Current Approaches to Improve Balance in Down Syndrome Population-A Systematic Review

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Abstract: Down syndrome is one of the most common chromosomal disorders in pediatrics characterized by variable intellectual disability, generalized joint laxity, and hypotonia that compromises their function and causes a delay in developing gross motor skills, poor balance, and coordination. Thus, this study aims to determine the current yet effective treatment approaches to improve balance in the Down syndrome population. The studies were explored across seven electronic databases that include MEDLINE, PubMed, Cochrane Library, Google Scholar, Scopus, PEDro, and Web of Science from inception till October 2020 comprised of experimental studies published in English language investigating the effects on balance in children and adults diagnosed with DS considering different interventions. A total of 1,570 records were retrieved from seven electronic databases published between the year's tenure of 2013-2020. 144 full-text papers were extracted to be reviewed, of which only 18 experimental studies were selected on the basis of inclusion criteria that involved 493 Down syndrome patients, investigated the effects of therapeutic exercises, manual therapy techniques, and patient-related instructions on standardized balance scales/tests. It was concluded that all the included trials demonstrated significantly profound effects in improving the static and dynamic balance of Down syndrome patients. Therefore, none of the interventions is declared as superior to another in terms of obtained results. Furthermore, these diverse interventions need to be investigated more for better understating and generalizability of outcomes.

Keywords: Down syndrome, Trisomy 21, Therapy, Proprioception, Equilibrium, Position Sense.

INTRODUCTION

Down Syndrome (DS), a subcategory of intellectual disability, is one of the most common chromosomal disorders in the pediatric population caused by full trisomy 21 (94%), mosaicism (2.4%), or translocations (3.3%) [1]. World Health Organization (WHO) documents the global incidence of children with Down Syndrome to be 1 out of 600-1000 live births [2]. The condition is characterized primarily by variable intellectual disability and peculiar physical features like distinct facial phenotype, short stature, and generalized joint laxity, and hypotonia with effect on health and development [3, 4]. Hypotonicity causes decreased muscular strength and activity tolerance and hypermobility in joints, compromising their function and delay in developing gross motor skills, poor balance, and coordination [1, 5, 6]. Evidence shows that motor development in this population has a different profile than that of a child without disabilities because the age category at which a specific motor level is reached is higher [7]. Besides, DS children may exhibit a wide range of co-morbidities affecting various systems like respiratory, cardiac, immune, endocrine, etc. [8]. Despite this fact, survival has increased considerably in the last 50 years from < 50% in the mid-1990s to 95% in the early 2000s with a life expectancy of 60 years [9]. One of the reasons for this improvement can be attributed to advancements in medical technology with prenatal detection and early intervention. A paradigm shift is observed in society's attitude towards the normalization of the lives of people with DS [8]. This has led to a better state of health, a higher degree of autonomy, integration, and inclusion of this population in the community during the last two decades [8]. Despite all these advances, the incidence has also grown in the last decades, drawing the attention of scientists from various fields on its causes, forms of manifestation, and ways of treating the children diagnosed with this syndrome with the development of a comprehensive therapeutic approach [7].

Multiple studies suggested that DS children present with decreased balance, affecting motor skill proficiency and physical activity. Therefore, approaches that deal with this issue are of utmost importance as their participation in various walks of life is increasing as well as in athletic and sports events

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[10, 11]. Moreover, improved gross motor skills and balances would help in increasing their role in life activities and enhancing their self-esteem [12]. Experimental Studies for Down syndrome to improve balance are scarce, creating a vacuum in this domain [8]. Thereby arising a need to explore various therapeutic approaches to ameliorate balance among the population [13].

Furthermore, to the best of author's knowledge, no such review that highlights various modes of intervention to improve balance is found. Therefore, this review intends to synthesize various effective and efficient methods that enhance balance in the DS population. Moreover, disseminate awareness amongst the rehab professionals regarding these methods to enhance their knowledge of diverse forms of intervention available and increase the horizon of the specialist, especially physical therapist, to improvise the plan of care. Thus, the identification of effective modes of intervention would enhance and upgrade therapists' skills, which will eventually benefit the Down syndrome population specifically and society in general. Therefore, the objective of this systematic review is to evaluate the current strategies to improve balance in the DS population, as well as to identify the most effective amongst them.

METHODS

This study followed Preferred Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines to ensure that the pertinent evidence was sourced and synthesized into the conscripting of this commentary.

Databases and Literature Surveillance

The studies were explored through a systematic approach across seven electronic databases: MEDLINE, PubMed, Cochrane Library, Google Scholar, Scopus, PEDro, and Web of Science from inception until October 2020. Filters about publication dates or language were applied. The authors used Medical Subject Headings (MeSH) to identify the related entry terminology in our searches comprised of *“Balance AND Down Syndrome”, “Interventions AND Balance AND Down Syndrome”, “Balance AND Down Syndrome: RCTs”.*

Inclusion Criteria

(1) Participants were children and adults diagnosed with DS, (2) Experimental studies, (3) Intervention constitutes of therapeutic exercise, manual therapy techniques, patient-related instructions, and orthotic devices, (4) Outcome measure; balance and standardized balance scale/test, (5) Studies published during 2013-2020, (6) Preferred language; English.

Exclusion Criteria

Data reported does not address the Down syndrome interventions searched, (2) Data reported was unable to analyze for balance specifically, (3) Literature preceding 2013, (4) Unavailable full-texts (5) Non-English studies (6) Duplication.

Study Selection

Literature Search was performed by the first author, and screening was executed according to the aforementioned eligibility criteria by reviewing titles. Furthermore, advice was sought from experienced reviewers for any disparity on inclusion/exclusion of studies reaching a final list of studies.

Data Extraction

The extraction of data was done by two researchers in a systematic way from the study list finalized by two independent reviewers. The extracted data included information on (1) Author and publication year (2) Characteristics of the participants (Number of Participants, Age, Gender, Severity of ID) (3) Intervention (Frequency, Duration) (4) Outcome Measures (5) Summary of results.

Risk of Bias

The risk of bias was evaluated by using the Cochrane tool for assessing the risk of bias [14] in random allocation, allocation concealment, blinding of participants and outcome assessment, incomplete outcome data, selective reporting, and other biases.

RESULTS

Selection and Characteristics of Studies

A total of 1,570 records were retrieved from seven electronic databases comprised of MEDLINE, PubMed, Cochrane Library, Google Scholar, Scopus, PEDro, and Web of Science published between 2013-2020. After the initial screening, 870 records were excluded due to unmatched title and abstract, whereas 556 removed due to duplications, irrelevant and non-English language. Further, 144 full-text papers were extracted to be reviewed, of which only 18

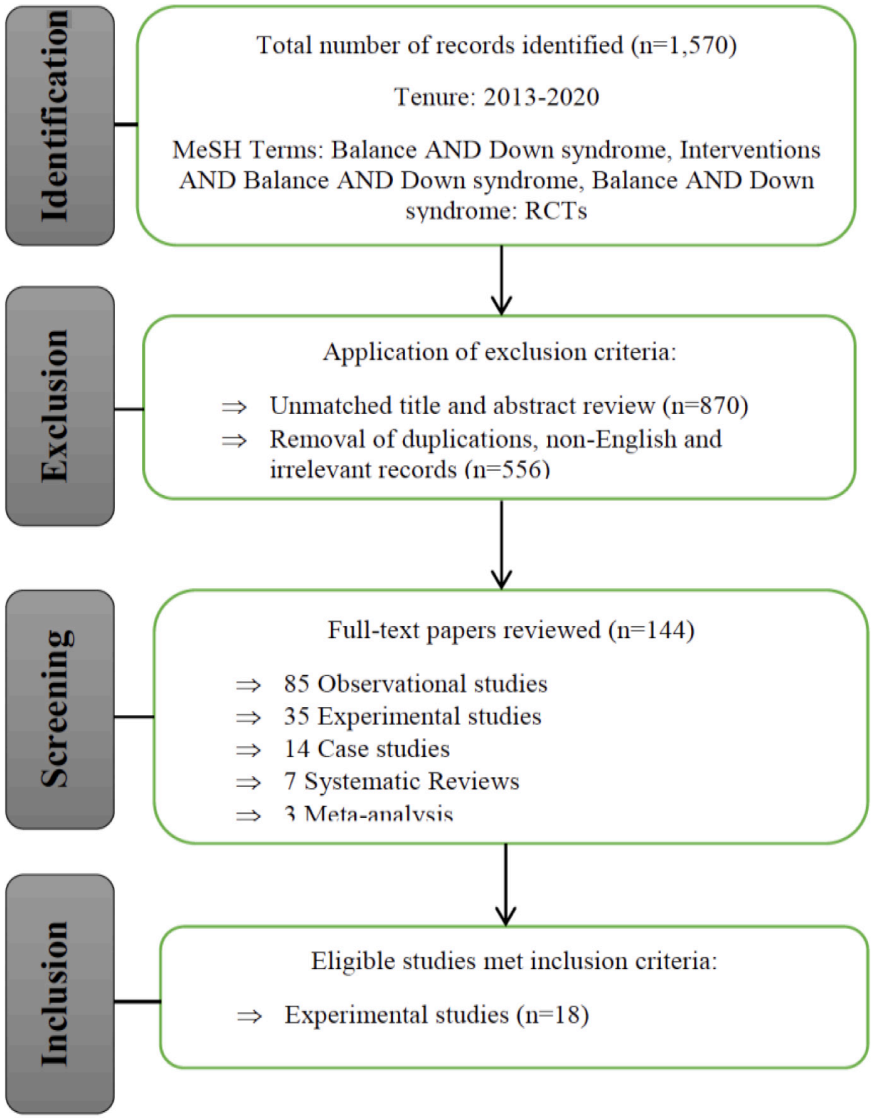

Figure 1: Represents the conceptualization of the review process.

experimental studies were selected on the basis of inclusion criteria that involved 493 Down syndrome patients, investigated the effects of therapeutic exercises, manual therapy techniques, patient-related instructions, and orthotic devices on standardized balance scales/tests.

The selection of criteria of studies was accomplished in the following subsequent phases, as shown in Figure **1**.

Synthesized Findings

Among the eighteen experimental studies, fourteen studies were Randomized Controlled Trials; three were Quasi-experimental, while only one was Non-randomized controlled trial. A study conducted by Alsakhawi *et al*. [15], Eid *et al*. [20], Ghafar *et al*. [21], and Reis *et al*. [22] investigated the effects of traditional/conventional physiotherapy with an adjunct intervention such as treadmill, core stability, isokinetic training, and virtual reality, and the investigation revealed that conventional therapy in combination with an adjunct intervention was more effective than solitary to improve balance among DS patients. Gheitasi *et al*. [16] and Ghaeeni *et al*. [26] showed the efficacy of core stability exercises, either alone or in combination with the swiss ball or resistance training, in improving static balance. Similar outcomes were reported by Boer *et al*. [17] and Hamed *et al.* [23] regarding aquatic therapy alone or in combination to balance exercises. Further, Eid [25] and Villarroya *et al*. [28] demonstrated comparable findings with whole-body vibration. Likewise, Kamatchi *et al*. [10] and Carter *et al*. [5] exhibited higher effectiveness of vestibular stimulation

Table 1: Main Characteristics of Participants in the Study (n=18)

Studies	Sample Size	Groups	Average Age	Severity of Intellectual Disability
Alsakhawi *et al*. 2019 [15]	45	IG_1 (n=15) IG_2 (n=15) CG (n=15)	4.59 ± 0.53	ND
Gheitasi *et al*. 2019 [16]	54	IG_1 (n=18) IG_2 (n=18) CG (n=18)	20.5.8±1.17 22.6±1.5 23.2±2.07	50-70
Didehdar and Kharazinejad 2019 [12]	20	IG (n=10) CG (n=10)	8.50±1.60	43.50±7.83
Boer *et al*. 2019 [17]	23	IG (n=13) CG (n=10)	31.4±7.4	ND
Akyol *et al*. 2018 [18]	30	G_1 (n=15) G_2 (n=15)	8.02 ± 4.32 9.12 ± 4.23	ND
Kamatchi *et al*. 2018 [10]	30	IG_1 (n=15) IG_2 (n=15)	6-9	$\geq$ 50
Carter *et al*. 2018 [5]	17	G_1 (n=9) G_2 (n=8)	9.9±2.8 18.4±1.7	ND
Ahmadi *et al*. 2018 [19]	13	IG (n=7) CG (n=6)	28.75 ±6.1 30 ±8.5	63.85 ±5.2 62 ±8.78
Eid *et al*. 2017 [20]	31	IG (n=15) CG (n=16)	10.26 ± 0.79 10.05 ± 0.68	50–69
Ghafar *et al*. 2017 [21]	26	IG (n=13) CG (n=13)	7.18 ± 1.85 7.40± 1.27	50-70
Reis *et al*. 2017 [22]	12	IG (n=7) CG (n=5)	9±2.5 8±2.5	ND
Hamed *et al.* 2016 [23]	30	IG (n=15) CG (n=15)	9.10 ±0.78 9.11 ±0.67	ND
Gutiérrez-Vilahú *et al.* 2016 [24]	22	G_1 (n=11) G_2 (n=11)	20.5 ±1.3 20.2 ±2.0	Low to Moderate
Eid 2015 [25]	30	IG (n=15) CG (n=15)	8.93± 0.7 9.26 ±0.79	57.06 ±2.98 57.6 ±3.08
Ghaeeni *et al*. 2015 [26]	16	IG (n=8) CG (n=8)	9.62 ±1.68 9.87±1.64	ND
Park *et al*. 2014 [27]	10	IG (N=10)	14.89 ± 0.78	ND
Nejadsahebi 2013 [11]	30	IG (n=15) CG (n=15)	18±0.3 19±0.4	ND
Villarroya *et al*. 2013 [28]	54	IG_1 (n=16) IG_2 (n=13) CG_1 (n=11) CG_2 (n=14)	15.93±2.48 15.64±2.93 14.53±2.67 15.40±1.81	ND

in improving balance. Moreover, Akyol *et al*. [18] and Ahmadi *et al.* [19] concluded that functional or gymnastics training with music has led to significant differences in balance. On the other hand, Didehdar and Kharazinejad [12], Park *et al.* [27], and Nejadsahebi [11] ascertained the significant effects of sensory integration, wobble board training, and rebound therapy, respectively as a single intervention in enhancing static and dynamic balance. However, Gutiérrez-Vilahú *et al.* [24] indicated that a combination of diverse management through core strength, ballet barre, proprioception, balance exercise, and

Table 2: Description of the Eligible Studies (n=18)

Studies	Study Design	Intervention	Duration	Measuring Scale/Test	Result
Alsakhawi *et al*. 2019 [15]	Randomized Controlled Trial	IG_1.Traditional exercise for 30 min + treadmill training for 20 minutes IG_2.Traditional exercise for 30 min + core stability training for 30 minutes CG- Traditional exercise for 60 minutes	3times/week for 8 weeks	Berg Balance Scale Biodex Balance System	Both IGs significantly improved. No significant difference observed between IGs
Gheitasi *et al*. 2019 [16]	Quasi-Experimental Study	IG_1.Core Stability + Swiss ball Exercise IG_2.Core Stability +Total Resistance Exercise CG-Daily Routine Activities	3 times/week for 8 weeks	Stork Test Y-Balance	Both IGs significantly improved. In Static Balance, SBE was better than TRX while in Dynamic Balance, TRX group was better than SBE
Didehdar and Kharazinejad' 2019 [12]	Quasi-Experimental Study	IG-Sensorimotor Integration training, 50 sessions of 40 minutes CG-Class Training program	6 times/week	Modified Stork Test Timed Up and Go Test	IG showed significant improvement in static and balance
Boer *et al.* 2019 [17]	Non-randomized Controlled Trial	IG-Aquatic Training Program for 35-45 minutes CG-ND	3 times/week for 6 weeks	Standing on One Leg 8ft Up and Go Sit-to-Stand	IG significantly improved than CG with strong to medium effect sizes
Akyol *et al*. 2018 [18]	Randomized Controlled Trial	G_1-Gymnastics Training with Music. 1.5-2 hours G_2.Gymnastics Training with Music. 1.5-2 hours	2 times/week for 16 weeks	Flamingo Balance Test Functional Reach Test	Significant differences in both groups; however, G_1 improved more than G_2
Kamatchi *et al*. 2018 [10]	Randomized Controlled Trial	G_1-Weight-Bearing Exercises for 30 minutes G_2.Vestibular Stimulation for 30 minutes	7 days/week for 6 weeks	Pediatric Balance Scale	G_2 showed higher effectiveness in improving balance than G_1
Carter *et al*. 2018 [5]	Randomized Controlled Trial	G_1 and G_2 received Vestibular Stimulation Exercise for 10 mins	2 times/week for 16 weeks	Bruininks Oseretsky Test of Motor Proficiency	Balance improved more in G_2 than G_1
Ahmadi *et al*. 2018 [19]	Randomized Controlled Trial	IG -Functional Strength Training for 60 mins CG-Usual activities	3 times/week for 6 weeks	Standing Stork Test	Significant improvement in IG
Eid *et al*. 2017 [20]	Randomized Controlled Trial	IG-Conventional Therapy for 45 min+ Isokinetic Training Program for 15 minutes CG-Conventional Physical Therapy for 1 hour	3 times/week for 12 weeks	Biodex Stability System	Both groups improved Significantly. However, IG > CG
Ghafar *et al*. 2017 [21]	Randomized Controlled Trial	G_1.Traditional Physical Therapy for 30 mins G_2= Wii based Program (Virtual Reality) for 30 mins	3 times/week for 8 weeks	Pediatric Balance Scale Timed Up and Go test Five-Times-Sit-To-Stand Test	Significant improvement in both groups. In between Group comparison, G_2 improved more than G_1

(Table 2). Continued.

Studies	Study Design	Intervention	Duration	Measuring Scale/Test	Result
Reis *et al*. 2017 [22]	Randomized Controlled Trial	IG- Virtual Reality Therapy + Usual activities, 16 sessions of 20 minutes CG-ND	4 times/week for 4 weeks	Pediatric Balance Scale	Statistically significant improvement in IG
Hamed *et al*. 2016 [23]	Randomized Controlled Trial	IG- Balance Exercise program+ swimming Training program (Aquatic Therapy) CG-Balance exercise Program	3 times/week for 12 weeks	Balance Master System	Significant improvement in IG
Gutiérrez-Vilahú *et al*. 2016 [24]	Randomized Controlled Trial	G_1 and G_1received same treatment warm-up activities (5–10 min), core strength and ballet barre exercises (15 min), proprioception exercises and balance (20 min), choreography (20 min), improvisational exercises and image recognition in a mirror (15 min), and relaxation (5–10 min) for the total 90 minutes	2 times/week for 18 weeks	Center of Pressure (COP) closed and open eyes	G_1 improved some parameters related to the use of visual input in controlling COP
Eid'2015 [25]	Randomized Controlled Trial	IG-Physical Therapy program + Whole-body Vibration training for 1 hour + 5-10 min CG- Physical therapy program for1 hour	3 times/week for 6 months	Biodex Stability System	Significant improvement in both groups IG>CG
Ghaeeni *et al*. 2015 [26]	Randomized Controlled Trial	IG- Jeffrey's Core stability Exercises for 45-60 minutes CG-ND	3 times/week for 8 weeks	Modified Stork Test	Significant progression in static balance was observed in IG
Park *et al*. 2014 [27]	Quasi-experimental Study	G_1- Wobble Board Training	Not mentioned	Center of pressure (COP) with eyes open and closed	Significant improvement observed
Nejadsahebi 2013 [11]	Randomized Controlled Trial	IG-Rebound Therapy for 20 minutes CG-ND	3 times/week for 8 weeks	BERG Standard Test Timed Up and Go	Significant improvement in IG, Dynamic balance > Static balance
Villarroya *et al*. 2013 [28]	Randomized Controlled Trial	IG-Whole Body Vibration CG-Squat Exercises	3 times/week for 20 weeks	Postural Parameters (COP)	IG had a positive effect on balance only under specific conditions

IG-Intervention Group; CG-Control Group; G-Group; ND-Not Mentioned; COP-Centre of Pressure.

choreography showed improvement in some parameters related to the use of visual input in controlling COP. The majority of studies were observed to provide the optimal duration of intervention, 3 times/week for 6, 8, or 12 weeks, while certain studies constitute of prolonged duration of 18-20 weeks or 6 months for the notable effects. Among various standardized balance assessments, Biodex Balance System, Stork Test, Timed Up and Go Test, Pediatric Balance Scale, and Center of pressure (COP) were used by a number of studies. However, due to heterogeneity among the selected articles and their outcomes, measures meta-analysis could not be performed. The characteristics and descriptions of the studies are represented in Tables **1** and **2**.

Risk of Bias

The risk of bias based on the author's judgment for each included trial was performed using Cochrane's Risk of Bias Tool, as shown in Table **3** and Figure **2**.

Selection Bias

Random Sequence Generation

All trials demonstrated low risk except for three studies [5, 17, 24] that represented a high risk.

Table 3: Cochrane Summary for Risk of Bias (n=18)

Studies	Random Allocation	Allocation Concealment	Participants Blinding	Outcome Assessment Blinding	Incomplete Outcome Data	Selective Reporting
Alsakhawi *et al*. 2019 [15]	✓	✓	×	×	×	✓
Gheitasi *et al*. 2019 [16]	✓	✓	×	?	✓	✓
Didehdar and Kharazinejad 2019 [12]	✓	✓	×	×	×	✓
Boer *et al*. 2019 [17]	×	×	×	×	×	✓
Akyol *et al*. 2018 [18]	✓	✓	×	×	×	✓
Kamatchi *et al*. 2018 [10]	✓	✓	×	×	×	✓
Carter *et al*. 2018 [5]	×	×	×	×	×	✓
Ahmadi *et al*. 2018 [19]	✓	✓	×	×	×	✓
Eid *et al*. 2017 [20]	✓	✓	×	✓	✓	✓
Ghafar *et al*. 2017 [21]	✓	✓	×	✓	×	✓
Reis *et al*. 2017 [22]	✓	✓	×	×	×	✓
Hamed *et al*. 2016 [23]	✓	✓	×	×	×	✓
Gutiérrez-Vilahú *et al*. 2016 [24]	×	×	✓	×	✓	✓
Eid 2015 [25]	✓	✓	×	✓	✓	✓
Ghaeeni *et al*. 2015 [26]	✓	✓	×	×	×	✓
Park *et al*. 2014 [27]	✓	✓	×	×	×	✓
Nejadsahebi 2013 [11]	✓	✓	×	×	×	✓
Villarroya *et al*. 2013 [28]	✓	✓	×	×	×	✓

✓, indicates low risk of bias.
×, indicates high risk of bias.
? , indicates that cannot ensure risk of bias.

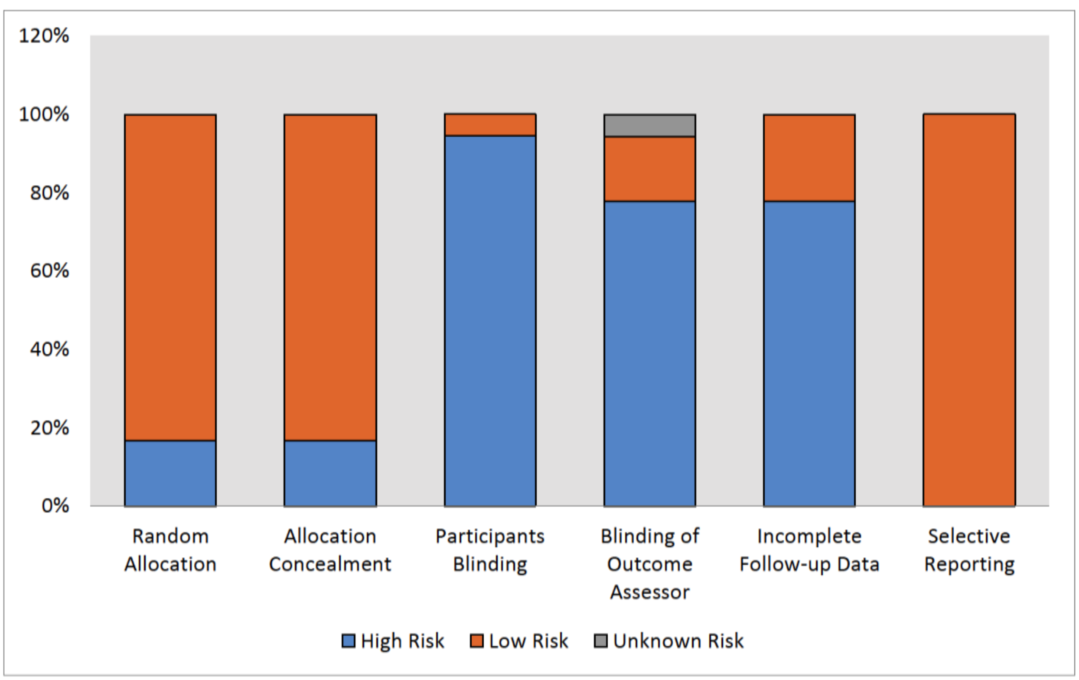

Figure 2: Represents Cochrane Risk of Bias Assessment.

Allocation Concealment

Similarly, all included studies trials demonstrated low risk except for three studies [5, 17, 24] that showed high risk.

Performance Bias

Blinding of Participants and Personnel

Only one study [24] out of eighteen showed a low risk of bias.

Detection Bias

Blinding of Outcome Assessment

Three studies [20, 21, 25] reported a low risk of bias. However, one study [16] showed unknown risk while the remaining studies demonstrated high-risk bias [5, 10-12, 15, 17-19, 22-24, 26-28].

Attrition Bias

Incomplete Outcome Data

Four out of eighteen studies [16, 20, 24, 25] reported the loss to follow-up data and incomplete outcome data, while the remaining showed the high risk of bias [5, 10-12, 15, 17-19, 21-23, 26-28].

Reporting Bias

Selective Reporting

All the included studies showed a low risk of bias. [5, 10-12, 15-28].

DISCUSSION

The review summarizes various interventions used to improve balance in persons with DS in the literature. The synthesized article into this commentary was reviewed by authors to ascertain the desired verdict.

Core Stability Exercises

Alsakhawi *et al*. [15] established the benefits of core stability training via Jeffrey's protocol included lumbar-pelvic proprioception retraining, specific spinal stabilization exercises, muscle contractions, and abdominal maneuvers in combination with treadmill and traditional training. Both the treatment approaches were found to be equally effective in improving static and dynamic balance as well as gait patterns. Besides, Gheitasi *et al*. [16] used some games and recreational practices for the motivation of training that has led to a significant statistical improvement between training groups, in particular to static balance in the Swiss ball training group. Moreover, the increase was higher in the dynamic balance and muscle endurance in the TRX training group. Besides, Ghaeeni *et al*. [26] showed that core stability exercises improve the static balance of Down syndrome children by developing strength and endurance of the core stabilization area. The mechanism is most probably related to the integration of proprioceptive feedback due to closed chain movements.

Virtual Reality

Ghafar et al. [21] used VR based Wii training constituted of football heading game that improves movements of trunk and extremities, Ski Slalom that elicits balance strategies and loading of the lower limbs, Table Tilt game elicits control over the whole body through dynamic balance on a virtual balance board. Likewise, Reis *et al*. [22] used two games from Kinect Adventures®, i.e., River Rush® and Hall of ricochets® that leads to improved quality of motor responses and a higher balancing score statistically significant. The findings revealed that VR is superior to traditional physiotherapy training in improving the balance in DS children that is partially due to the training repetition that enhances the recovery of brain plasticity as well as motivates patients to interact and contribute in simulated environments to perform a specific therapeutic exercise.

Aquatic Therapy

Hamed *et al*. [23] established a statistically significant difference in balance scores due to the hydrostatic pressure of water that in turn reduces the static work, thereby counterbalance the gravity and supports the weight for the assumption of correct posture. Similarly, Boer *et al*. [17] found medium effect sizes for the functional ability and dynamic balance and small effect size for static balance. Besides, aquatic therapy was safer than other interventions as a child in water may exert greater freedom of movement that may assist in increasing the body's proprioception and making the movement easier to learn.

Vestibular Stimulation

Carter *et al*. [5] ascertain that vestibular stimulation exercise programs could increase balance and agility in the DS population, possibly increasing their functional ability. Similarly, Kamatchi *et al*. [10] also indicated the higher effectiveness of vestibular stimulation over weight-bearing exercises in improving balance; however, these exercises are more consistent with providing proprioceptive feedback to enhance movement control with respect to speed and timing. Moreover, weight-bearing exercises have been shown to have significant effects on balance and gait in patients with no or moderate cognitive/physical impairment.

Whole Body Vibration

Eid [25] demonstrated the combined effectiveness of whole-body vibration in improving balance and muscle strength of knee flexors and extensors. This speculated that vibration might be one of the strongest methods for stimulating proprioceptors attributed to improving balance. Besides, Villarroya *et al.* [28] indicated that whole-body vibration had positive effects on balance only under specific conditions, with altered visual and somatosensory input.

Miscellaneous Interventions

Several studies advocated different interventions that have resulted in substantially different yet significant outcomes. Park *et al*. [27] indicated that wobble board training enhances the proprioception that leads to the compensation of disturbed vision in DS adolescents. Nejadsahebi [11] revealed that rebound therapy is effective in enhancing static and dynamic balance in DS children. Consequently, the benefits of exercise in this population are more than improving physical health. Furthermore, Gutiérrez-Vilahú *et al*. [24] suggested that dance therapy improved some of the parameters related to visual input in controlling COP as young DS individuals had impaired COP control when eyes open and closed as compared to the normal population. Akyol *et al*. [18] determined the significant effects of gymnastic training with music on dynamic balance and coordination in the DS population. Also, Ahmadi *et al.* [19] described the feasibility of functional training as a safer form of exercise with no reported adverse consequences documented to date. In addition, Eid *et al*. [20] declared isokinetic exercises as an acceptable form of exercise that encourages the DS participants to become more active as individuals who are at high risk of physical inactivity consequences. Didehdar and Kharazinejad [12] indicated profound effects of sensorimotor integration in improving static and dynamic balance in comparison to usual activities. Moreover, sensorimotor integration skills may also provide these children with the necessary time to participate in the favorite games along with their peers. These diverse interventions yield positive effects on the balance; however, due to the heterogeneity of recent trends, the implications are arguable.

LIMITATIONS

The number of studies did not provide an adequate description of the intervention; moreover, in some of the evidence, the control group and severity of the disability were not demarcated. Yet, more male participants were explored than females in a number of trials. Consequently, our study had a small sample size due to the scarcity of literature in the included tenure. Moreover, the small sample size limited the generalizability of results due to heterogeneity of age and intellectual disability. Some interventions had a shorter duration with no follow-up, so the desirable effects were unable to sustain. The diversity of interventions also has some clinical implications due to the higher risk of chronic diseases in the DS population. The underlying mechanism of some is still ambiguous.

Furthermore, certain studies used field tests to evaluate the research variables. Although in some of the interventions, usual activities were not controlled, that may lead to biased outcomes. In addition, outcome assessors were often found to be unblinded to the given intervention.

STRENGTHS

To the best of author's knowledge, no review article documenting emerging trends to improve balance in the DS population has been conducted in the world. The study scrutinized clinical trials that profoundly affect balance, analyzed on the standardized checklists to reduce bias and produce reliable conclusions.

FUTURE RECOMMENDATIONS

Further trials are suggested to be conducted on the aforementioned interventions that encourage and open a wide range of research to establish the most efficient program for the DS population. Therefore, future clinical trials can extend the duration of management with a larger sample size to determine the intervention's long-term sustainability to increase the generalizability of health-related outcomes.

CONCLUSION

It was concluded that all the included trials demonstrated significantly profound effects in improving the static and dynamic balance of Down syndrome patients. Therefore, none of the interventions was declared as superior to another in terms of obtained results. Furthermore, these diverse interventions need to be investigated more for better understating and generalizability of outcomes. In addition, age and disability spectrum along with underdiagnosed co-occurring conditions should be considered for the management of the Down syndrome population in future studies.

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CONFLICT OF INTEREST

The authors reported no disclosure or competing interests.

FUNDING

Not applicable.

ABBREVIATIONS

DS = Down syndrome

COP = Center of Pressure

TRX = Total Resistance Exercise

VR = Virtual Reality

ND = Not Mentioned

IG = Intervention Group

CG = Control Group

n = Number

IG_1 = Intervention Group 1

IG_2 = Intervention Group 2

G_1 = Group 1

G_2 = Group 2

CG_1 = Control Group 1

CG_2 = Control Group 2

SBE = Swiss ball exercise

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