific psychosocial effects remains limited and requires further study [4,9]. Review findings indicate that digital physical activity interventions can support physical activity, fitness, and the development of selected motor skills in individuals with intellectual and developmental disabilities [10].

Studies involving children and adolescents with Down syndrome have shown the benefits of virtual reality-based therapy for overall motor function, dynamic balance, and muscular endurance [11]. Aquatic programs also represent a promising way to support physical activity among children and adolescents with disabilities. Because of buoyancy, the aquatic environment reduces the effective load on the musculoskeletal system, while water resistance can be used to train strength and movement control. The hydrostatic and hydrodynamic properties of water can facilitate exercise for individuals with limited motor function. A scoping review by Ogonowska-Slodownik et al. indicates that aquatic therapy for children and adolescents involves, among other approaches, physical exercises, aquatic skills training, and swimming programs, with observed benefits primarily relating to motor and psychosocial functioning [12].

Physical activity is a multidimensional factor that supports the health and development of children and adolescents with Down syndrome. Its significance extends beyond preventing excess body weight and improving physical fitness, encompassing the development of motor skills, cognitive-motor functions, independence, social participation, and selected aspects of

well-being. Despite the growing number of studies and reviews concerning the impact of physical activity on balance, motor performance, and physical fitness in individuals with Down syndrome [3,7], as well as on their autonomy and quality of life [4], there remains a need for an integrated approach to these issues, taking into account the interrelationships between psychomotor development, independence, social participation, and the quality of life of children and adolescents with Down syndrome.

Aim of the work

The aim of this narrative review is to present and synthesize current scientific evidence on physical activity levels, sedentary behaviors, and barriers to and facilitators of physical activity participation among children and adolescents with Down syndrome, as well as the associations between different forms of physical activity and motor development, cognitive functioning, autonomy, social participation, and quality of life in this population.

Methods

This study used a narrative literature review design. The literature review was based on scientific publications from the years 2023-2026, available in the PubMed, Scopus, Web of Science, PsycINFO, and SPORTDiscus databases, with supplementary consideration of older works of significant empirical and theoretical importance. Additionally, the reference lists of selected review articles, meta-analyses, and clinical guidelines were analyzed to identify relevant studies meeting the established thematic criteria. The search scope included the terms: Down syndrome, physical activity, exercise, motor skills, child, adolescent, and quality of life.

Publications meeting the inclusion criteria were selected for the main narrative synthesis:

1. Scientific publications, systematic reviews, meta-analyses, and thematically relevant narrative reviews from the years 2023-2026, with the option to include older works of significant importance to the topics discussed.
2. Studies concerning children and adolescents with Down syndrome, with particular focus on the 0-18 age group, as well as studies covering broader age ranges, if it was possible to isolate results related to the pediatric population.

3. Publications analyzing levels of physical activity, sedentary behavior, participation in sports and recreational activities, as well as barriers to and facilitators of physical activity.
4. Studies evaluating the associations of physical activity or the effects of exercise interventions regarding at least one of the following areas: motor development and fitness, balance, coordination, muscle strength, functional mobility, autonomy, social participation, quality of life, or body composition.
5. Observational and interventional studies, including randomized controlled trials, non-randomized studies, and cross-sectional studies, as well as reviews enabling the analysis of available results and their methodological limitations.

The following were excluded:

1. Publications unrelated to the topic under investigation.
2. Studies of other intellectual disabilities and neurodevelopmental disorders that did not provide data specific to Down syndrome nor relevant context for the issues discussed.
3. Studies focusing exclusively on pharmacological interventions, surgical procedures, or other medical procedures unrelated to the physical activity and functional outcomes addressed in this review.
4. Non-scientific materials.
5. Duplicate bibliographic records and publications for which the available information was insufficient to assess their relevance to the review.

The process of identifying, selecting, and including publications is illustrated by a simplified flow diagram inspired by PRISMA 2020 (Figure 1). Given the narrative nature of the study, the diagram is used solely to present the structured selection process.

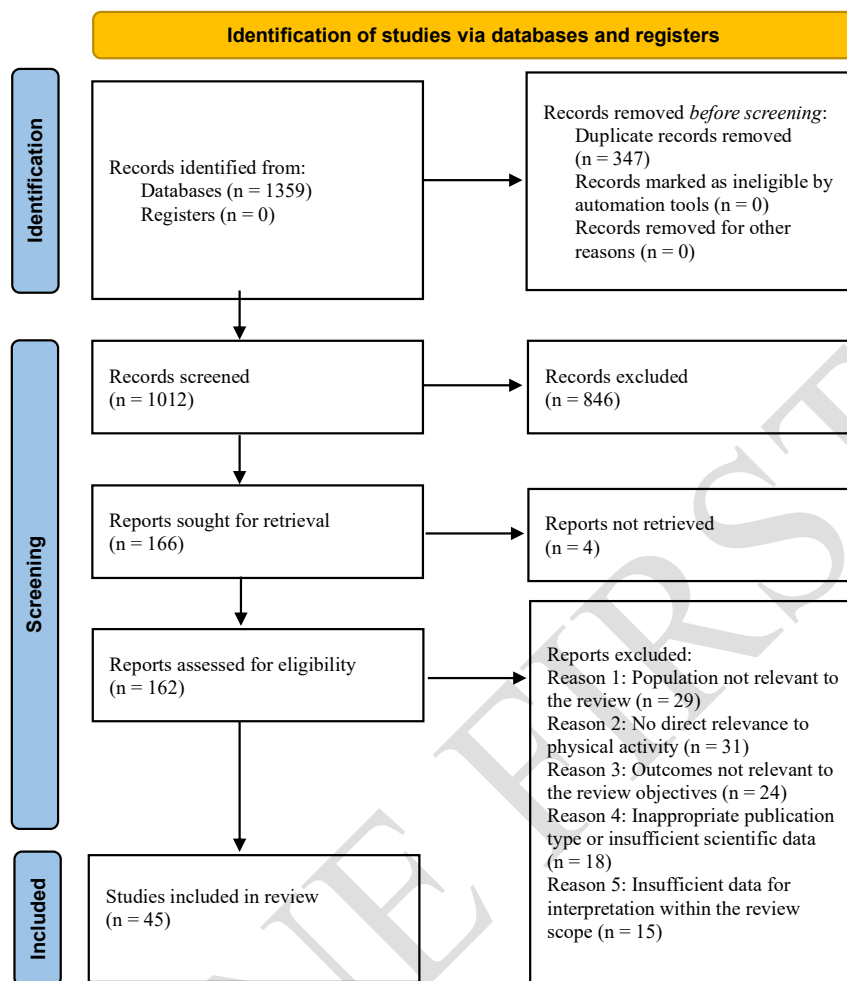


Figure 1. Simplified publication flow diagram inspired by PRISMA 2020 guidelines

Forty-five publications relevant to the study's scope were included in the narrative synthesis. The selection of publications was based on their alignment with the review's objective, currency, methodological nature, and significance to the issues discussed. When interpreting the results, particular attention was paid to methodological limitations, including small sample sizes, the absence of control groups, short intervention durations, and reliance solely on assessments by parents or caregivers. A distinction was made between associations observed in cross-sectional studies and effects evaluated in intervention studies, avoiding causal inferences based on observational data. The findings were synthesized narratively. Because of substantial heterogeneity in populations, interventions, and endpoints, the authors did not attempt to directly compare effect sizes across all studies. Conclusions were formulated taking into account the nature, consistency, and limitations of the available evidence. Physical activity was not viewed as a substitute for standard medical, rehabilitative, or educational care but rather

as a potential element supporting the functioning of children and adolescents with Down syndrome.

Literature review results

Specifics of the psychomotor development of children and adolescents with Down syndrome

Characteristic neuromuscular and biomechanical factors influence the psychomotor development of children with Down syndrome (reduced muscle tone, excessive joint mobility, decreased muscle strength, and difficulties with balance and postural control). Coexisting cardiac defects, visual and hearing impairments, musculoskeletal abnormalities, overweight, and limited opportunities for spontaneous participation in physical activity are also important [1,2,8,13,14]. Reduced muscle tone can contribute to difficulties in maintaining postural stability and trunk control, as well as to delayed motor development. However, hypotonia is not synonymous with muscle weakness, although it may coexist with reduced muscle efficiency and difficulties in stabilization and movement control [1,2].

Reduced muscle tone and joint-ligamentous laxity can affect the development of balance, gait, and other motor skills, but they do not constitute a contraindication to physical activity. Appropriately adapted and graded movement interventions can support the development of stabilization, postural control, and motor functions in children with Down syndrome [2,14]. Studies have shown that resistance training can increase lower-limb muscle strength in children and adolescents with Down syndrome, while programs combining strengthening exercises with balance or agility training can also improve balance and motor proficiency [15-17].

Infants with Down syndrome develop independent walking more slowly than typically developing children, and regular treadmill stepping practice can shorten the time required to achieve independent walking [6,18]. Furthermore, individually tailored, higher-intensity treadmill training may facilitate earlier onset of walking and the development of more mature gait parameters [19].

Children with Down syndrome also exhibit difficulties in performing tasks requiring speed, balance, and postural control. Early levels of motor proficiency and postural control may be associated with later motor functioning, highlighting the importance of timely, task-oriented intervention [20]. Coordination impairments may also involve bilateral and visual-motor

coordination [2,21]. Research indicates that balance and coordination abilities can improve with appropriately tailored training. Programs incorporating strengthening and balance exercises, dual-task training, and Pilates can enhance balance, functional performance, and gross motor coordination [17,22,23].

Recent studies indicate that regular cycling training can support certain aspects of executive function in individuals with Down syndrome. An 8-week intervention study showed improvements in cognitive planning after cycling training, although it found no significant changes across all assessed cognitive domains [24]. Appropriately designed strength and aerobic training can help improve both strength and physical capacity [15]. In a non-randomized pilot study, a 12-week exercise program was associated with improvements in daily executive functioning, although significant improvements were not observed across all cognitive tests used [25]. Meanwhile, a study on assisted cycling training showed improvements in manual dexterity and specific parameters of cognitive planning, with changes across these domains being interrelated [24].

Physical activity level of children and adolescents with Down syndrome

The physical activity levels of children and adolescents with Down syndrome often fall below recommended health guidelines, although study findings vary depending on the population studied and the measurement method used [5,26-28]. Available data point specifically to limited participation in moderate- and vigorous-intensity activities, highlighting the need for initiatives that support regular physical activity in this population [26-28].

Characteristics of daily physical activity

Studies using objective measurements of physical activity indicate that the daily activity of children and adolescents with Down syndrome consists largely of light-intensity activity. The findings suggest that limitations concern not only the overall amount of physical activity but also the proportion of higher-intensity activity [5]. Both organized and unorganized physical activity can contribute to the overall activity levels of individuals with Down syndrome. During organized activities, vigorous-intensity physical activity accounts for a larger proportion, whereas light-intensity activity predominates during unorganized activities. The results suggest

that these two types of activity can complement each other and increase overall physical activity levels [29].

Sedentary behaviors

Sedentary behavior refers to activities characterized by low energy expenditure, performed primarily while sitting or in a semi-reclined position. They are not synonymous with insufficient physical activity, as a child may engage in planned physical activity while simultaneously spending a significant portion of the rest of the day in sedentary behavior. Studies employing objective measurement methods indicate that sedentary behaviors constitute a substantial part of the daily lives of children and adolescents with Down syndrome. Recent research highlights the need to assess not only total physical activity levels but also sedentary time and the structure of daily activity [5,28]. Sedentary time among children with Down syndrome may also be influenced by social and environmental factors. Potential determinants include the availability of suitable conditions and resources that facilitate physical activity, as well as support from parents, caregivers, and teachers. This suggests that sedentary behaviors in this population should not be attributed solely to disability-related limitations [27]. The pattern of how sedentary time accumulates throughout the day may also have health implications. Prolonged, uninterrupted periods of sitting may induce adverse metabolic responses, whereas regularly interrupting sitting with brief bouts of physical activity may mitigate some of these effects [30]. However, it should be noted that the evidence presented comes from studies involving the general population, including adults. Therefore, their application to the population in question requires caution.

Differences compared to typically developing peers

Research indicates that children and adolescents with Down syndrome may engage in less moderate- and vigorous-intensity physical activity than their typically developing peers. At the same time, they may engage in more light-intensity activity and spend less time in sedentary behavior [5]. Participation in physical activity is influenced by social and environmental factors. Significant barriers include limited availability of appropriately adapted programs and specialized staff, transportation difficulties, and the attitudes and support of parents or caregivers. The individual physical and psychological capabilities of people with Down

syndrome also play a role. Conversely, interest in a given activity, motivation, and the availability of appropriate support can facilitate regular participation [8,31].

Relationship of activity to age, sex, and health status

Limited access to adapted programs, specialized staff, and transportation, along with insufficient support from the social environment, can reduce opportunities for regular physical activity [8]. Differences in physical fitness and motor competence also play a role, potentially limiting the participation of adolescents with Down syndrome in more demanding forms of activity and sports [2]. Therefore, maintaining an active lifestyle during adolescence requires not only individually tailored exercise but also an accessible, supportive environment [2,8,29].

Data regarding differences in physical activity levels between girls and boys with Down syndrome are inconclusive. A study by Xanthopoulos et al. found no significant sex differences in the time spent on moderate- to vigorous-intensity physical activity among adolescents with Down syndrome, whereas sex-related differences were observed in the group without Down syndrome [5]. These results suggest that sex should not be considered a consistent, independent predictor of physical activity levels in children and adolescents with Down syndrome.

Health status can significantly affect the ability and willingness of children with Down syndrome to engage in physical exertion. Co-occurring conditions and disorders, such as cardiovascular defects, obesity, obstructive sleep apnea, endocrine disorders, and musculoskeletal issues, can affect exercise tolerance, functional performance, and the ability to participate in specific activities [7,32,33]. Reduced motor proficiency, including limitations in strength, balance, and coordination, may further hinder engagement in more demanding forms of physical activity [2]. The presence of a comorbid condition should not necessarily preclude participation in physical activity. Exercise type, intensity, and conditions should be tailored to the child's health status, fitness level, and functional capabilities [2,32].

Physical activity may be associated with the degree of adiposity in young people with Down syndrome. The study by Xanthopoulos et al. [5] showed that higher levels of light physical activity and lower levels of sedentary behavior were associated with reduced visceral fat. The association between moderate- and vigorous-intensity physical activity and visceral fat was weaker [5].

Available evidence suggests age-related differences in the level and pattern of physical activity among children and adolescents with Down syndrome. A study involving 32 child-

parent pairs found that adolescents spent significantly more time in sedentary behaviors and less time in light-intensity physical activity than school-aged children. In both age groups, step counts and time spent in light-, moderate-, and vigorous-intensity physical activity were lower on weekends than on weekdays [28]. Similar age-related patterns were reported in the study by Xanthopoulos et al. [5], which found a negative correlation between age and time spent in light-intensity physical activity and a positive correlation between age and time spent in sedentary behaviors among young people with Down syndrome. However, no statistically significant association was found between age and time spent in moderate- to vigorous-intensity physical activity. These findings suggest that age-related changes in movement behaviors may primarily involve light-intensity physical activity and sedentary time rather than all physical activity intensity levels to the same extent [5,28].

Sex-related differences remain a significant issue. The available study by Xanthopoulos et al. [5] found no statistically significant differences between girls and boys with Down syndrome in time spent in moderate- to vigorous-intensity physical activity, whereas such differences were observed among participants without Down syndrome. At the same time, girls with Down syndrome spent less time in light-intensity physical activity and more time in sedentary behaviors than boys. Thus, the absence of significant sex-related differences in moderate- to vigorous-intensity physical activity does not rule out differences in other aspects of movement behavior. However, findings from a single study are insufficient to establish sex as an independent factor associated with lower physical activity levels across the entire population of children and adolescents with Down syndrome [5].

In the context of the observed age-related differences, the organization of physical activity may also be important [29]. Studies have shown that organized and unorganized forms of physical activity differ in terms of activity intensity. Participants engaged more frequently in organized activities, during which a greater proportion of time was spent in vigorous-intensity activity, whereas unorganized activities were associated with more time spent in light-intensity activity. These two forms may therefore complement each other in the daily lives of individuals with Down syndrome. However, the study by Izquierdo-Gomez and Shields also included adolescents and young adults, which limits the extent to which its findings can be directly applied exclusively to the pediatric population [29].

Impact of physical activity on psychomotor development

Physical activity can support motor and functional development in children and adolescents with Down syndrome by improving muscle strength, balance, postural control, coordination, and overall physical fitness (Table 1). Studies have used various interventions (treadmill training; strength, balance, and stabilization exercises; Pilates; aquatic exercises; cognitive-motor training; and exergaming). Results indicated that well-designed exercise programs can improve specific motor skills, balance, functional mobility, and physical fitness. However, the magnitude and scope of the effects depend on the participants' age, the type of intervention, its intensity and duration, and the measurement tools used [3,7,34,35].

Table 1. The impact of physical activity on the motor and functional development of children and adolescents with Down syndrome

Functional domain	Synthesis of available evidence	References
Gross motor skill development	Gross motor development is typically delayed in children with Down syndrome; targeted movement interventions can support the development of fundamental motor skills. Research indicates the beneficial effects of activities such as Pilates, exercises targeting foot function, and multicomponent programs. Improvements are usually most evident in the specific tasks trained; therefore, improvements should not be assumed to transfer fully to all aspects of gross motor skills.	[2,7,23,36,37]
Balance and postural stability	Balance is among the most extensively studied areas of physical intervention for children with Down syndrome. Meta-analyses and reviews of randomized controlled trials (RCTs) indicate improvements primarily in dynamic balance and overall postural control. Beneficial outcomes have been observed following treadmill training, core stability exercises, Pilates, hippotherapy, and task-oriented programs. Evidence regarding static balance is less conclusive, and the heterogeneity of protocols limits the comparison of the effectiveness of specific methods.	[3,22,23,36,38,39]
Motor coordination and agility	Programs requiring whole-body control, changes in body position, movement adaptation in response to stimuli, and the performance of complex tasks can improve specific aspects of motor coordination. Beneficial effects have been observed with activities such as Pilates and dual-task training. However, such improvements are highly dependent on the specific nature of the trained activities and do not necessarily transfer	[2,22,23,36,38]

	automatically to other sports or activities of daily living.	
Muscle strength and functional performance	Resistance training and multicomponent programs can improve muscle strength and selected components of physical fitness in children and adolescents with Down syndrome. The functional impact is greater when exercises are task-oriented and resemble daily activities, such as standing up, moving around, or climbing stairs. An increase in muscle strength should not automatically be equated with an increase in functional independence.	[7,36]
Mobility and gait pattern	Movement-based interventions can improve selected aspects of functional mobility. Recent reviews confirm the beneficial outcomes of treadmill training, stabilization exercises, hippotherapy, and task-oriented programs. Improvements in specific mobility parameters have also been observed in older children following dual-task training. The evidence does not support the conclusion that the gait pattern is fully normalized or that all achieved effects are lasting.	[3,22,36,38,39]
Executive functions, attention, and cognitive-motor integration	Physical activity can influence specific executive functions, particularly response inhibition and cognitive flexibility. Research on dual-task training indicates the potential for simultaneous improvements in certain postural and cognitive parameters. Exergaming and other digital interventions can support perceptual-motor integration; however, the evidence base remains limited by small sample sizes, methodological diversity, and the lack of a clear advantage over traditional forms of exercise.	[2,10,38,40]

Types of physical activity interventions

Physical activity programs for children and adolescents with Down syndrome vary in terms of the type of exercise, intensity, frequency, duration, and intended outcomes (Table 2). The choice of intervention should be based on the child's age, level of motor development, functional ability, health status, and interests.

Table 2. Selected forms of physical activity – their impact on the functioning of children and adolescents with Down syndrome

Intervention type	Synthesis of available evidence	Limitations and interpretation	References
Aerobic training	Aerobic activity programs can improve selected components of cardiorespiratory fitness and general physical fitness in children and adolescents with Down syndrome. A more recent systematic review indicates that some pediatric studies have observed improvements in cardiorespiratory fitness.	Protocols vary in duration, intensity, and type of exertion; therefore, it is currently impossible to identify a single optimal aerobic training model for all children with Down syndrome.	[7]
Strength and resistance training	Resistance training can improve muscle strength and selected components of physical fitness in individuals with Down syndrome. Recent analyses confirm its benefits, primarily in upper- and lower-limb strength.	Some data come from studies involving adults; therefore, the results should not be directly extrapolated to the entire pediatric population. Improved strength does not automatically translate to improved functional independence.	[7,41]
Balance exercises and postural stabilization	This is one of the best-documented intervention areas. A 2025 meta-analysis demonstrated improvements primarily in dynamic balance and overall balance scores. A more recent review of RCTs confirms the beneficial effects of numerous task-oriented and physiotherapeutic interventions.	However, results for individual balance components are less conclusive, and comparing methods is limited by heterogeneity in protocols and assessment tools.	[3,36]
Treadmill training	More recent reviews synthesizing earlier studies indicate that treadmill training can support balance as well as the development and function of locomotion in children with Down syndrome. In a meta-analysis concerning balance, the treadmill was identified as one of the more promising methods.	The key studies investigating ways to promote earlier acquisition of independent walking in infants predate 2023.	[3,36]

Cycling	Cycling engages lower-limb strength, coordination, and dynamic balance, and can serve as a functional form of physical activity. It is addressed in the broader literature regarding physical activity interventions for adolescents with Down syndrome.	Direct intervention studies regarding teaching children with Down syndrome to ride a bicycle predate the 2023-2026 timeframe. Therefore, the article, based solely on recent literature, did not make strong claims regarding its effectiveness as a standalone therapy.	[7]
Swimming and aquatic exercises	Swimming and aquatic exercises are used for children and adolescents with disabilities, including Down syndrome. Recent reviews indicate potential benefits, primarily for motor function and physical fitness, and swimming is among the most commonly practiced aquatic activities.	The evidence base specific solely to children with Down syndrome is smaller than that for balance or land-based exercises. The transfer of skills acquired in the aquatic environment to land-based functioning cannot be assumed to occur automatically.	[7,12,36]
Pilates and core stability	A 2024 randomized study showed that incorporating Pilates into a physiotherapy program can improve balance and gross motor coordination in children with Down syndrome. This trend in the findings is also supported by more recent reviews.	Larger sample sizes and long-term follow-up are needed to determine the durability and generalizability of the observed effects.	[3,23,36]
Exercises targeting foot function	In children with Down syndrome and coexisting pes planus, foot muscle training may improve selected motor function parameters. A 2024 RCT provides direct evidence regarding this specific intervention.	This finding concerns a specific subgroup of children with Down syndrome and pes planus; therefore, it should not be generalized to all children with Down syndrome.	[36,37]
Hippotherapy	A randomized study demonstrated the beneficial effects of hippotherapy on balance, functional mobility, and functional independence in children with Down syndrome. The intervention was also included in a more recent	The availability of the therapy, its standardization, and the number of trials limit the ability to determine its superiority over other forms of physiotherapy.	[36,39]

	review of RCTs regarding balance.		
Dual-task / cognitive-motor training	Studies from 2023-2024 indicate that training combining motor and cognitive tasks can improve balance, performance under dual-task conditions, and selected cognitive parameters in children and adolescents with Down syndrome. A more recent study from 2026 also supports potential improvements in balance and functional mobility.	Sample sizes remain relatively small, and protocols vary in the cognitive and motor tasks involved. Consequently, it is impossible to determine the optimal dosage or the durability of the effect.	[22,35,38]
Exergaming and virtual reality	A systematic review with meta-analysis indicates that therapy utilizing VR and exergaming can improve balance and muscular endurance in children and adolescents with Down syndrome. In a 2026 comparative study, exergaming and cognitive-motor training improved selected parameters of balance and functional mobility.	The number of studies remains limited, the technologies and protocols employed vary, and the evidence does not justify treating exergaming as a method superior to all traditional forms of exercise.	[11,35]
Multi-component programs	Programs combining aerobic, strength, balance, and functional elements can influence several components of fitness simultaneously. Reviews indicate improvements in areas such as muscular fitness, balance, aerobic capacity, and functional ability, depending on the program design.	Due to the simultaneous use of multiple elements, it is difficult to determine which component is responsible for the observed improvement. A multicomponent program is not necessarily more effective than training targeting a specific deficit.	[3,7,23]
Durability of effects	Available interventions primarily demonstrate short-term effects. More recent reviews highlight the need for studies with long-term follow-up and more standardized protocols.	Improvement observed immediately after the intervention should not be automatically interpreted as a lasting functional or developmental change.	[3,7,11,23]

Physical activity, autonomy, and independence

The autonomy and independence of children and adolescents with Down syndrome encompass the ability to take action, make choices, and participate in daily life with minimal assistance. This is not solely a matter of physical capability; it also depends on cognitive and communication functions, health status, adaptive capacity, caregiver support, and environmental accessibility. Physical activity can foster autonomy by improving mobility, strength, balance, and the ability to perform functional tasks (Table 3) [4].

Table 3. Potential role of physical activity in promoting independence and participation among children and adolescents with Down syndrome

Functional domain	Synthesis of available evidence	References
Independence in activities of daily living	Motor proficiency may be one of the prerequisites for performing activities of daily living; however, improvements in motor parameters should not be directly equated with increased independence. Among children and adolescents with Down syndrome, greater frequency of and engagement in household activities were associated with higher levels of specific functional skills, including those related to daily activities, socio-cognitive functioning, and responsibility. These associations were cross-sectional in nature, precluding the determination of a causal direction.	[42,44]
Mobility and independent movement	Balance, walking ability, and overall functional performance are key components of mobility. A meta-analysis of studies involving children with Down syndrome demonstrated the beneficial impact of exercise, particularly on dynamic balance, with promising results observed following interventions such as treadmill training and core stability exercises. A study of children aged 6-12 found that reduced walking ability was associated with poorer physical, social, and academic functioning, as well as a lower quality of life. However, these associations do not prove that improving gait alone leads directly to full independence.	[3,43]
Acquisition of functional motor skills	Adapted physical activity can improve specific functional movement capabilities, strength, stability, and motor task performance. Skills applicable to the daily environment are of particular clinical importance; however, the transfer of training effects beyond the intervention setting should be assessed separately. Current reviews indicate benefits from various forms of activity, yet the significant diversity of protocols precludes the identification of a single optimal method.	[2,44]
Sense of agency and competence	Movement-based interventions can support motor skills as well as selected aspects of cognitive, emotional, and physical functioning. However, direct evidence of	[2,8]

	increased self-efficacy or a sense of agency in children with Down syndrome is limited. Therefore, mastering a new motor skill can be viewed as a potential factor fostering a sense of competence, but not as a proven outcome of every movement-based intervention.	
Participation in family, school, and social life	Participation depends on both the child's functional abilities and environmental factors. Studies of children and adolescents with Down syndrome have shown that greater environmental support is associated with increased engagement in household activities. A scoping review identified the physical and psychological capabilities of the individual with Down syndrome, support from parents and caregivers, the availability of suitable programs, transportation, and social and environmental factors as important barriers to and facilitators of participation. This implies that improving motor function does not, in itself, guarantee increased participation.	[8,31,42]
Importance of physical activity and sport for future independence	Physical activity and sport can support physical fitness, mobility, social participation, and quality of life, while also fostering an active lifestyle. However, there is insufficient evidence that participation in sport alone leads directly to independent functioning in adulthood. Autonomy is a multidimensional phenomenon that also depends on cognitive and adaptive functions, communication, family support, social opportunities, and environmental factors. Therefore, sport may be considered one of the factors supporting the development of independence, rather than a standalone determinant of independence.	[27,31,44]

Physical activity and quality of life

Quality of life among children and adolescents with Down syndrome is multidimensional, encompassing physical, emotional, social, and school-related functioning. Its level is influenced by the child's health status and functional capabilities, as well as by family and environmental factors [4,45]. Physical activity may be one of the factors associated with quality of life. Research has demonstrated that children with Down syndrome score lower on quality-of-life measures than typically developing children and that physical activity levels correlate with specific quality-of-life domains, including physical and school functioning, as well as the total score [27]. However, due to the cross-sectional nature of the study by Alqahtani et al. [27], the direction of this relationship cannot be determined: while increased activity may foster better functioning, children with better health and greater physical fitness may simultaneously possess a greater capacity for engaging in physical activity.

Data from intervention studies also point to the potential for beneficial changes. In a randomized study by Al-Nemr and Reffat, adding a Pilates program to standard physiotherapy was associated not only with improvements in balance and gross motor coordination but also with a more favorable change in quality-of-life scores [23]. These results suggest that improvements in motor function may coincide with improvements in broader aspects of a child's functioning; however, a single study cannot be considered proof that every form of physical activity improves quality of life.

Research on individuals with Down syndrome has shown that physical activity and sports programs can yield benefits regarding autonomy and selected physical, psychological, and social aspects of quality of life [4]. At the same time, the authors highlight the heterogeneity of interventions, the variety of measurement tools used, and methodological limitations, all of which make it difficult to determine the magnitude and durability of the effects. The potential impact of physical activity on quality of life extends beyond improvements in fitness or strength. Such activity can create opportunities to develop motor skills, enhance mobility, engage in recreational pursuits, and foster social connections. However, these benefits depend on the availability of suitable activities, support from family and caregivers, and the tailoring of programs to the child's capabilities and preferences. Consequently, the evaluation of intervention outcomes should encompass not only physical fitness parameters but also aspects of functioning and participation relevant to daily life [4].

Thus, current data indicate a beneficial association between physical activity and specific dimensions of quality of life among children and adolescents with Down syndrome, although the strength of the evidence remains limited. It cannot be concluded that improvements in physical fitness alone lead directly to sustained improvements across all domains of quality of life; larger intervention studies featuring sufficiently long follow-up periods and standardized quality-of-life assessments are needed [4,23,27].

Barriers and facilitators of participation in physical activity

Participation in physical activity among children and adolescents with Down syndrome is a multifactorial phenomenon. It depends on the child's level of motor proficiency, health status, and interests, as well as parental attitudes, the availability of transport, costs, the organization of activities, staff competence, and the degree of environmental adaptation [28] (Table 4).

Table 4. Barriers and facilitators of physical activity participation among children and adolescents with Down syndrome

Domain	Barriers	Facilitators	References
Individual and health-related factors	Physical and cognitive limitations, motor difficulties, and co-occurring health issues can hinder participation. Anxiety, a lack of interest in a specific form of physical activity, or low motivation may also play a role.	Tailoring activities to the child's physical and cognitive capabilities, health status, and preferences – fostering interest in the activity, a desire to improve health, and a sense of success.	[8,28,31]
Family and caregivers' attitudes	Overprotectiveness, concerns about injury and safety, limited parental time, and competing family responsibilities can reduce opportunities for participation.	Encouraging physical activity, engaging in activities together, organizing transport and sessions, and fostering positive attitudes among parents and other family members are important factors that facilitate participation.	[8,28,31]
Costs, transport, and time management	The costs of activities and equipment, transportation difficulties, lack of time, and family responsibilities can limit regular participation in the activity.	Accessible transportation and activities offered close to home, and programs compatible with daily family life increase the likelihood of regular participation.	[8,28]
Availability of suitable programs	A lack of tailored programs and specialized staff is among the most frequently reported barriers. Formal availability of activities does not necessarily translate into actual opportunities for participation, if the level of difficulty or the programs organization does not meet the child's needs.	The availability of suitable programs, the ability to modify tasks, and the presence of individuals experienced in working with children with Down syndrome facilitate participation.	[8,28]
Qualifications of the instructors	A lack of knowledge or experience on the part of the instructors can result in both imposing excessive demands and unjustifiably limiting the child's activity.	Tailored communication, exercise demonstrations, the gradual scaling of difficulty, and the flexible modification of tasks can enhance a child's genuine engagement.	[8,28]
Social and peer support	Lack of support, negative attitudes, and behaviors within the social environment, and limited opportunities for contact with peers can reduce participation.	Support from family and peers, the opportunity to engage in shared activities, and the chance to build relationships and friendships are among the	[8,28]

		frequently identified supportive factors.	
Motivation, interests, and nature of the activities	An activity that is unsuited to the child's preferences, excessively difficult, or not engaging enough may limit interest and participation.	Enjoyment of the activity, personal interest, a sense of achievement, and the opportunity to choose foster regular participation.	[8,28]
Local environment and policy	Inadequate infrastructure, a lack of transport, a limited number of local programs, and insufficient systemic support can restrict activity, even when the child and family are highly motivated.	Accessible facilities and transportation, local programs, appropriate equipment, and systemic solutions supporting the activity of children with Down syndrome increase opportunities for participation.	[8,28,31]

Practical implications

Available data indicate that physical activity can be a key element in supporting the development and daily functioning of children and adolescents with Down syndrome and that exercise programs should be tailored to the child's age, fitness level, cognitive abilities, co-existing conditions, and individual goals [2,3]. Physical activity interventions can improve balance, muscle strength, motor competence, and functional mobility, among other outcomes; however, improving a single fitness parameter does not automatically lead to greater independence or a better quality of life [2,3,27].

Program selection should prioritize feasibility, safety, and the potential for regular implementation rather than focusing solely on the type of intervention. Exercises should be progressive, offer opportunities for success, and, whenever possible, relate to tasks relevant to the child's daily functioning [2,3]. However, the heterogeneity of available programs makes it impossible to identify a single optimal method [3]. Activity planning should also consider family and environmental factors. The availability of suitable programs and specialists, transportation, support and attitudes of parents or caregivers, and personal interest in the activity are key determinants of participation [8].

Studies on participation in home-based activities indicate that greater environmental support is associated with higher levels of engagement among children and adolescents with Down syndrome [31]. From a practical standpoint, therefore, the goal should not be solely to improve physical fitness parameters but rather to create conditions that enable regular, safe, and child-accepted activity that can be pursued at home, at school, and in the local community.

Outcome assessment should encompass fitness, mobility, and participation, as well as – where appropriate – quality of life [8,27,31].

Discussion of the review results

The results of this narrative review indicate that physical activity can significantly support the functioning of children and adolescents with Down syndrome; however, the extent of its impact varies by area. The most consistent data relate to improvements in physical fitness, balance, muscle strength, and selected motor skills, whereas evidence concerning autonomy, cognitive function, social participation, and quality of life is more complex and requires cautious interpretation [2,3,8,28].

One of the best-documented effects of physical activity is improved postural control. A meta-analysis by Lei et al. [3] included eight randomized controlled trials involving 260 participants. Of these, six studies (n=203) were included in the pooled analysis of dynamic balance, while five studies (n=168) contributed to the pooled analysis of overall balance. The meta-analysis demonstrated statistically significant improvements in both dynamic and overall balance following exercise interventions. These findings are functionally significant, as postural control is essential for safe walking, changing direction, navigating obstacles, and performing many activities of daily living. At the same time, the heterogeneity of the interventions employed makes it impossible to identify a single method as optimal for all children.

A randomized study by Al-Nemr and Reffat [23] also showed that improvements in balance and gross motor coordination were greater when Pilates exercises were combined with standard physiotherapy than with physiotherapy alone [23]. However, the benefits should not be limited to balance.

Resistance training can improve muscle strength and selected aspects of functional fitness. A meta-analysis by Stojanović et al. [41] indicates the beneficial effects of resistance training on limb strength, physical functioning, exercise capacity, and balance in individuals with Down syndrome. However, some included studies involved adults; therefore, these findings cannot be directly generalized to the entire pediatric population. Furthermore, a more recent meta-analysis of randomized trials showed beneficial changes in body weight, BMI, and body fat content following physical activity interventions, though it also covered a broader age range of individuals with Down syndrome [7].

A review of the literature by Montalva-Valenzuela et al. supports physical activity as a key element in preventing adverse changes in body composition, but it does not justify attributing an independent therapeutic effect to it across all metabolic disorders [7]. The relationship between activity levels and adiposity remains a significant issue [5,7,32]. Xanthopoulos et al. [5] demonstrated that, among adolescents with Down syndrome, higher levels of light physical activity and lower levels of sedentary behavior were associated with a more favorable visceral adiposity profile. However, because the study was cross-sectional, the direction of this relationship cannot be determined; lower activity levels may promote increased adiposity, while higher body mass and poorer physical fitness can also hinder engagement in physical activity.

A review by Vandoni et al. [2] highlights the interrelationship between motor and executive skills, as well as the need to tailor interventions to the individual needs of children with Down syndrome. Meanwhile, a systematic review by Scott et al. [40] demonstrated potential benefits of physical activity, primarily regarding response inhibition and cognitive flexibility, though the authors also identified important methodological limitations and a risk of bias in the available studies [40]. Consequently, there is currently no basis to conclude that every form of physical activity improves all executive functions.

The association between physical activity and quality of life is similarly complex. Alqahtani et al. [27] demonstrated that children with Down syndrome had lower quality-of-life scores than typically developing children and that certain activity indicators were associated with specific quality-of-life domains. However, these associations were weak and derived from a cross-sectional study. An interesting exception is a study by Al-Nemr and Reffat on Pilates, which observed, alongside improvements in motor parameters, a more favorable change in quality-of-life scores [23]. Nevertheless, larger, longer-term studies are still needed that incorporate quality-of-life measures as a planned endpoint.

Meanwhile, findings regarding autonomy and participation indicate that a child's physical fitness is merely one element of a broader system. Brugnaro et al. [31,42] demonstrated associations between functional skills and participation in the home environment. Furthermore, Brugnaro et al. [31] found that greater engagement in household activities was associated with more favorable environmental support. A review by Oliveira Souto et al. confirmed that participation among individuals with Down syndrome depends on personal, social, and environmental factors, including parental support, transportation, and the availability of appropriately designed programs and qualified professionals [8]. A recent review by Yang et al.

[28] further organizes these factors within a socio-ecological model, identifying the individual, family, community, and policy levels as interacting determinants of activity. This implies that the effective promotion of activity cannot be limited to a recommendation to “exercise more”. It is worth noting that even a well-designed program will have limited impact if the family lacks transportation, suitable activities are unavailable in the local environment, or the instructor fails to adapt their communication style and the level of difficulty. A more justified approach involves individualizing the workload, grading difficulty, and selecting activities that can continue outside the therapeutic setting [8,28].

Taken together, the evidence suggests that the primary significance of physical activity may stem not from a single physiological effect but from its simultaneous impact across multiple levels of functioning. Improvements in balance, strength, or physical fitness may enhance an individual’s ability to perform a task; however, only when these changes are combined with an appropriate environment, adequate support, and genuine opportunities for participation may they translate into greater autonomy and a better quality of life. At the same time, the current evidence base remains limited by small sample sizes, heterogeneous interventions and outcome measures, and few long-term follow-up studies. Future research should therefore focus not only on short-term changes in physical fitness parameters but also on their transfer to everyday functioning, the durability of effects, and outcomes that are meaningful from the perspective of children and their families.

Interpreting the presented results requires taking into account the methodological limitations of the analyzed studies, specifically, small sample sizes, the heterogeneity of interventions, the diversity of outcome assessment tools, and limited data regarding the long-term maintenance of benefits. The limitations of this review result from its narrative nature, the absence of a formal risk of bias assessment for individual studies, and the diversity of the populations analyzed. The manuscript and bibliography were last updated on October 9, 2026; however, the exact date of the final literature search was not documented. Therefore, the conclusions presented should be interpreted taking into account the nature of the consistency and the limitations of the available evidence, avoiding overgeneralization of the observed associations and intervention effects.

Conclusions

Available data indicate that physical activity can be a significant factor supporting psychomotor development, functional ability, participation, and selected aspects of quality of life in children and adolescents with Down syndrome. The most consistent findings relate to improvements in balance, muscle strength, specific motor skills, functional mobility, and overall physical fitness. Various interventions have shown benefits, including aerobic and resistance exercises, balance and coordination training, Pilates, treadmill training, hippotherapy, cognitive-motor programs, and exergaming.

The impact of physical activity on autonomy, social participation, and quality of life is more complex. Improvements in physical fitness do not automatically lead to greater independence, as a child's functioning depends on cognitive abilities, health status, family support, the availability of suitable activities and transportation, instructor competence, and environmental conditions. Therefore, interventions should be individualized, functional, and tailored to the child's needs, capabilities, and preferences.

The current evidence base remains limited by small sample sizes, program heterogeneity, varied measurement tools, and a scarcity of studies with long-term follow-up. Particular caution is required when interpreting associations observed in cross-sectional studies as causal relationships. Larger, well-designed intervention studies are needed to evaluate not only physical performance but also the durability of effects, participation, independence, and quality of life.

Physical activity should be regarded as a complementary component of comprehensive care for children and adolescents with Down syndrome rather than a substitute for medical, rehabilitative, or educational interventions.

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