Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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Investigating the Effectiviness of Exercise in Improving Balance for Children with Down Syndrome: A Systematic Review

Bachelor's thesis in Human Movement Science
Supervisor: Karin Roeleveld (NTNU/BEV)
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Abstract

Background: Children with Down Syndrome show a delay in developing both postural control and voluntary components of motor control when compared to peers. The delay applies to starting positions against gravity, such as balance control and performing composite activities. ***Objective***: This systematic review aimed to investigate if exercise can improve balance in children with DS, and which type of training can have the greatest impact. ***Methods***: RCT and clinical trials published between 2013 and 2023 were selected by searching in PubMed. We used the keywords ('physical activity' OR 'exercise' OR training) AND ('Down Syndrome'[Title] OR 'Trisomy 21'[Title]) AND balance. Articles older than 2013, articles that did not include children with DS, and articles that were not RCT or clinical trials were excluded from this systematic review. ***Results***: There were significant improvements in balance in five out of eight investigated articles. ***Conclusion***: The investigation shows that combined training programs and Wii balance board training had a great impact on balance in children with DS. The systematic review did find some weaknesses in the investigated articles that can be taken into consideration for further research. ***Keywords***: Balance, exercise, Down Syndrome.

Bakgrunn: Barn med Downs syndrom viser en forsinkelse i utviklingen av postural kontroll og frivillige komponenter av motorisk kontroll, sammenlignet med jevnaldrende. Forsinkelsen gjelder startposisjoner mot tyngdekraften, som balansekontroll og utførelse av sammensatte aktiviteter. ***Objektiv:*** Målet med denne litteraturstudien var å finne ut om trening kan bedre balanse hos barn med DS og hvilken type trening som kan ha mest effekt. ***Metode:*** RCT og kliniske studier publisert mellom 2013 og 2023 ble valgt ut i denne studien ved å søke i databasen, PubMed. Vi brukte søkeordene ('physical activity' OR 'exercise' OR training) AND ('Down Syndrome'[Title] OR 'Trisomy 21'[Title]) AND balance. Artikler som var eldre enn 2013, de studiene som ikke omhandlet barn og ungdom med DS, samt artikler som ikke var RCT eller kliniske studier ble ekskludert i denne studien. ***Resultat:*** Det var en signifikant forbedring i balanse hos fem av åtte undersøkte artikler. ***Konklusjon***: Undersøkelsen viser at kombinerte treningsprogram og trening med Wii balansebrett hadde god effekt på balanse hos barn med DS. Denne litteraturstudien fant noen svakheter i de undersøkte artiklene som kan tas i betraktning for videre forskning. ***Nøkkelord:*** Balanse, trening, Downs syndrom.

Introduction

Down syndrome (DS) is a congenital, genetic condition. The most common cause of DS is one extra chromosome connected to chromosome 21 (ca. 95%). Therefore, the condition is also called Trisomy 21. There are two more variants of DS. One is "translocation" where one extra chromosome 21 attaches to another pair of chromosomes (4%). The last variant is the case of mosaic where there will occur one extra chromosome 21 in some cells (1%) (Østby & Halvorsen, 2017). It's diagnosed by a genetic test, mostly from a blood sample. Most of the people with DS have a developmental disability where the degree varies. These developmental disabilities occur and are already visible early in children and young people. Difficulties like heart defects, vision and hearing difficulties, delayed movement development, balance, low tension in muscles, learning difficulties and communication, and language difficulties vary in the context of the disparities of disability that already exist in children and young people with DS (Oslo universitetssykehus, 2017).

Today, the overall goal related to interventions is that people with DS should be able to live good and meaningful lives, develop and have good opportunities for participating. The ICF – International Classification of Function – represents a framework for habilitation and should be used when planning and implementing habilitation measures. According to ICF, a child's participation in a life situation is the result of a complex interaction between personal factors, such as age, preferences, type and degree of disability, and the physical and social environment. Because of the varies in the degrees of disability, the children can be followed up in groups, based on the level of disability, their resources, challenges, and age.

World Health Organization (WHO) defines physical activity as "any body movement produced by skeletal muscles that requires energy expenditure" (World Health Organization, 2022). It is proven that physical well-being helps to prevent and still be able to live a good life with diseases such as heart disease, stroke, diabetes, different type of cancers, and hypertension, maintain healthy body weight, and improve mental health, quality of life, and well-being. WHO has guidelines and recommendations that provide details for different age groups and people with specific difficulties and disabilities on how much physical activity is needed for good health. For children and adolescents living with a disability they "should do at least an average of 60 minutes per day of moderate-to-vigorous intensity. Mostly aerobic, physical activity, across the week" (World Health Organization, 2022). They should also do vigorous- intensity aerobic activities and those that strengthen muscles and bone, at least three days a week. It is known that children and adolescents with DS are at risk of inactivity, obesity, and reduce physical fitness. Possible causal explanations for inactivity can be physiological factors, reduced postural control and balance, and also non-physiological factors such as motivation and other phycological factors (Østby & Halvorsen, 2017).

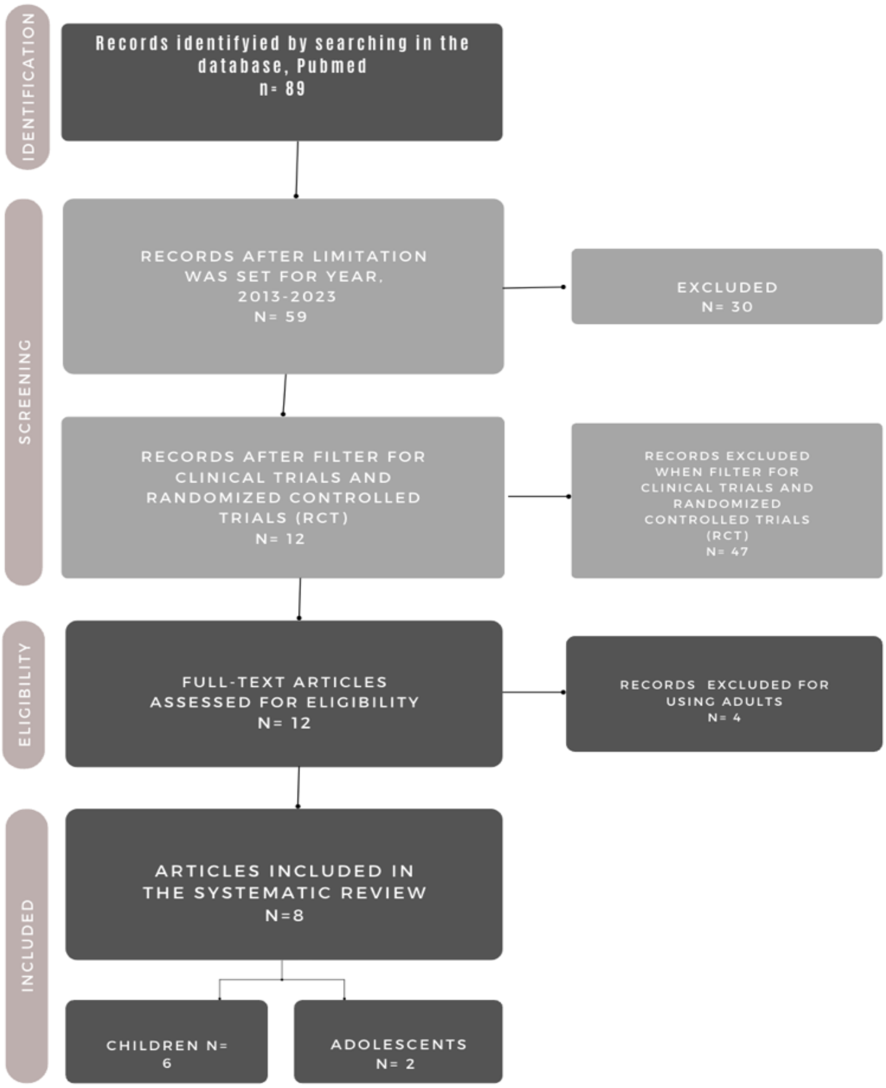
It is well-documented that children with DS show a delay in developing both postural and voluntary components of motor control when compared to peers. Postural control also called postural stability or postural orientation is defined as *"The ability to maintain or control the center of mass in relation to the base of support to prevent falls and complete desired movements"* (Aly & Abonour, 2016). Two processes are essential for postural control. The sensory organizational process involves sensory systems including visual, somatosensory, and vestibular systems in the central nervous system, and the motor adjustment process, which involves executing coordinated and properly scaled musculoskeletal responses (Aly & Abonour, 2016). Children with DS generally follow a similar pattern of gross motor development as those with normal development. However, the majority of children with DS experience a delay in their motor development. The delay applies to starting positions against gravity, such as balance control and performing composite activities. Anatomical conditions, loose ligaments and tendons, reduced balance, reduced cognitive function and visual difficulties are some causes of gross motor delay (Østby & Halvorsen, 2017).

Children with DS often display balance issues, which can manifest as a widened base of support, frequent falls, and difficulties with everyday activities such as walking and descending stairs. As an effect of exercise and physical activity, balance can be improved in children with DS. Research has shown a significant correlation between balance problems and muscle weakness and that maintaining muscle strength at an adequate level is essential for performing daily living activities (Aly & Abonour, 2016).

The aim of this systematic review was therefore, to investigate if exercise can improve balance in children with Down Syndrome, and which type of training can have the greatest impact.

Methods

The literature was found by using the database PubMed. Using the keywords ('physical activity' OR 'exercise' OR training) AND ('Down Syndrome'[Title] OR 'Trisomy 21'[Title]) AND balance, resulted in 89 articles. Some limitations were made. The year of publication was set from 2013 to 2023. Further, the studies had to be randomized controlled trials or clinical trials and include DS or Trisomy 21 in the title. Based on these inclusion criteria, 12 results were found. Out of these 12 articles, four of them were excluded. The exclusion criteria were 1) articles older than 2013, this is because the older articles did not include children and they were not RCT or clinical trials, 2) not RCT or clinical trials, and 3) does not include adolescents or children. In total eight original articles are included and used in this systematic review. These eight articles that are included are relevant because they contain research on different physical activities and exercises used to assess balance in children with DS.



Results

Table 1 shows that seven out of eight studies were RCTs, while one was a Quasi RCT, where the participants are assigned to different groups of the study, some receive the study medication and others receive a placebo, using an allocation that is not truly random (EUPATI, 2023). All articles included a training group, and a control group with DS except for article 6 which included one group with DS and one group without DS, where in this systematic review we will focus on the differences within the DS group. The age of the participants in the studies was 4-20 years old.

Articles 1,4, 5, and 8 used Biodex Balance System (BBS) to measure overall stability. The BBS platform can tilt in any direction with a maximum of 20 degrees (*Biodex Balance System*, 2023). Biodex Balance System has eight levels of stability from the least stable level (level 1) to the most stable level (level 8) (Eid, 2015).

To measure functional balance the Berg balance scale was used in article 1 where a scale ranging from 0-4 indicates if the task is performed independently (4) or if the children are unable to complete the task (0). A maximum possible score of 56 indicated no identifiable balance difficulties (Alsakhawi & Elshafey, 2019).

Eurofit Test Battery assesses physical fitness and includes different trials including the Flamingo balance test which is a single-leg balance test. Article 2 used the Flamingo balance test to measure balance in the control group and study group (Naczk et al., 2021).

Articles 3 and 7 evaluated gross motor development through the Test of Gross Motor Development. The TGMD-2 identifies deficits in gross motor development by evaluating 12 skills grouped into locomotor skills and object control skills. A maximum score of 48 points in the locomotor and object control subsets indicates better performance (Raghupathy et al., 2022).

Articles 3 and 6 used a balance board to evaluate postural control and assess balance, measured in mm/min and mm/s. In article 3, a Wii Balance Board with the RombergLab software calculated Pressure areas with eyes open (PC EO) and eyes closed (PC EC) (Gómez Álvarez et al., 2018).

Article 6 used Loran Engineering SrL, Italy, Software “FootChecker” 4.0 to collect COP displacement in four different conditions C1-C4 (Villarroya et al., 2013).

Along with the cognitive component of motor planning, article 7 used the Four Square Step Test to measure dynamic balance. Better performance in seconds was considered the actual score, and children with DS scoring higher than 20 seconds were at risk of falls (Raghupathy et al., 2022).

Paediatric balance scale was used by Article 7 to assess functional balance skills. The scale is a 14-item measure and has a grading scale of 0 points (lowest function) to 4 points (highest function) and a maximum score of 56 points (Raghupathy et al., 2022).

The group who received the traditional exercise program (TEP), the group with treadmill training in addition to TEP, and the core stability training group in addition to TEP in article 1 improved in all variables from the pre-test to the post-test (table 2). However, the treadmill training group and core stability training group improved more compared to the traditional exercise program group in functional balance and stability index, but there were no statistically significant differences between the treadmill training group and core stability training group in balance.

Article 4 showed improvement in all variables for both the group who received standard physical therapy and the group who received a trampoline-based SSC training program in addition to standard physical therapy. There was a greater improvement in postural indices for the trampoline based- SSC group than the standard physical therapy group from pre- to post-treatment. The results show a significant medium improvement in all indices for the standard physical activity group and a large improvement for the trampoline-based SSC group.

Article 8 showed improvement in the pre-test for all variables for both the group who received a physical therapy program in addition to WBV training and the group who only received physical therapy training. High scores in the stability indices indicated poor balance and therefore the reduction in the post-test mean values represents balance improvement. There was a statistically significant improvement in the group who received physical therapy training in addition to WBV training in all variables ($p>0.0001$) when compared to the group who only received physical therapy training.

There were improvements in all variables in both the neuromuscular training group and the traditional Indian dance group in Article 7. There was a significant improvement between the two groups in GMQ standard TGMD-2, locomotor TGMD-2, and FSST. However, the Indian dance group and the neuromuscular training group improved the same on the paediatric balance scale.

The group who continued normal daily activity in Article 3 showed no significant improvement in any of the variables, but the experimental group who received an exercise program based on the use of the Nintendo Wii (WBBG) improved in three out of five variables – PE EC, TGMD-2, and Manipulation. The experimental group had an improvement in the post-test in the TGMD-2 compared to the group who continued normal daily activity.

The group with DS who did not perform WBV training in Article 6 showed no improvement in any of the variables however, the DS group who performed WBV training showed improvement in two out of three variables under the closed-eye, compliant-foot-support condition (C4). They did not test if the group who performed WBV training improved more than the group who did not perform WBV.

Article 2 did not show any significant change when comparing between the group who received a swimming program with water-based exercises, and the group who maintained normal daily activity.

Article 5 showed no significant difference in the three variables pre-treatment between both groups, but there was a significant improvement post-treatment in all variables for both groups. There was more improvement in the group who received a traditional exercise program in addition to mechanical vestibular stimulation compared to the group who received a traditional exercise program in addition to regular balance exercise.

Table 1: Characteristics from the original articles included in this systematic review

Authors	Population with Down Syndrome and sample size	Age	Tests	Type of Activity	Duration
1.Alsakhawi et al. (2019) RCT	Total (n) = 45 Group A, traditional exercise program(n) = 15 Group B, treadmill training (n) = 15 Group C, core stability training (n) = 15	4-6 years	Biodex Balance System (Bioex Medical Systems, Version 3.1) Berg balance scale	Group A: A traditional exercise program with instructions to improve posture control and balance. Group B: A traditional exercise program with instruction and treadmill training. Group C: Traditional exercise program with instruction and core stability exercise	Group A: 60 min (traditional exercise program) Group B: 30 min (traditional exercise program) + 20 min (treadmill training) Group C: 30 min (traditional exercise program) + 3x 30 min per week (core stability training)
2.Naczk et al. (2021) RCT	Total (n) = 22 Group c, normal daily activity (n) = 11 Group t, water-based exercise, swimming program (n) = 11	Group c: 14.4 ± 1.97 years Group t: 14.9 ± 2.35 years	Eurofit Test (Eurofit Test Battery) - Flamingo Balance test	Group c: Normal daily activity Group t: Participated in a water-based exercise and a swimming program	First stage: lasted 4 weeks with swimming sessions of 70 minutes Second stage: lasted 4 weeks with swimming sessions of 80 minutes Third stage: lasted 15 weeks with swimming sessions of 90 minutes Fourth stage: lasted 10 weeks with swimming sessions of 90 minutes
3.Álvarez et al. (2018) RCT, Quasi-experimental study	Total (n) = 16 CG, normal daily activity (n)= 7 WBBG, experimental group with an exercise program based on the Nintendo Wii (n)= 9	6-12 years	Test of Motor Gross Development (TGMD-2) Nintendo Wii Balance Board (RombergLab software)	CG: Normal daily activity WBBG: Used the Wii fit software version along with the Wii balance board to play games such as Super Hula Hoop, Heading Soccer, and Ski Jumping + normal daily activities	Five weeks with two weekly sessions and a 20-minute duration
4.Azab et al. (2022) RCT	Total (n) = 32 CG, standard physical therapy (n) = 16 SSC group, standard physical therapy along with minitrampoline-based SSC (n) = 16	7-9 years	Biodex Balance System (Bioex Medical Systems)	CG: Received standard physical therapy SSC group: Received standard physical therapy in addition to a trampoline- based SSC training program	CG: 45 minutes per session standard physical therapy SSC group: 45 minutes per session of standard physical therapy + 15 minutes, twice per week for 12 weeks (SSC)

5.Nahla et al. (2022) RCT	Total (n) = 30 Group A, traditional exercise program in addition to regular balance exercise (n) = 15 Group B, traditional exercise program in addition to mechanical vestibular stimulation (n) = 15	7-10 years	Biodex balance system	Group A: Received physical therapy program including balance Group B: Received physical therapy program including mechanical vestibular stimulation	For both groups: 1 hour/ 3 sessions per week for successive 3 months. 45 minutes traditional exercise program. Group A: 15 minutes of regular balance exercise in addition to the 45 minutes of traditional exercise program. Group B: 15 minutes of mechanical vestibular stimulation in addition to the 45 minutes of traditional exercise program.
6.Villaroya et al. (2013) RCT	DS group (n)= 29 nDVSG VDSG	11-20 years	Static standing C1 FIX-SUP/OE C2 FIX-SUP/CE C3 COMP-SUP/OE C4 COMP-SUP/CE	DS group: The DS group was divided into two groups, one group performed WBV training, and the other group did not perform WBV training	The participants in the WBV group exercised three times per week. The balance of each participant was assessed at baseline and within the next 15 days after the last WBV training.
7.Raghupathy et al. (2022) RCT	Total (n) = 36 Neuromuscular training (n) = 18 Traditional Indian dance group (n) = 18	6-10 years	Gross Motor Development-2 (TGMD-2) The Four Square Step Test (FSST) Paediatric balance scale	Control group: Undertook neuromuscular training Experimental group: Received traditional Indian dance.	The training intensity and duration was equal for both groups. A supervised structured practice session lasted for 60 minutes a day including 10 minutes of warm- up and cool-down exercise. Three practice sessions a week for six weeks.
8.Mohammed Ahmed Eid. (2015) RCT	Total (n) = 30 Control group, physical therapy program (n) = 15 Study group, physical therapy program in addition to WBV training (n) = 15	8-10 years	Biodex Stability System	Control group: Received physical therapy program Study group: Received the same program as the control group in addition to WBV training	Control group: 1 hour, three times per week, for 6 successive months Study group: 1 hour, three times per week + 5-10 minutes (WBV), 6 successive months

RCT= Randomized controlled trial, CG= control group, WBBG = Wii Balance Board Group, SSC= Stretch-shortening, C1: openeyes/fixed-foot-support; C2: closed-eyes/fixed-foot-support; C3: openeyes/compliant-foot-support; C4: closed-eyes/compliant-foot-support, WBV = Whole Body Vibration , *Significant (p<0.05

Table 2: Results from the original articles with reported outcome measures

Author	Measures	Pre-treatment	Post-treatment	Significance of change	Study group vs. control group
1.Alsakhawi et al. (2019)	Functional balance Overall stability	Functional balance Overall stability Group A: 32.5± 3.8 4.20± 0.40 Group B: 31.7± 3.3 4.6±0.289 Group C: 33.2± 2.5 5.1± 0.15	Functional balance Overall stability Group A: 38± 2.58* 5.40± 0.70* Group B: 43.8± 2.9* 6.9±0.33* Group C: 45± 2.12* 7.4± 0.54*	Group A: Improvement in all variables Group B: Improvement in all variables Group C: Improvement in all variables	Improved more
2.Naczk et al. (2021)	Balance	Balance T: 13.7± 2.00 C: 14.8± 2.95	Balance T: 10.6± 8.39 C: 14.0± 3.28	Group T: Same Group C: Same	No improvement
3.Álvarez et al. (2018)	PC EO PC EC TGMD-2 Locomotion	CG WBBG PC EO 0.06± 0.0 0.06±0.04 PC EC 0.05±0.19 0.05±0.03 TGMD-2 63.86±6.34 63.00±5.39 Locomotion 33.71±3.69 34.56±5.94 Manipulation 30.14±6.67 28.44±5.46	CG WBBG PC EO 0.04± 0.03 0.07±0.05 PC EC 0.04±0.02 0.02±0.19 TGMD-2 63.14±7.99 71.67±7.75* Locomotion 33.71±4.82 36.67±3.39 Manipulation 29.43±5.86 35.00±5.50	CG: No improvement WBBG: Improvement in PC EC, TGMD-2, and manipulation	Improvement in the post-test in the TGMD 2 between the groups
4.Azab et al. (2022)	APSI MLSI OSI	CG SCC APSI 3.11±0.54 2.87±0.51 MILSI. 2.97±0.40 3.08±0.45 OSI 3.18±3.10 3.10±0.43	CG SCC APSI 2.83±0.36* 2.10±0.66* MILSI. 2.87±0.38* 2.48±0.56* OSI 2.92±0.43* 2.46±0.33*	CG: Improvement in all variables SCC: Improvement in all variables	Improved more
5.Nahla et al. (2022)	APSI MLSI OASI	Group A Group B APSI 3.52±0.65 3.6±0.58 MILSI 1.89±0.52. 1.72±0.41 OASI. 3.78±0.49. 3.67±0.52	Group A Group B APSI 3.3±0.67* 2.75±0.62* MILSI 1.7±0.53* 1.3±0.2* OASI. 3.48±0.54** 2.7±0.5**	Group A: Improvement in all variables Group B: Improvement in all variables	Improved more
6.Villaroya et al. (2013	ML AP Mean velocity	nDVSG: RMS-ROM AP RMS-ROM ML Mean velocity C1 1.35±0.85 2.0±1.3 16.0±8.0 C2 1.2±0.6 1.8±1.1 20.0±7.0 C3 2.4±01.3 4.5±3.2 37.0±19.0 C4 2.2±1.2 4.7±2.6 48.0±26.0 VDSG: RMS-ROM AP RMS-ROM ML Mean velocity C1 1.35±0.95 2.4±1.8 20.0±12.0 C2 1.2±0.5 2.4±1.4 24±32 C3 2.9±1.3 4.7±3.2 37.0±20.0 C4 3.3±2.4 4.9±2.1* 65.0±33.0*	nVDSG: RMS-ROM AP RMS-ROM ML Mean velocity C1 1.5±1.1 2.1±1.3 16.0±8.0 C2 1.6±1.6 1.9±0.7 20.0±11.0 C3 2.8±1.5 3.7±1.2 36.0±28.0 C4 2.7±1.5 3.7±1.5 39.0±19.0 VDSG: RMS-ROM AP RMS-ROM ML Mean velocity C1 1.4±1 1.9±0.7 15.5±9.5 C2 1.3±0.6 2.8±2.3 23.0±20 C3 2.9±2.5 4.2±2.1 35.0±24 C4 2.4±1.2 3.2±1.6 45.0.±24	nDVSG: No improvement VDSG: Improvement in C4	Not investigated
7.Raghupathy et al. (2022)	GMQ standard TGMD-2, Locomotor TGMD-2, Object control TGMD-2, FSST, Paediatric balance scale	NMT TID GMQ standard TGMD-2 85.94±19.08 90.29±14.12 Locomotor TGMD-2 35.88±6.7 34.76±4.29 Object control TGMD-2 36.59±11.25 40.12±5.12 FSST 19.41±2.24 19.0±1.37 Paediatric balance scale 50.24±2.33 50.06±2.3	NMT TID GMQ standard TGMD-2 97±19.38** 120.76±7.76** Locomotor TGMD-2 40.24±6** 45.88±1.58** Object control TGMD-2 40.12±8.89 46.29±2.14 FSST. 17±2.15** 14.7±1.36** Paediatric balance scale 54.1.41 53.65±1.32	NMT: Improvement in all variables TID: Improvement in all variables	Same
8.Mohammed Ahmed Eid. (2015)	Stability index Mediolateral Anteroposterior Overall	Study Control Mediolateral 1.38±0.16 1.37±0.15 Anteriopostierior 1.14±0.12 1.14±0.13 Overall 1.4±0.11 1.42±0.09	Study Control Mediolateral 1.09±0.15** 1.24±0.09** Anteriopostierior 0.92±0.8** 1.05±0.08** Overall 1.19±0.14** 1.37±0.12**	Study group: Improvement in all variables Control group: Improvement in all variables	Improved more

PC EO = Area of movement of the Pressure Center with Eyes Open, PC EC = Area of movement of the Pressure Center with Eyes Closed, TGMD-2 = Test of Gross Development, WBBG = Wii Balance Board Group, CG = Control Group, SSC = Stretch-shortening, APSI = anteroposterior stability index, MLSI = mediolateral Stability index, OASI = overall stability index, OSI = overall stability index, RMS-ROM, root mean square of COP excursion; AP, anterior–posterior; ML, medial–lateral, nDVSG = Down Syndrome group, no WBV, DVSG = Down Syndrome group, WBV = Whole Body Vibration, GMQ = Gross Motor Quotient, FSST = Four square step test, NMT= neuromuscular training, TID= Traditional Indian dance, *Significant ($p<0.05$), **Significant ($p<0.001$)

Discussion

The main findings in this systematic review were that five out of eight study groups improved more than their control group in balance. Two of the three remaining groups were two study groups that had no improvement compared to their control group, and the last one was not investigated. However, there were some positive changes within the study and control groups from pre-treatment to post-treatment. As mentioned earlier, balance is one of several challenges in the motor development of children and adolescents with DS.

There are several ways to improve balance and postural control, and Li et al. (2013) found in their article that exercises such as treadmill walking, balance exercise, and weight-bearing exercise on children with DS had a positive effect (Li et al., 2013). Article 2 was the only study in this systematic review with no improvement in balance, this may be due to their type of exercise used to improve balance, which was a 33-weeks swimming program given to the study group, and where the control group maintained normal daily activity. It should be mentioned that there is a small amount of studies concerning the influence of a swimming program on balance of adolescents with DS. Swimming exercise is a training form that mainly improves muscles in the upper-limb, such as muscles in the back, arms, chest and shoulders, but also core muscles, glutes, legs, quads and calves (Merethe Kvam, 2022). According to our findings strength training is significantly to improve balance in children with DS. Seen in the context of our findings, we believe that it could be beneficial in Nazck et al's (2021) study to include another type of exercise, in addition to swimming, which strengthens the lower limb, and helps to regain and improve balance.

The majority of the control groups in this systematic review were given a regular strength-training program, and the study groups were given a regular strength-training program in addition to another form of activity that should improve balance. We found that, in connection to this, it seems like the study groups improved balance more than the control groups.

It should be mentioned that the articles contained different duration and intensities and thus may have influenced the results. Due to little research on duration and intensity, it is difficult to say anything about how long an intervention should last to improve balance in children with DS. Judging from the articles we have included, the intervention varies from five weeks to 33 weeks, and based on our main findings where five out of eight studies improved more than their control group, we see that there were greater results on an intermediate intervention time on three, and six months. Except for article 3 which lasted for five weeks and had improvement in balance. It is difficult to say whether they achieved great results because of the duration, or assigned training in the different groups. The control group was told to continue doing daily activities which may mean that they did not do any form of exercise to improve balance, and in contrast, the study group used a Wii balance board to improve balance with two weekly sessions of 20 minutes. This can make it difficult to say anything about the validity of the result (Gómez Álvarez et al., 2018). This is also confirmed and can be seen in the remaining three articles. They all mention that it would have been an advantage if the intervention lasted longer and that there was better follow-up.

There were found weaknesses in all the articles considered in this systematic review. Alsakhawi et al.(2018) had a total of 45 participants in their article. They mentioned that their sample size might be a weakness because it may have an impact on the generalization of the results (Alsakhawi & Elshafey, 2019). A larger sample size provides a larger amount of data that can be researched, which in turn can say something about the validity of the study and whether the results can be a generalization to children and young people with DS or not. Another weakness was to not include participants with DS in both the control and study group, and not investigating which one of the two groups that improved more in balance (Villarroya et al., 2013). The lack of a functional scale to evaluate the balance was also a weakness (Nahla et al., 2022). Lack of information on the role of some of the tests in the articles leads to weaknesses in the generalizability of the results, e.g., the role of trampoline-based SSC exercises in children with DS (Azab et al., 2022). Other weaknesses shows that there is too little research on different intervention methods and their effect on balance, like WBV (Eid, 2015). High pre-test values in the paediatric balance scale could have made it difficult to consider if the intervention did affect balance or not, and therefore difficult to say what benefits the intervention can have in later studies for children with moderate to serve issues (Raghupathy et al., 2022). It is also important to look at whether the children's interest, commitment, and willingness to participate and perform the interventions may have affected the results that have been found.

Four of the articles that were investigated in this systematic review used a combination of traditional/physical exercise programs in addition to more specific exercise (core stability, treadmill, WBV, SSC, mechanical vestibular stimulation), which was intended to improve balance in children with DS. Li et al. (2013) carried out a review to look at the impact of physical exercise interventions on physical fitness for individuals with DS. Their findings showed that there was a significant effect of exercise training on muscle strength where there was a combination of, among others, resistance training and balance exercise, a combination of treadmill training and game-like exercise. In one of the studies, they found that there was only an improvement in upper-limb muscular endurance but no improvement in lower-limb muscle, where impaired gait patterns can be seen as a result (Li et al., 2013). The four articles in this systematic review that had a combination of exercise programs in both study and control groups with improvement in balance, can be seen in agreement with Li et al. (2013) who concluded that to maintain balance for individuals with DS, muscular endurance through a combined exercise program might improve balance.

In addition to some of the articles using physical therapy programs and traditional training programs, one article used a Nintendo Wii along with a Wii balance board to improve balance. This is a slightly more modern way to exercise, and it consists of new technology if we compare this to the other articles in this systematic review. As we have seen Wii balance board did improve balance in children with DS. Another study with similar results that tests whether the Wii balance board has an effect on children with DS or not, and supports our findings are presented by Berg et al. (2012) in their article “Motor Control Outcomes Following Nintendo Wii Use by a Child With Down Syndrome”. They found that repeated practice of Wii bowling, baseball, rhythm boxing, and snowboarding led to an improvement in upper-limb coordination, balance, postural stability, and limits of stability control (Berg et al., 2012). The use of a Nintendo Wii with a Wii balance board could be highly valuable from a methodological perspective, as it encourages early engagement in programs aimed at promoting motor development in children with DS (Gómez Álvarez et al., 2018).

Conclusion

To sum up, this systematic review aimed to investigate if exercise can improve balance in children with Down Syndrome, and which type of training can have the greatest impact. In conclusion, the investigation in this systematic review shows that combined training programs including traditional/physical exercise programs in addition to more specific exercises e.g., core stability, treadmill, WBV, SSC, and mechanical vestibular stimulation had a great impact on balance. Wii balance board training also greatly impacted balance in children with DS. However, there were some weaknesses in terms of sample size and the duration of the intervention. We suggest that it could be an advantage if further research includes interventions with longer duration to be able to say something about long-term effects.

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