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Effects of vitamin D supplementation and aerobic exercises on balance and physical performance in children with Down syndrome

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Abstract

Background/Aims Children with Down syndrome are prone to vitamin D deficiency. Vitamin D supplements are commonly used to treat and prevent vitamin D deficiencies. There is growing evidence that support the role of vitamin D improving muscles and central nervous system function. The aim of this study was to investigate the interaction effects of vitamin D supplementation combined with aerobic exercises and conventional physical therapy on balance and physical performance in children with Down syndrome.

Methods A randomised controlled trial was conducted for 38 children with Down syndrome, with ages ranging from 8 to 12 years. They were divided randomly into two groups. The control group (n=19) received conventional physical therapy and aerobic exercises, while the study group (n=19) received conventional physical therapy, aerobic exercises and vitamin D in the form of an oral daily dose of vitamin D_3 400 IU (cholecalciferol). The children in both groups participated in the same physical therapy for 45 minutes, 3 days a week for 12 weeks, and undertook 15 minutes of aerobic exercise after the physical therapy sessions. Balance was evaluated by using the Biodex Stability System and physical performance was evaluated by using the 6-Minute Walk Test.

Results All groups showed a significant improvement in the medial-lateral stability index, the anterior-posterior stability index, the overall stability index and the 6-Minute Walk Test after treatment (P<0.05). The study group showed a significant improvement in the measured variables compared with that of the control group (P<0.05).

Conclusions Vitamin D supplements, combined with aerobic exercises and conventional physical therapy, could improve balance and physical performance in children with Down syndrome. Therefore, vitamin D and aerobic exercises should be considered as an adjunctive to physical therapy.

Key words: Aerobic exercises; Balance; Down syndrome; Physical performance; Vitamin D

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Introduction

Down syndrome is a condition in which a baby is born with an extra chromosome, which occurs in 1 per 700–1000 live births (Weijerman et al, 2008). Children with Down syndrome have several clinical symptoms, including orthopaedic, cardiovascular, neuromuscular, visual, cognitive and perceptual impairments (Gupta et al, 2011). They have deficits in hand–eye coordination, laterality, visual motor control, reaction time, strength, and balance (Galli et al, 2008).

Balance issues are common among children with Down syndrome as a result of neuromuscular disorders, such as hypotonia, retained primary reflexes and slow performance of volitional reactions (Luz Carvalho and Vasconcelos, 2011). In addition, balance reaction is affected because of insufficient co-contraction caused by muscle weakness, intellectual disability, sensory integration dysfunction, cartilage hypoplasia, and low bone mineral density (Russell et al, 2013). Individuals with Down syndrome are typically have unstable postural control, as they are unable to respond rapidly to changes in the environment, and take longer to initiate and complete a motor task (Galli et al, 2008).

Moreover, children and adolescents with Down syndrome have low peak aerobic capacity, physical activity and muscular strength, particularly of the lower extremities, compared

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to typically healthy individuals (Pitetti et al, 2013). Children with Down syndrome have lower participation rates in the recommended amount of daily physical activity because of reduced physical or behavioural skills, obesity, reduced muscle strength and cardiovascular fitness compared with typically developing children (Barr and Shields, 2011).

Physical performance is defined as one's ability to carry out activities that require physical actions, ranging from self-care (activities of daily living) to more complex activities that require a combination of skills, often with a social component or within a social context (Patient-Reported Outcomes Measurement Information System, 2014).

Body composition and muscle strength might serve as control parameters for gross motor, balance, fine motor and functional performance in school-aged children with and without Down syndrome (Beqaj et al, 2018). Muscular strength in children with Down syndrome is affected by various clinical symptoms, including orthopaedic, neurological and cognitive impairments (Lewis and Fragala-Pinkham, 2005). The physical performance of individuals with Down syndrome has also been reported to be impaired. The activities of self-care involving fine motor skills have been described to be most delayed, whereas mobility performance appears to be a stronger aspect of functioning (Dolva et al, 2004).

Conventional physical therapy and regular physical activity are essential for children with Down syndrome to obtain gross motor skills, improve physical abilities, enhance functional movement, minimise the development of compensatory movement patterns and adopt a more physically active lifestyle (Shields et al, 2009).

Children and adolescents with Down syndrome are more prone to having low blood concentrations of 25-hydroxy vitamin D (25(OH)D) for several reasons, including lack of exposure to sunlight, lower intake of vitamin D-rich food or supplements, tendency to become obese, and use of various medications (Grant et al, 2015). For many decades, vitamins and herbal supplementation, in various doses, have been recommended for children with Down syndrome, with the aim of relieving thyroid or gastrointestinal dysfunctions, or improving cognitive abilities or immune function (Blair et al, 2008).

Evidence suggests that vitamin D plays an important role in immune regulation as vitamin D receptors are found on several immune cells, and vitamin D metabolites seem to modulate T cell proliferation and dendritic cell function (Arnson et al, 2007). The genomic effects of vitamin D lead to the synthesis of new proteins that enhance muscle cell contractility, proliferation, and differentiation (Ceglia and Harris, 2013). Activation of the vitamin D receptor in muscle tissue enhances movement of myosin over the actin filaments through activation of calcium release. These effects in muscle may be associated with decreased risk of falls in the elderly, as well as increased muscle strength, lower injury risk and improved athletic performance associated with sufficient vitamin D levels (Abrams et al, 2018).

Previous studies have investigated the beneficial effects of vitamin D supplementation associated with aerobic training. Vitamin D supplementation combined with aerobic training reduced some metabolic syndromes, such as as obesity, diabetes, hyperglycemia and insulin resistance, and could prevent cardiovascular risk factors (Babaei et al, 2015). In addition, Ebid et al (2017) found that in children with severe burns, vitamin D and exercise training for 12 weeks improved muscle strength, lean body mass and gait.

Aim

The authors hypothesised that vitamin D, in conjunction with aerobic exercises and a conventional physical therapy programme, could improve balance and physical performance in children with Down syndrome. Therefore, the purpose of this study was to investigate the interaction effects of vitamin D and aerobic exercises on balance and physical performance in children with Down syndrome.

Methods

Study design

This study is a randomised controlled trial and was conducted at the College of Applied Medical Science at Najran Univiersity, Saudi Arabia.

Ethical approval

The Deanship of Scientific Research at the Najran University approved this study (approval number: NU/MID/16/021). In addition, the research study was registered on the Clinical Trials database (NCT03783338). Interviews were conducted with the children's parents to explain the purpose, potential benefits and the procedure of the study, and written informed consent was obtained before participation.

Participants

Participants were recruited from a comprehensive rehabilitation centre in Najran, Saudi Arabia. A total of 47 children with Down syndrome were assessed for eligibility. To be eligible, the children had to meet the following inclusion criteria:

- Were sufficient with 25(OH)D with levels more than 30 nanograms/milliliter (ng/ml) (Holick et al, 2011)
- Were not consuming oestrogens, steroids or other medications that could interfere with vitamin D metabolism
- Could stand and walk independently
- Had mild intellectual disabilities that were determined by a clinical psychologist and were capable of understanding verbal instructions.

Children were excluded if they had:

- Medical conditions that would severely limit their participation
- Visual and hearing impairments
- Musculoskeletal deformities of the lower limbs.

Six children were excluded as they did not meet the inclusion criteria, and three children were excluded as their parents declined to participate in the study. A total of 38 children (23 boys and 15 girls) with Down syndrome, with ages ranging from 8 to 12 years, participated in this study.

Eligible children were assigned randomly to two groups. The control group consisted of 19 children (12 boys and 7 girls) who received conventional physical therapy and aerobic exercises. The study group consisted of 19 children (11 boys and 8 girls) who received conventional physical therapy, aerobic exercises and vitamin D in the form of an oral daily dose of vitamin D_3 400 IU (cholecalciferol). All children were instructed to limit strenuous exercise during the study. The completion rate was 94.7%, as two children dropped out from the study group. One child had an accident outside of the study and was unable to complete the intervention and the other had to leave because they went travelling with their parents. Accordingly, 36 children (22 boys and 14 girls) completed the study.

Randomisation

Following the baseline measurements, the randomisation process was performed for 38 children using sealed envelopes. Children were stratified with regards to age and sex to be equally distributed among the two groups. The investigator prepared 38 closed envelopes with each envelope containing a card labelled with the name of the group. Each child opened an envelope that determined whether they were allocated to the control or the study group. Figure 1 shows the experimental design of the study.

Measures

Anthropometric measurements (weight, height and body mass index) were recorded using a stadiometer (Seca, Leicester, UK) and a calibrated electronic weight scale (HD-351, Tanita, Illinois, USA) (Gjonbalaj et al, 2018). Dietary intake was monitored throughout the study period through diet diaries to make sure the intake of food containing vitamin D was equal between the two groups.

Each child was assessed for vitamin D levels, balance and physical performance at baseline and after 12 weeks of the treatment programme by the same examiner, who was blinded to the group allocation of the children.

Balance

The Biodex Stability System (Biodex Inc, Shirley, NY) was used to measure postural stability under dynamic stress. The Biodex Stability System is reliable and enables objective

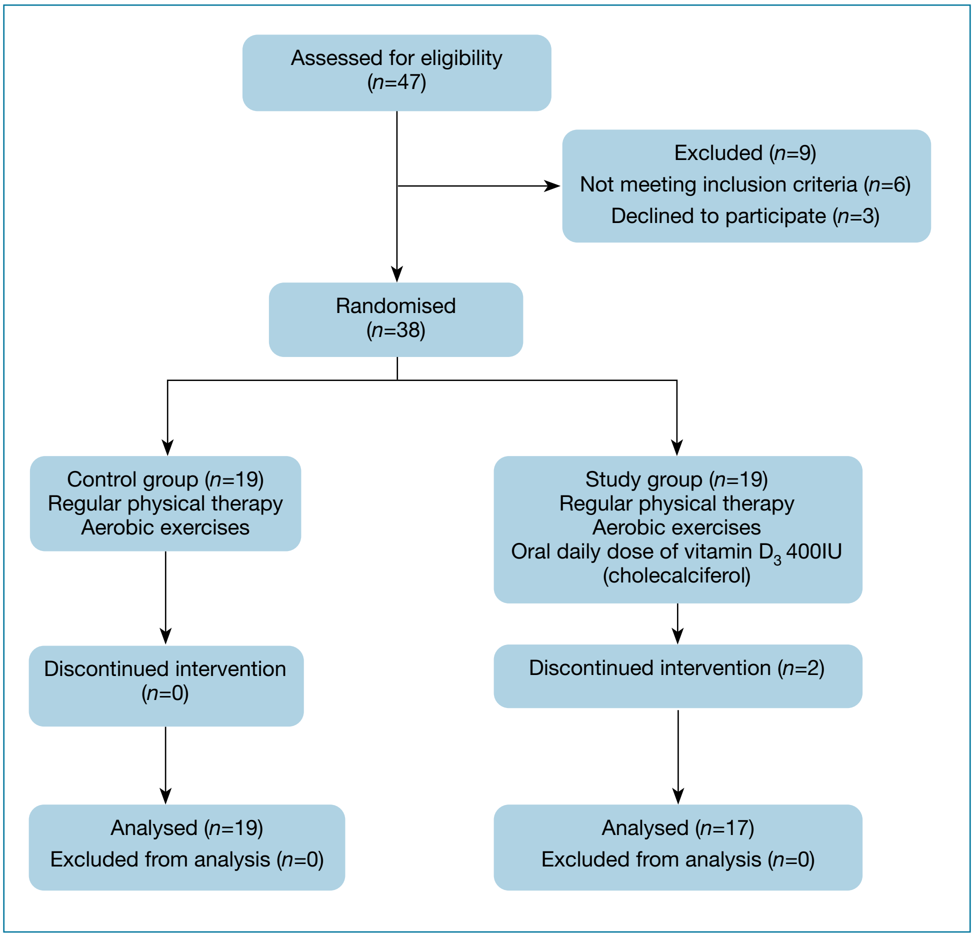

Figure 1. Flow diagram showing the experimental design of the study.

assessment of balance (Perron et al, 2007). It consists of a circular platform that allows tilting up to 20° in the anterior-posterior and medial-lateral axes simultaneously. From the degrees of tilt on the anterior-posterior and medial-lateral axes, the Biodex Stability System calculates the medial-lateral stability index, the anterior-posterior stability index and the overall stability index. These indexes are standard deviations that assess fluctuations around the zero-horizontal point. The medial-lateral stability index and the anterior-posterior stability index assess the fluctuations from horizontal along the anterior-posterior and medial-lateral axes of the Biodex Stability System respectively. In contrast, the overall stability index is a composite of the medial-lateral stability index and anterior-posterior stability index and is sensitive to changes in both directions (Arnold and Schmitz, 1998). The higher scores in these outcomes indicate poor balance. The test–retest intraclass correlation coefficients (ICCs) for overall stability index, anterio-posterior stability index, and medial-lateral stability index were 0.85, 0.78, and 0.84 during static condition and 0.77, 0.77, and 0.65 during dynamic condition respectively (Arifin et al, 2014).

Children were assessed while they were in a bilateral stance with their eyes open at the most stable level (level 8) that permitted minimal movement of the platform (Testerman and Griend, 1999). The children were instructed to stand in the centre of the locked platform, look forward, keep their arms by their sides, and asked to maintain the centre of pressure in the smallest concentric rings (balance zones) of the Biodex Stability System monitor. The balance measurement test was repeated three times and the mean was obtained for data analysis.

Physical performance

The 6-minute walk test (6MWT) was used to assess physical performance. The 6MWT is a standardised endurance test where children are asked to walk as far as possible over 6 minutes and is reflective of the ability to perform daily physical activities. The child walked on an unobstructed rectangular pathway with cones at the turning points. The therapist followed the child closely with a stopwatch to ensure safety and to measure the exact distance walked in 6 minutes. The 6MWT is proven to be safe, easy to perform, and provides a simple and inexpensive means of measuring functional exercise capacity in children (Geiger et al, 2007).

Intervention

Conventional physical therapy programme

The children in both groups participated in the same physical therapy programme for 45 minutes, 3 days a week for 12 weeks. It consisted of proprioceptive and neurodevelopmental training, facilitation of muscle contraction, balance and postural control exercises that included training of postural reactions (righting, equilibrium and protective reactions) and keeping balanced while standing during weight shifting forward then backward alternatively. All exercises and their durations are shown in Table 1.

Aerobic exercises

After a 10-minute rest following conventional physical therapy, the children in both groups performed aerobic exercises by walking on a treadmill (Zan 800, Germany) for 15 minutes, 3 days a week for 12 weeks. The investigators explained the procedure and goals of the exercise to all children before starting the exercise protocol. The children were instructed to stop immediately if they felt pain, faint or shortness of breath.

Walking was selected as the exercise as the children had balance issues with a high risk of falling, as reported by the children's parents. A pulsometer (Tunturt TPM-400, Japan) was used to detect pulse rate before, during and after training. The speed and inclination of the treadmill were controlled by pre-selected software (standard Bruce protocol; Bruce et al, 1949a, b). Children performed the aerobic exercise session through three phases:

- Warming up phase (5 minutes): children walked at an intensity of 60% of their maximum heart rate (HR_{max}) with an initial speed of 2.0 kph and 0° inclination
- Activity phase (5 minutes): children walked at an intensity that was increased gradually from 60% to 70% of HR_{max}. Similarly, the speed and inclination were gradually increased from 2.0 kph to 3.0 kph and from 0° to 5° respectively (Lin and Wuang, 2012)
- Cooling down phase (5 minutes): children walked at an intensity of 60% of their HR_{max}, with a speed of 2.0 kph and 0° inclination.

Vitamin D supplementation

Vitamin D_3 (cholecalciferol) is the preferred form of vitamin D for supplementation. The children in the study group took 400 IU of vitamin D_3 orally once daily, as recommended by the American Academy of Paediatrics (Braegger et al, 2013).

Statistical analysis

Sample size calculation was performed before the study using G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) (F tests multivariate analysis of variance: repeated measures, within-between interaction, α=0.05, β=0.2, Pillai V=0.19, and effect size=0.49) and revealed that the appropriate sample size for this study was 35.

Patient characteristics were compared between groups using an independent *t*-test. Sex distribution was compared between the groups using the Chi-squared test. The

Table 1. Types of exercises and their duration undertaken in conventional physical therapy for the study and control groups

Type of exercise	Duration (minutes)
Proprioceptive training	5
Neurodevelopmental training	15
Facilitation of muscle contraction for hip extensors, quadriceps, hamstrings, anterior tibial group and calf muscles bilaterally	10
Balance and postural control exercises	15

Shapiro–Wilk test and Levene's test for homogeneity of variances were conducted to check normal distribution of data and homogeneity between groups respectively. Mixed design multivariate analysis of variance was performed to compare the effect of time (pre versus post) and the effect of treatment (between groups) on 25(OH)D, anterior-posterior stability index, medial-lateral stability index, overall stability index and 6MWT. Bonferroni corrections were carried out for subsequent multiple comparison. Partial squared eta was considered as the effect size. The level of significance for all statistical tests was set at $P<0.05$. Statistical analysis was conducted through the Statistical Package for Social Sciences (version 25) for Windows.

Results

Demographic characteristics of participants

The participant characteristics of both groups are shown in Table 2. There was no significant difference in the mean age, weight, height between groups ($P>0.05$). There was no significant difference in sex distribution between groups ($P=0.73$). Mean body mass index (± standard deviation) of the children in the study and control groups were 17.84 ± 2.57 and 17.67 ± 2.18 respectively and there was no significant difference ($P=0.83$). Therefore, there was no effect on balance and physical performance results.

Effect of treatment on 25(OH)D, anterior-posterior stability index, medial-lateral stability index, overall stability index and Six-Minute Walk Test

A summary of the results of the mixed multiple anlaysis of variance is presented in Table 3. The overall effect revealed that there was a significant interaction of treatment and time (Wilks' lambda=0.09; $F(5,30)=56.65$, $P=0.001$, $\eta^2=0.9$). There was a significant main effect of time (Wilks' lambda=0.04; $F(5,30)=116.44$, $P=0.001$, $\eta^2=0.95$). There was a significant main effect of treatment (Wilks' lambda=0.26; $F(5,30)=16.73$, $P=0.001$, $\eta^2=0.73$). Table 4 shows descriptive statistics of 25(OH)D, anterior-posterior stability index, medial-lateral stability index, overall stability index and 6MWT and the significant level of comparison between groups, as well as significant levels of comparison between, before and after treatment in each group.

Between-group comparison

There was no significant difference between both groups in all parameters before treatment ($P>0.05$). After treatment there was a significant increase in the levels of 25(OH)D in the children in the study group compared with the children in the control group ($P>0.001$). In addition, there was a significant decrease in anterior-posterior stability index, medial-lateral stability index and overall stability index of the study group compared with the control group ($P>0.001$). The distance walked during the 6MWT significantly increased in the study group after treatment compared with the control group ($P>0.001$).

Table 2. Demographic characteristics of participants in the study and control groups

		Study group	Control group	
		Mean ± SD	Mean ± SD	*P*
Age (years)		9.5 ± 1.14	9.72 ± 1.36	0.61
Weight (kg)		25.19 ± 3.2	26.00 ± 2.28	0.39
Height (cm)		119.11 ± 4.86	121.55 ± 4.38	0.12
Body mass index (kg/m²)		17.84 ± 2.57	17.67 ± 2.18	0.83
Sex	Male	11 (70%)	12 (63%)	0.73
	Female	8 (30%)	7 (37%)	

SD: standard deviation.

Table 3. Summary of the results of mixed multiple anlaysis of variance design for the time × group interaction effect, time effect and treatment effect

	Time × group interaction	Main effect of time	Main effect of treatment
25(OH)D	F (1,34)=122.94, *P*=0.001, partial η^2=0.78	F (1,34)=177.78, *P*=0.001, partial η^2=0.83	F (1,34)=66.1, *P*=0.001, partial η^2=0.66
APSI	F (1,34)=54.59, *P*=0.001, partial η^2=0.61	F (1,34)=202.19, *P*=0.001, partial η^2=0.85	F (1,34)=2.29, *P*=0.13, partial η^2=0.06
MLSI	F (1,34)=64.23, *P*=0.001, partial η^2=0.65	F (1,34)=148.75, *P*=0.001, partial η^2=0.81	F (1,34)=7.92, *P*=0.008, partial η^2=0.18
OVSI	F (1,34)=55.38, *P*=0.001, partial η^2=0.62	F (1,34)=143.95, *P*=0.001, partial η^2=0.8	F (1,34)=10.8, *P*=0.002, partial η^2=0.24
6MWT	F (1,34)=78.68, *P*=0.001, partial η^2=0.69	F (1,34)=151.17, *P*=0.001, partial η^2=0.81	F (1,34)=11.78, *P*=0.002, partial η^2=0.25

6MWT: 6-Minute Walk Test; 25(OH)D: 25-hydroxy vitamin D; APSI: anterior-posterior stability index; MLSI: medial-lateral stability index; OVSI: overall stability index; partial η^2; partial squared eta (effect size).

Within-group comparison

The study group showed a significant increase in 25(OH)D levels after treatment compared with before treatment (*P*<0.001), while there was no significant change in 25(OH)D levels of the control group (*P*>0.05). There was a significant decrease in anterior-posterior stability index, medial-lateral stability index and overall stability index of both groups after treatment compared with before treatment (*P*>0.01). Similarly, there was a significant increase in 6MWT distances of both groups after treatment compared with before treatment (*P*>0.001).

Discussion

This study investigated the effects of vitamin D supplementation combined with aerobic exercises training on balance and physical performance in children with Down syndrome. The results showed that the study group demonstrated a significant improvement in balance and physical performance compared with the control group after 12 weeks of the treatment programme. Therefore, vitamin D supplementation and aerobic exercises should be included in the rehabilitation programme of these children. This study has confirmed the need for motivating and effective training modalities rather than conventional methods of rehabilitation.

The results showed that the serum concentrations of 25(OH)D had increased in the study group when compared with pre-treatment mean values and with those of the control group. The increase in 25(OH)D levels was consistently associated with the improvement in postural balance and physical performance in the study group.

Regarding postural balance, the children in the study group could achieve the lowest values of balance assessment in terms of anterior-posterior stability index, medial-lateral stability index and overall stability index. This indicated improvement in their balance, as the lower scores of the Biodex Stability System indicate good balance.

Regular exercise training has been shown to improve postural balance in individuals with Down syndrome through improving muscle strength and reactivation of proprioceptors, which in turn improves the proprioceptors' role in sensing the amount, speed and timing of joint positioning (Gupta et al, 2011). In addition, aerobic training provides not only improvement in cardiovascular measures, but also postural balance, proprioception and power in gross motor tasks (Barnard et al, 2019).

Vitamin D deficiency, when combined with disabilities, further increases postural sway, which is linked to increased risk of falls. This is a major issue in people with neurodisabilities, who are more prone to falls and fractures. The risk of falls in individuals with developmental disabilities can be reduced by correcting vitamin D deficiency (Baek et al, 2014).

The improvement in balance performance could be mediated through a neural effect as vitamin D affects neuromuscular control and neural coordination, and there is growing

Table 4. Mean 25(OH)D levels, APSI, MLSI, OVSI and 6MWT of the study and control groups

	Study group	Control group		
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	***P***
25(OH)D (ng/mL)				
Before treatment	32.16 ± 1.5	32.11 ± 1.53	0.05 (–0.97 to 1.08)	0.91
After treatment	41.83 ± 2.33	33 ± 2.52	8.83 (7.18 to 10.47)	0.001
MD (95% CI)	–9.67 (–10.8 to –8.52)	–0.89 (–2.02 to 0.24)		
	P=0.001	*P*=0.12		
APSI				
Before treatment	1.57 ± 0.14	1.52 ± 0.12	0.05 (–0.04 to 0.14)	0.25
After treatment	1.23 ± 0.13	1.41 ± 0.14	–0.18 (–0.28 to –0.08)	0.001
MD (95% CI)	0.34 (0.29 to 0.39)	0.11 (0.06 to 0.15)		
	***P*=0.001**	***P*=0.001**		
MLSI				
Before treatment	1.51 ± 0.1	1.47 ± 0.13	0.04 (–0.04 to 0.11)	0.39
After treatment	1.18 ± 0.11	1.41 ± 0.1	–0.23 (–0.29 to –0.14)	0.001
MD (95% CI)	0.33 (0.27 to 0.36)	0.06 (0.02 to 0.11)		
	***P*=0.001**	***P*=0.001**		
OVSI				
Before treatment	1.73 ± 0.13	1.75 ± 0.12	–0.02 (–0.09 to 0.07)	0.79
After treatment	1.38 ± 0.19	1.66 ± 0.11	–0.28 (–0.39 to –0.17)	0.001
MD (95% CI)	0.35 (0.3 to 0.4)	0.09 (0.03 to 0.13)		
	***P*=0.001**	***P*=0.001**		
6MWT (metres)				
Before treatment	260.33 ± 13.86	262.77 ± 12.31	–2.44 (–11.32 to 6.43)	0.58
After treatment	298.44 ± 13.24	268.94 ± 12.52	29.5 (20.77 to 38.23)	0.001
MD (95% CI)	–38.11 (–43.28 to –32.93)	–6.17 (–11.34 to –0.99)		
	***P*=0.001**	***P*=0.001**		

6MWT: 6-Minute Walk Test; 25(OH)D: 25-hydroxy vitamin D; 95% CI: 95% confidence interval; APSI: anterior-posterior stability index; MD: Mean difference; MLSI: medial-lateral stability index; OVSI: overall stability index; SD: Standard deviation.

evidence supporting the neurotrophic effect of vitamin D (Annweiler et al, 2010). In addition, vitamin D deficiency has been associated with a reduction in nerve conduction, and vitamin D appears to regulate neurotransmission by acting as a neuro-steroid hormone, as the improvement of postural balance involves both strong bones and good neuromuscular control (Buell and Dawson-Hughes, 2008).

The results of this study demonstrated that the study group showed a significant improvement in the walked distance in the 6MWT when compared with the control group. This improvement may be attributed to the combined effect of aerobic exercises and vitamin D supplementation.

The improvement in physical performance is directly proportional to the improvement in both peripheral and central circulation and the ability to consume and use oxygen, which are primarily dependent on specific key physiological adaptations such as increased red blood cell count, cardiac output, oxidative enzymes and slow twitch muscle fibres (Kubukeli et al, 2002). Aerobic exercises improve submaximal heart and respiration rates, aerobic performance, muscle strength and endurance, gross motor skills, and anaerobic power in children with Down syndrome (Lewis and Fragala-Pinkham, 2005). This supports the results in the present study describing improved balance and physical performance in the study group. These results are consistent with the finding of Lotan et al (2004), who proposed 8 weeks of appropriate treadmill training programme for children with intellectual disability (aged 5–10 years) and reported improvement in muscle strength and physical fitness.

Vitamin D supplementation plays an important role in neuromuscular control, and improves muscle strength, overall function and coordination (Annweiler et al, 2010). At the neuromuscular system level, vitamin D regulates muscle protein synthesis that could affect muscle mass, facilitates excitation coupling, and regulates intramuscular and intra-mitochondrial calcium concentrations (Bischoff-Ferrari, 2012). Vitamin D deficiency may lead to loss of type II muscle fibres, resulting in atrophy of the proximal muscles, decreased muscle strength, functional performance, gait speed and higher body sway. However, when older women with vitamin D-deficiency were supplemented with vitamin D for 6 months, improvements of knee extension strength and walking distance were reported (Verhaar et al, 2000).

Considering the beneficial effects, cost-effectiveness and minimal adverse effects of vitamin D, the authors encourage elevating serum 25 (OH)D levels to the minimal recommended level and optimising serum vitamin D levels above 30 ng/mL to decrease burdens of vitamin D deficiency and improve overall health, postural balance and physical performance in children with Down syndrome.

Limitations

The study has some limitations, including the short duration of the study and lack of follow up, which limits the ability to monitor the long-term effects of treatment. In addition, all the selected children had mild intellectual disabilities; therefore, generalising results to individuals with moderate and severe intellectual disabilities should be made with caution. Future studies are recommended to investigate the long-term effect of vitamin D supplementation in individuals who have moderate and severe forms of intellectual disabilities.

Conclusions

The findings from this study showed that vitamin D supplementation, combined with aerobic exercises and conventional physical therapy, had beneficial effects on balance and physical performance in children with Down syndrome. Vitamin D and aerobic exercises should be considered as an adjunctive therapy when planning rehabilitation programmes for children with Down syndrome. These findings should be viewed in the context of studies associating low vitamin D status with impairment in balance and physical performance, with subsequent recommendations of widespread supplementation.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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