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The effectiveness of dance movement therapy for individuals with Down syndrome: a pilot randomised controlled trial

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Abstract

Background Individuals with Down syndrome (DS) exhibit deficits in static and dynamic balance abilities and maladaptive functions. This study aimed to determine the effectiveness of dance movement therapy (DMT) group intervention in individuals with DS.
Methods The 31 participating individuals with DS, aged 5–29 years, were randomly divided into intervention (n = 16) and control (n = 15) groups. Posturography was used for static balance measurement, timed up and go test for dynamic balance measurement and the Achenbach System of Empirically Based Assessment (ASEBA) questionnaire for adaptive function and behavioural problem measurement in participants before and after the DMT interventions. The intervention group underwent 60-min DMT intervention once a week for 10 times, while the control group had usual daily activities.
Results The results revealed a statistically significant difference and large effect sizes in dynamic balance [(f(1, 29) = 4.52, P = 0.04, $\eta_p{}^2$ = 0.14)] in the intervention group compared with the control group. There were no statistically significant differences in static balance and ASEBA scores between the groups.
Conclusions This study found that the DMT interventions helped to improve the dynamic balance in individuals with DS.

Keywords dance movement therapy, Down syndrome, posturography, stratified randomised control trial, timed up and go test

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Background

Down syndrome (DS) is caused by trisomy of chromosome 21, and the deterioration of intelligence quotient (IQ) is severe to moderate (Glasson *et al*. 2002; Roizen & Patterson 2003).

Individuals with DS have deficits in intellectual function, gross (Malak *et al*. 2015) and fine (Spanò *et al*. 1999) motor function, motor coordination (Edgin *et al*. 2010), sensory integration (Uyanik *et al*. 2003), and both dynamic and static balance capabilities (Rigoldi *et al*. 2011; Jankowicz-Szymanska *et al*. 2012; Villarroya *et al*. 2012; Aranha *et al*. 2016). In particular, they have a lower static balance capacity than those with typical development (Pitetti *et al*. 2013; Ghaeeni *et al*. 2015; Gutiérrez-Vilahú *et al*. 2016). Aly & Abonour (2016) and Pau *et al.* (2012) reported that static balance ability is extremely important for maintaining balance in individuals with DS to prevent falls and injuries.

Moreover, individuals with DS have comorbid characteristics. The comorbid characteristics of individuals with DS, including maladaptive behavioural problems, have been reported to be attention deficit (Myers & Pueschel 1991; Dykens *et al.* 2002; Roizen & Patterson 2003), aggression (Myers & Pueschel 1991; Roizen & Patterson 2003), withdrawal tendency (Dykens *et al.* 2002), stubbornness (Myers & Pueschel 1991), oppositional nature (Myers & Pueschel 1991; Dykens *et al.* 2002) and anxiety (Myers & Pueschel 1991; Dykens *et al.* 2002).

According to the American Dance Therapy Association (2020), dance movement therapy (DMT) is defined as 'the psychotherapeutic use of movement to promote emotional, social, cognitive and physical integration of the individual'. Dance movement therapists focus on helping clients with developmental disabilities, including intellectual disabilities (IDs), and improving motor skills, body image, communication, confidence, social behaviours and behavioural problems (Levy 2005). For these clients, repeated activities are valuable as DMT (Levy 2005).

DMT does not require any language, and repeated interventions involving imitation, music and nonverbal physical communication are expected to foster adaptability to the situation and contribute to the reduction of maladaptive behaviours. In particular, it is expected to effectively reduce maladaptive behaviours in children and adults with DS because individuals with DS have a high level of interest in music and greater emotional and movement responses to music (Stratford & Ching 1989; Virji-Babul *et al.* 2013).

Few DMT studies have focused on individuals with DS; however, a previous before–after trial on DMT for individuals aged 5–18 years showed that DMT had a positive impact on body composition, cardiorespiratory fitness, lower extremity isometric muscle strength, and static and dynamic balance (Parab *et al.* 2019). In a previous study (Parab *et al.* 2019), the four-square step test, which is a dynamic balance test, was used to assess individuals' ability to step over obstacles with forward, backward and lateral movements (Dite & Temple 2002; Dawson *et al.* 2018). The Pediatric Balance Scale, which is a modification of Berg Balance Scale for functional balance in school-age children, has also been used (Franjoine *et al.* 2003). The results of both balance tests have indicated improvement after DMT interventions.

Our previous study on the effectiveness of DMT on 21 children with ID, aged 3–6 years, showed that static balance measured through the one-leg stand test increased significantly after 10 DMT group sessions (Takahashi *et al.* 2022). However, because the measurement lacks objectivity, the findings need to be confirmed through objective measurement methods. Moreover, we also believe that DMT is effective not only for young children with IDs but also for young children to middle-aged adults with IDs.

In the present study, we investigated the effectiveness of DMT on the static and dynamic balancing abilities of individuals with DS using a stratified randomised controlled trial (RCT) design to reduce the factors and equalise the baseline characteristics of the intervention and control groups. Moreover, this study investigated the effectiveness of DMT on the adaptive function and behavioural problems of individuals with DS. We referred to the CONSORT 2010 statement for the study design (Schulz *et al.* 2010).

Methods

Participants

The participants were recruited by the parents' associations of DS in Japan. The inclusion criteria in this study were individuals with DS aged 3–30 years who were able to stand and walk by themselves. Individuals diagnosed with epilepsy symptoms and serious hearing or visual problems or individuals restricted from participating in physical activities by a doctor were excluded.

The number of recruited participants was based on the sample size of a previous controlled clinical trial on DMT for individuals with ID. That study included 20 participants each in the intervention and control groups (Barnet-Lopez *et al.* 2016). Thirty-two individuals with DS were registered in this study, and one individual with DS who had epilepsy symptoms was excluded. Finally, 31 individuals with DS aged 5–29 years were included in the study.

This study was approved by the Kyoto University Graduate School and Faculty of Medicine Ethics Committee (C-1359-5). The participants and their guardians were provided detailed information about the research and their right to withdraw from the study at any time during the study. The participants or the guardian provided written informed consent.

Measurements

The participants and their guardians were enquired about fundamental information, including growth history and present height and weight.

Intelligence quotient

Wechsler intelligence scales were used to measure the participants' IQ. There are three types of Wechsler intelligence scales depending on age: Wechsler Preschool and Primary Scale of Intelligence (WPPSI) for preschool and early elementary-aged children, Wechsler Intelligence Scale (WISC) for children between the ages of 6 and 16 years and Wechsler Adult Intelligence Scale (WAIS) for adults. In this study, the Japanese versions of the WPPSI-III, WISC-IV and WAIS-III were used, depending on the participants' age (Japanese WAIS-III Publication Committee 2006; Japanese WISC-IV Publication Committee 2010; Japanese WPPSI-III Publication Committee 2017).

Four participants were administered with the WPPSI-III, 17 participants with the WISC-IV and 8 participants with the WAIS-III by the primary researcher. One participant in each of the intervention and control groups wished to discontinue the IQ measurement during the baseline measurements and did not complete.

Static balance – posturography

Posturography was performed with the participant standing on a force plate for static balance measurements. This study referred to the previous studies on posturography for individuals with DS. In addition, a previous study on individuals with typical development and those with impaired balance ability was referred to (Mochizuki & Mineshima 2000). The participants were instructed to stand upright barefoot (Villarroya *et al.* 2012; Wang *et al.* 2012; Chen *et al.* 2015), with their arms on their sides (Cimolin *et al.* 2011; Villarroya *et al.* 2012; Wang *et al.* 2012; Chen *et al.* 2015), with eyes open (EO) and closed (EC) for 30 s (Villarroya *et al.* 2012), and to look at the visual target that was set up at 1.5 m from them at the eye level (Cimolin *et al.* 2011; Rigoldi *et al.* 2011; Villarroya *et al.* 2012). The feet were 10 cm apart (Mochizuki & Mineshima 2000), and an eye mask was used to cover the eyes during the EC trials (Matsuzaki 1986). The measurement was performed thrice for both EO and EC conditions (Wang *et al.* 2012) with a 1-min short break between each examination (Villarroya *et al.* 2012; Kachouri *et al.* 2016). The data were recorded at 200 Hz, and the shortest total length was used as the best result for analysis (Kachouri *et al.* 2016).

The force plate provided a description of body sway in terms of displacement of the participants' centre of pressure (COP). The total sway and root mean square (RMS) were measured.

The total length represents the total length of sway traversed by the COP (Lemay *et al.* 2014), which is the point of the vertical ground reaction force (Winter 1995). Anteroposterior (AP) sway and mediolateral (ML) sway were measured in the RMS. RMS in AP sway and ML sway represents the average body sway and the standard deviation of COP replacements based on the average location (Rocchi *et al.* 2002; Bigelow 2008; Memari *et al.* 2013, 2014). The positions of the RMS in the AP and ML directions are calculated using the following equations (Memari *et al.* 2013, 2014):

$$\text{RMS AP} = \sqrt{\frac{\Sigma_{n=1}^{N}(X_n - X_{\text{mean}})^2}{N}}$$

$$\text{RMS ML} = \sqrt{\frac{\Sigma_{n=1}^{N}(Y_n - Y_{\text{mean}})^2}{N}}$$

The measurements were performed by licensed occupational therapists and research collaborators.

Dynamic balance – timed up and go test

The timed up and go (TUG) test is widely used to measure an individual's lower extremity function, mobility and fall risk (Podsiadlo & Richardson 1991;

Dawson *et al.* 2018). In this study, we considered TUG test suitable for dynamic balance measurement to assess lower extremity function and mobility.

According to previous studies, TUG test was used with the aim of dynamic balance measurement, including four different locomotor tasks: (1) standing up from a chair, (2) walking 3 m forward, (3) changing direction by 180° and walking 3 m forward and (4) sitting back in the chair (Shumway-Cook *et al.* 2000; Marchese *et al.* 2004; Nakatani *et al.* 2008). Participants were required to begin in a seated position with their knees and hips at a 90° angle and the feet completely on the floor. Their backs were required to be placed against the backrest with both their hands on their laps (Podsiadlo & Richardson 1991). The participants were instructed to stand up and walk as fast as possible after the signal of 'Hai'. The measurement was performed using a manual stopwatch and started when the participants got up and ended when they sat back in the chair (Habib & Westcott 1998; Williams *et al.* 2005; Nicolini-Panisson & Donadio 2013). The participants had three trials after the explanation and demonstration, and the fastest record was used (Villamonte *et al.* 2010). The measurements were performed for all 31 participants by licensed occupational therapists and research collaborators.

Questionnaire – Achenbach System of Empirically Based Assessment: Adult Behavior Checklist, Child Behavior Checklist and Teacher Report Form

The Achenbach System of Empirically Based Assessment (ASEBA) provides an evidence-based assessment of participants' adaptive function and behavioural, emotional and social problems (Achenbach 2015). The applicable age ranges from 1 year and 6 months to 59 years (Achenbach 2015).

The following three types of forms are included in ASEBA: (1) Adult Behavior Checklist (ABCL) for adults and the elderly, which is filled out by the parent of the participant (Funabiki & Murai 2015); (2) the Child Behavior Checklist (CBCL) for young children and school-age children, which is filled out by the parents of the participants (Achenbach & Ruffle 2000; Itani *et al.* 2001; Funabiki 2017; Funabiki & Murai 2017b); and (3) the Teacher Report Form (TRF) for young children and school-age children, which is filled out by the teacher of the schools attended by the participants (Achenbach & Ruffle 2000; Achenbach 2015; Funabiki & Murai 2017a).

ASEBA is composed of a total score and internalising and externalising problems. In internalising problems, anxious/depressed, somatic complaints and withdrawals were included. Among externalising problems, attention problems and aggressive behaviours are included. The total score is the integration of all the scores.

The ASEBA consists of a total of 100 to 126 questions and is scored 0 = not true, 1 = somewhat or sometimes true and 2 = very true or often true.

The results of the questionnaires are expressed as *T*-scores. There are three ranges in the *T*-score: 64 points or less, the normal range; 65–69 points, the border range; and 70 points or higher, the clinical range. In this study, the total score, internalising problems and externalising problems were used as the results.

The ABCL and CBCL were distributed to parents directly from the primary researcher, and TRF was distributed to teachers through the participants or their parents and collected by the primary researcher by mail from the teachers. Questionnaires that were not completed in either the pretest or posttest were excluded from the final data.

Randomisation

After the pretest for collecting the baseline measurements, the individuals with DS were randomly divided into two groups. A stratified RCT method was used to increase the reliability and validity of this study. According to previous studies (Pau *et al.* 2012; Aly & Abonour 2016), static balance ability is extremely important for maintaining balance in individuals with DS to prevent falls and injuries. Because vision, vestibular and somatosensory systems are important for balance control (Shumway-Cook & Horak 1986), and static balance abilities can influence the results of this study, we used the total length, RMS of ML sway and RMS of AP sway in the EO condition for randomisation.

IQ was used as a factor influencing the study results in grouping in the static balance measurement of a previous study (Kachouri *et al.* 2016); therefore, IQ was also used in the present study. Moreover, because a previous study showed sex-related differences in the ability to hold the standing posture (Silva *et al.* 2017), randomisation was performed based on participants' sex.

The participants' names were anonymised to prevent their identification. All participants were paired according to static balance abilities, IQ and sex and then indiscriminately assigned to either the intervention or control group. Random assignment was performed by the primary researcher (Fig. 1).

Group

This study was conducted as a single-blind and stratified RCT comparing intervention and control groups before and after 10 DMT interventions. Participants in both groups were blinded to the investigators. In the previous studies, only the effects of DMT before and after intervention were investigated based on previous studies (Barnet-Lopez *et al.* 2016; Parab *et al.* 2019), and therefore, follow-up was not performed.

The intervention group underwent 10 sessions of 60-min DMT group interventions, and the control group was instructed to maintain their usual daily activities. The intervention group was divided into four small groups of three to five participants according to their age and schedule before the intervention began. The participants were divided into either under 12 years old (elementary school students) or over 13 years old (middle school students). Two participants participated in a group other than the two age groups because of the convenience of their parents. When the participants were absent from a session, they were allowed to join the session in another group or a make-up session as a follow-up session.

Intervention

Based on previous studies using standard DMT interventional techniques for individuals with ID (Barnet-López *et al.* 2015; Barnet-Lopez *et al.* 2016), the group intervention was originally planned as the

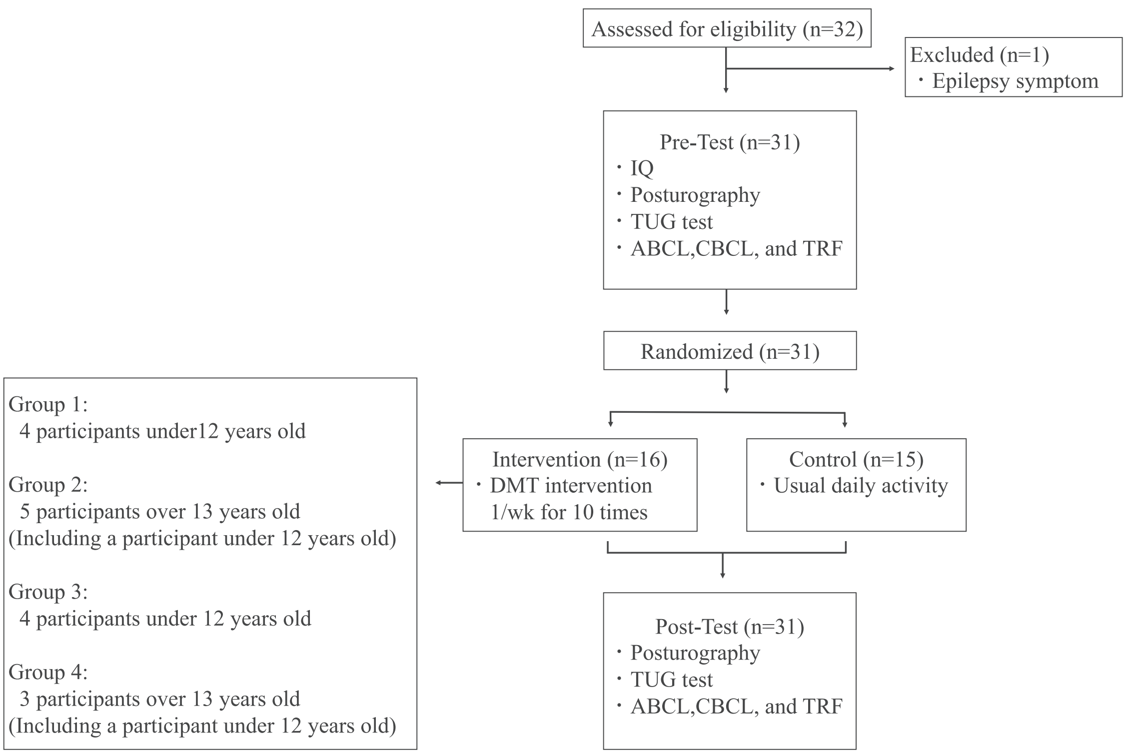

Figure 1. Flow diagram. ABCL, Adult Behavior Checklist; CBCL, Child Behavior Checklist; DMT, dance movement therapy; TRF, Teacher Report Form; TUG test, timed up and go test.

3-month programme period with 60-min twice-a-week 26 sessions. However, most parents of the participants expressed their inability to bring the participants to the sessions twice a week for 26 sessions.

Hens & Dunphy (2020) reported that an approximately 10-week DMT intervention with one session a week can be effective for individuals with ID; therefore, we assumed that a 10-week DMT intervention could be effective in the present study as well. Ten DMT sessions were carried out for approximately 3 months in the form of a 60-min once-a-week session.

The DMT group interventions were provided by a certified registered dance movement therapist of the American Dance Therapy Association and Japanese Dance Therapy Association as the group leader and a certified occupational therapist as a co-group leader who explained and understood the purpose and content of the intervention. Only the participants with DS participated in the DMT group interventions, and their parents and siblings waited in the waiting room during the interventions.

Each of the DMT group session was similarly composed and comprised four sections: warm-up, main activity I, main activity II and cool-down (Barnet-López *et al.* 2015; Barnet-Lopez *et al.* 2016).

At the beginning of the warm-up (approximately 10 min), the participants were asked to sit on a chair in a circle. Each participant had the secure therapeutic space to express their stillness and gentle one's own inner movements (Levy 2005; Pallaro 2007; Chaiklin & Wengrower 2009) with the music they requested. The therapist respected their authentic movements to express their inner feelings (Levy 2005; Chaiklin & Wengrower 2009).

During the warm-up, they were also encouraged to sit on the balance disc to play around the balance with music while mirroring the therapist's movements (Levy 2005) and through improvisational movements (Chaiklin & Wengrower 2009). In main activity I (approximately 20 min), the participants were encouraged to stand up to create imagery movements (Levy 2005) dynamically with props, including repetition of some created dance steps by participants and hopping on a balance ball with the therapist with the music requested by them playing in the background. The therapist and participants also performed synchronised movements. During main activity II (approximately 20 min), the participants were encouraged to freely dance and create movements using the 'Efforts' of Laban movement analysis (Levy 2005; Chaiklin & Wengrower 2009) with the purpose of enhancing control of upper and lower limb movements. In particular, we thought that 'Efforts' could improve the quality of the participants' movement because continued movement while changing the quality of the movement, such as speed, requires specific motor control. Synchronised movements and mirroring were continued while they created movements on a circuit. During cool-down (approximately 10 min), using the same music each week, after slowly swaying their bodies in a circle or dancing gently in a sitting position in a circle, each participant was encouraged to share their movement experiences or feelings of the session. At the end of the activity, the therapist wished each participant goodbye using their name (Barnet-López *et al.* 2015; Barnet-Lopez *et al.* 2016) (Fig. 2).

Data analysis

Statistical analyses were performed using IBM SPSS version 26. The baseline data of the intervention and control groups were compared using the independent *t*-test (Imai *et al.* 2014). To analyse the differences in outcomes between the groups before and after the intervention, two-way repeated measures of analysis of variance were applied using time as a repeated measure factor and intervention as a between-groups factor (Orcy *et al.* 2012). If the interaction effects were significant, a simple main effects test was performed as a *post hoc* test (Murayama *et al.* 2015). Effect sizes were calculated to clarify not only the effect of the intervention but also the size of the effect using partial eta squared (η_p^2) (Cohen 1988). The effect sizes were classified into the following three categories: small (0.01), moderate (0.06) and large (0.14) (Cohen 1988). Statistical significance was set at $P < 0.05$. The P value is expressed up to two decimal places and rounded to the nearest whole number.

Results

All the participants completed the DMT group interventions, and there were no dropouts in this study.

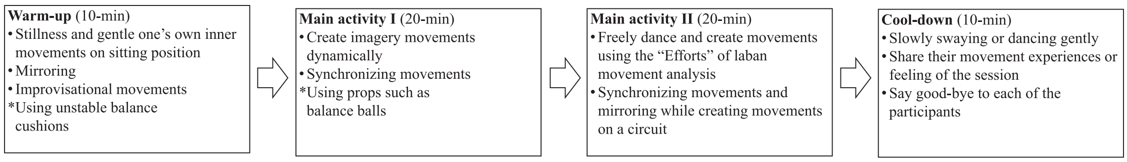

Figure 2. The flow diagram of dance movement therapy (DMT) sessions and the elements of activities in the DMT intervention. Music was played at the request of the participants in the sessions.

Randomisation

The average of the total scores in the two groups was equal, and there was no statistically significant difference between the two groups. In fact, the two groups were considered equal. One person in each of the intervention and control groups wished to discontinue the IQ measurement. Thus, finally, no significant difference between the intervention (n = 15, mean IQ 42.67 ± 2.87) and control groups (n = 14, mean IQ 42.71 ± 2.52) was observed (P = 0.96). Moreover, static balance measurement could not be performed for one participant in the intervention group because of the inability to stand for 30 s during measurement (Table 1).

Posturography

There were no statistically significant differences and no large effect sizes in all measurements between EO and EC (Table 2).

Dynamic balance – timed up and go test

The results showed a significant interaction in dynamic balance measurements and showed large effect sizes [(f(1, 29) = 4.52, P = 0.04, η_p^2 = 0.14)]. As a result of the *post hoc* test, there was a statistically significant difference between the posttest and the pretest in the intervention group (P = 0.00) (Table 3).

Questionnaire – Achenbach System of Empirically Based Assessment: Adult Behavior Checklist, Child Behavior Checklist and Teacher Report Form

Adult Behavior Checklist and Child Behavior Checklist

The Japanese version of the ABCL was administered to 7 participants aged 18 years, the Japanese version of the CBCL to 21 participants aged 6–18 years and the CBCL 1.5–5 to 3 participants under 6 years.

There was no statistically significant difference and no large effect sizes in all categories between the groups, and the mean of all scores was within the normal range at the pretest and posttest (Table 4).

Table 1 Demographic data

	Intervention (n = 16)	**Control (n = 15)**	***P* value**
Sex (male/female)	10:6	8:7	0.62
Age	12.94 ± 6.55	13.00 ± 6.38	0.98
Height (cm)	128.00 ± 18.39	130.31 ± 16.97	0.72
Weight (kg)	31.99 ± 13.86	35.33 ± 14.54	0.52
	Intervention (n = 15)	**Control (n = 15)**	***P* value**
Static balance eyes open (posturography)			
Total length (cm)	988.28 ± 417.71	949.01 ± 451.72	0.81
RMS ML (cm^2)	0.80 ± 0.37	0.56 ± 0.22	0.05
RMS AP (cm^2)	0.80 ± 0.49	0.70 ± 0.99	0.73

$^*P < 0.05$.

RMS AP, root mean square anteroposterior; RMS ML, root mean square mediolateral.

Table 2 The result of total length, RMS ML and RMS AP with EO and EC

		Pretest		Posttest		Interaction		Effect size
		Mean value ± SD	Range	Mean value ± SD	Range	*f* value	*P* value	η_p^2
EO								
Total length (cm)	Intervention (*n* = 15)	988.28 ± 417.71	(548.65–1877.64)	1023.83 ± 415.93	(602.89–1920.10)	0.51	0.48	0.02
Control (*n* = 15)	949.01 ± 451.72	(465.22–1916.39)	959.16 ± 399.99	(459.90–1809.24)				
RMS ML (cm^2)	Intervention (*n* = 15)	0.80 ± 0.37	(0.40–1.61)	0.72 ± 0.32	(0.36–1.57)	1.28	0.27	0.04
Control (*n* = 15)	0.56 ± 0.22	(0.25–1.07)	0.60 ± 0.22	(0.28–1.03)				
RMS AP (cm^2)	Intervention (*n* = 15)	0.80 ± 0.49	(0.27–1.90)	0.81 ± 0.62	(0.24–2.30)	0.31	0.58	0.01
Control (*n* = 15)	0.70 ± 0.99	(0.17–4.19)	0.56 ± 0.31	(0.19–1.28)				
EC								
Total length (cm)	Intervention (*n* = 14)	1029.49 ± 454.59	(543.49–1983.86)	1049.64 ± 419.00	(605.32–1933.70)	0.02	0.90	0.00
Control (*n* = 14)	946.35 ± 478.68	(468.01–1991.43)	970.63 ± 451.84	(456.96–1922.32)				
RMS ML (cm^2)	Intervention (*n* = 14)	1.26 ± 1.65	(0.34–6.72)	0.63 ± 0.24	(0.39–1.08)	2.59	0.12	0.09
Control (*n* = 14)	0.63 ± 0.26	(0.23–1.11)	0.68 ± 0.24	(0.36–1.09)				
RMS AP (cm^2)	Intervention (*n* = 14)	0.84 ± 0.75	(0.28–2.94)	0.62 ± 0.44	(0.21–1.74)	0.00	0.98	0.00
Control (*n* = 14)	0.83 ± 0.84	(0.22–3.39)	0.61 ± 0.32	(0.15–1.12)				

The interaction is time and intervention factors. η_p^2 was used to present the effect sizes as small (0.01), moderate (0.06) and large (0.14).

$^*P < 0.05$.

EC, eyes closed; EO, eyes open; RMS AP, root mean square anteroposterior; RMS ML, root mean square mediolateral; SD, standard deviation.

Table 3 The result of TUG test

	Pretest		Posttest		Interaction		Effect size	Simple main effects
	Mean value ± SD	Range	Mean value ± SD	Range	*f* value	*P* value	η_p^2	*P* value
Intervention (*n* = 16)	8.29 ± 2.30	(5.49–13.94)	6.87 ± 1.69	(4.85–10.49)	4.53	0.04*	0.14	0.00*
Control (*n* = 15)	7.40 ± 2.69	(5.86–16.82)	7.51 ± 1.54	(5.24–10.86)				0.85

The interaction is time and intervention factors. η_p^2 was used to present the effect sizes as small (0.01), moderate (0.06) and large (0.14).
*$P < 0.05$.
SD, standard deviation; TUG test, timed up and go.

Table 4 The result of ABCL and CBCL

		Pretest		Posttest		Interaction		Effect size
		Mean value ± SD	Range	Mean value ± SD	Range	*f* value	*P* value	η_p^2
Total score	Intervention (*n* = 16)	56.50 ± 6.53	(44.00–69.00)	55.06 ± 8.60	(44.00–70.00)	0.20	0.66	0.01
	Control (*n* = 14)	54.21 ± 6.17	(41.00–63.00)	51.64 ± 6.11	(43.00–61.00)			
Internalising problems	Intervention (*n* = 16)	53.25 ± 10.59	(33.00–70.00)	53.31 ± 11.51	(33.00–79.00)	0.69	0.41	0.02
	Control (*n* = 14)	47.86 ± 5.52	(39.00–57.00)	45.64 ± 5.40	(34.00–54.00)			
Externalising problems	Intervention (*n* = 16)	53.94 ± 7.88	(34.00–64.00)	50.63 ± 9.42	(33.00–68.00)	0.05	0.82	0.00
	Control (*n* = 14)	52.57 ± 6.11	(40.00–60.00)	49.86 ± 5.17	(44.00–58.00)			

The interaction is time and intervention factors. η_p^2 was used to present the effect sizes as small (0.01), moderate (0.06) and large (0.14).
*$P < 0.05$.
ABCL, Adult Behavior Checklist; CBCL, Child Behavior Checklist; SD, standard deviation.

Table 5 The result of TRF

		Pretest		Posttest		Interaction		Effect size
		Mean value ± SD	Range	Mean value ± SD	Range	f value	P value	η_p^2
Total score	Intervention (n = 8)	59.63 ± 9.05	(49.00–73.00)	58.25 ± 6.02	(50.00–67.00)	2.17	0.17	0.17
	Control (n = 5)	54.20 ± 12.46	(39.00–69.00)	57.60 ± 8.33	(49.00–67.00)			
Internalising problems	Intervention (n = 8)	52.38 ± 9.77	(38.00–66.00)	52.25 ± 7.67	(39.00–65.00)	0.74	0.41	0.06
	Control (n = 5)	49.60 ± 11.80	(38.00–65.00)	53.40 ± 5.64	(48.00–62.00)			
Externalising problems	Intervention (n = 8)	60.63 ± 6.76	(54.00–71.00)	58.13 ± 5.72	(48.00–65.00)	4.19	0.07	0.28
	Control (n = 5)	53.20 ± 11.52	(41.00–65.00)	58.00 ± 7.71	(48.00–68.00)			

The interaction is time and intervention factors. η_p^2 was used to present the effect sizes as small (0.01), moderate (0.06) and large (0.14).

*$P < 0.05$.

SD, standard deviation; TRF, Teacher Report Form.

Teacher Report Form

The Japanese version of the TRF was administered to 12 participants aged 6–18 years and the Caregiver-TRF to 1 participant under 6 years.

There was no statistically significant difference between the groups in all categories, but there were large effect sizes in total scores and externalising problems. The mean of all scores was within the normal range in the pretest and posttest (Table 5).

Discussion

In this study, DMT interventions using an RCT design were conducted in individuals with DS. The 31 individuals with DS participated in 10 DMT group interventions where they were assessed using posturography for static balance, TUG test for dynamic balance and ASEBA questionnaire for adaptive function and behavioural problems. The results showed that there was a statistically significant difference and large effect sizes in dynamic balance in the intervention group and no statistically significant difference in static balance and ASEBA. But there were large effect sizes in total scores and externalising problems in TRF.

Dynamic balance

In a previous study on the differences in biomechanical strategies between individuals with typical development and those with DS during the sit-to-stand, walk-out, turn-around, walk-in and stand-to-sit phases of the TUG test, individuals with DS took longer to complete the entire test than those with typical development (Beerse *et al.* 2019). However, through the DMT interventions, the participants could increase their dynamic balance for the following reasons.

First, walking is a repetitive forward motion of the right and left legs alternately, which involves shifting the body's centre of gravity and the movement of various body parts (Shumway-Cook & Woollacott 1995; Kikuchi 2013).

Walking by individuals with DS is characterised by narrow walking and a slower walking speed than that of individuals with typical development (Kanbayashi & Ikeda 1988; Kikuchi 2013). It has been reported that the arm movements of individuals with DS are reduced (Kikuchi 2013), and their walking is characterised by outward movement of the legs with flexion of the knee joint (Kikuchi 2013).

In this study, during intervention, the participants repeatedly performed the same created dance steps by participants or foot movements with the therapist as synchronised movements and mirroring while dancing or moving to music. This may have helped improve walking rotation speed during activities (Hackney & Earhart 2010). Moreover, the activities may have helped to extend their knee joint when they stepped out and to increase the stride length. According to Pereira *et al.* (2019), dance steps help motor gait adjustment to improve the walking speed.

Improving walking rotation speed and stride length and extending the knee joint are considered to contribute to walk-out and walk-in during the TUG test; as a result, dynamic balance improved.

Static balance

The reason for not improving static balance may be that the intervention did not provide sufficient physical load for the participants in this study.

In the intervention in this study, the participants chose music that was played while the activities were carried out. Music has the characteristic of inducing movements as a groove (Repp & Su 2013). Music provides spontaneous movements and changes the quality of movements through rhythm and tempo (Repp & Su 2013). In the intervention, most of the music the participants chose were fast tempo and rhythm songs, which easily provided dynamic movements. The characteristic that induces the movement to music may have been effective in maintaining body posture during the dynamic movements of the participants in the study. However, the characteristics that induce movement during music may not be effective during static activities. For instance, using the created imagery movements, the participants were encouraged to hold a posture similar to that of an animal for a couple of seconds; however, instead of continuing to hold their posture, they started moving with the music immediately after assuming the posture. As a result, the activities involving maintenance of the centre of gravity at the base of the support continuously for a certain duration could not be completed.

In the future studies, it will be necessary to consider what kinds of DMT activities can contribute to the improvement of static balance.

Questionnaire – Achenbach System of Empirically Based Assessment: Adult Behavior Checklist, Child Behavior Checklist and Teacher Report Form

Even though previous studies reported that individuals with DS have maladaptive behavioural problems, such as attention deficit (Myers & Pueschel 1991; Dykens *et al.* 2002; Roizen & Patterson 2003), aggression (Myers & Pueschel 1991; Roizen & Patterson 2003); withdrawal (Dykens *et al.* 2002) and oppositional nature (Myers & Pueschel 1991; Dykens *et al.* 2002), the results of ABCL, CBCL and TRF were within the normal range for all categories at the pretest in this study. The results of the questionnaire did not show any statistical difference between the groups in the posttest as well.

Although a small sample performed TRF, its substantial effect was considered large. However, the change in scores did not exceed either border or clinical range. Because no such effect size was observed for CBCL, whether these changes in effect size are due to the DMT interventions needs to be examined in the future.

Limitation

The first limitation of this study was the wide age range of participants. The age range was 5–29 years, and the stage of development was different for each participant. Consequently, the height and weight of the younger participants may have changed with physiological growth during the study period. A previous study reported that the height of individuals with DS was closely related to age and stride length (Kanai *et al.* 2015). It has also been reported that with increasing age, height increases, which further increases stride length and affects walking (Kanai *et al.* 2015). Future studies should investigate the effects of DMT in a specific age group of individuals with DS, and the changes in height and weight during the study period should be monitored.

The second limitation was that because of severe ID, it may have been difficult for participants to understand the method of measurements or to maintain attention during the measurements. Therefore, the number of participants in each measurement was different, and some participants required the measurement methods to be explained and demonstrated more than once, including the practice of measurements. Moreover, for these reasons, it was difficult to perform all the default measurements, and the measurement results were assumed to be the best values.

Third, based on a previous study with approximately 20 participants in the intervention and control groups (Barnet-Lopez *et al.* 2016), we aimed to include 20 participants in each group; however, only 15 participants were finally included in each group in the present study.

For future studies, it is important to validate the present findings on DMT effects through studies with a larger sample size and adequate follow-up, which could help more clearly demonstrate the therapeutic effect of DMT in individuals with DS.

Conclusions

Individuals with DS have weakness in static and dynamic balance and maladaptive functions. This study aimed to assess the effectiveness of 10 DMT group interventions for 31 individuals with DS aged 5–29 years by measuring posturography for static balance measurement, TUG test for dynamic balance measurement and ASEBA questionnaire for adaptive function and behavioural problem measurement.

This study is significant because it is the first to assess the efficacy of DMT on specific outcomes according to the characteristics of individuals with DS. The present findings indicate that DMT is a potential new treatment modality that can help improve the dynamic balance in individuals with DS aged 5–29 years.

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Conflict of interest

The authors declare that there is no conflict of interest.

Data availability statement

The data generated or analysed during this study are included in this published article (and its supporting information files).

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