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Prenatal dance activity enhances foetal and postnatal cognitive and motor development

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ABSTRACT

Introduction: No research has examined the impact of any physical-artistic-cognitive activity on foetal neurodevelopment. The aim of the study was to investigate the efficacy of a unique prenatal dance activity in pre- and postnatal cognitive and motor development as a complementary health care practice. *Methods:* 26 clinically uncomplicated primiparas and multiparas with singleton pregnancies and their later born children were examined in this prospective study at the University of Pécs, Hungary. The activity group participated in supervised, 60-min, twice-weekly, moderate-intensity prenatal dance classes for 19.56 ± 3.97 weeks, whereas the control group did not. We determined the developmental ages of their children with the Bayley Scales of Infant and Toddler Development in both groups at 5 weeks of age and in the activity group at 33 months of age. *Results:* Prenatal dance activity did not cause any adverse outcomes. Infants in the activity group had significantly higher mean developmental ages than the control group regarding cognitive skills ($P < 0.001$), receptive ($P < 0.001$) and expressive communication ($P = 0.007$), fine ($P < 0.001$) and gross motor ($P = 0.001$). As toddlers their mean developmental ages were significantly higher than their mean calendar age regarding cognitive skills ($P = 0.001$), receptive ($P = 0.001$) and expressive communication ($P = 0.001$),

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fine ($P = 0.002$) and gross motor ($P = 0.001$). *Conclusions:* Our results confirm the safe implementation of this prenatal dance activity and the more advanced cognitive and motor development of children in the activity group as infants compared to the control group and as toddlers compared to the norm. These results offer a novel approach to dance in pre- and postnatal clinical practice.

KEYWORDS

pregnancy, dancing, foetus, cognitive, motor, development

INTRODUCTION

Dancing is not one of the prenatal lifestyle pieces of advice usually recommended to enhance intrauterine brain development, although it may have the potential to provide an excellent basis for cognitive and motor development already in the uterus and to support it even after birth. Although studies have shown positive foetal effects of separate physical, musical, and cognitive activities during pregnancy, no research has examined the impact of prenatal dance on foetal neurodevelopment. In our study we aim to demonstrate that dance deserves more attention as a possible complementary therapy in prenatal care and may provide the basis for postnatal development, as it offers all benefits of the combination of physical exercise, cognitive and musical activity.

In utero conditions bear crucial implications for long-term health status [1], therefore serious attention needs to be paid to maternal and environmental influences during pregnancy. Neurodevelopment is exposed to these factors from the third week of gestation [2]. In the complex process of intrauterine brain development characterized by high plasticity, in addition to internal effects, external ones such as environmental stimuli affecting the human foetus may also cause alterations in either a positive or a negative way [3–5].

Researchers have confirmed the beneficial impact of prenatal physical activity (PA) on foetal health, brain development, and later cognitive performance [6–10]. One physiological reason for the positive influence may be an increase in blood volume and placental function, suggesting the greater transport of oxygen and nutriments to the brains of physically active participants' foetuses [11].

Nevertheless, PA levels are still low worldwide. Although this is a leading risk factor for non-communicable diseases and can have a negative effect on mental health and quality of life [12, 13] most people still lead sedentary lifestyles during pregnancy [14]. National guidelines have been prepared to define the intensity, regularity, and duration, as well as the recommended and contraindicated forms of prenatal exercises [15–17] to encourage those who are expecting to choose from a range of safe, appropriate, and well-tolerated activities.

We propose dance to be investigated separately, since in addition to physical, it also bears cognitive, social, emotional, and artistic qualities. Dance is a complex sequence of steps and movements of a person, a couple, or a group that harmonizes different parts of the body in a structured, choreographed, or improvised manner, with or without sound, mostly rhythmically [18].

In recent years, the number of investigations examining the health-preserving and healing effects of dance and its application for various clinical groups has also been increasing [19–27], but its applicability in several areas, such as prenatal care, is still under-researched, especially for foetal outcomes.

From a foetal neurological perspective, the clinical rationale for prenatal dance activity (PDA) may be multifactorial and exert extra external stimuli on the foetus. In addition to physical effects, they are exposed to more music - which may contribute to healthy [28] or better [29] neurodevelopment -, they may feel the rhythmic, synchronized movements performed to it, and may benefit from their mother's cognitive activities - which may affect foetal blood flow [30] - and positive maternal feelings.

To the best of our knowledge, ours is the first scientific research to examine the safety of dance during pregnancy and its effects on foetal and postnatal cognitive and motor development.

The objectives of our study were to investigate the safety and to assess the efficacy of a moderate-intensity prenatal dance method in foetal and postnatal development. Our hypothesis was that the activity has no negative effect on gestational, birth, or neonatal outcomes. We also hypothesized that children of dancing participants would perform better in developmental tests as infants compared to the control group and as toddlers compared to the norm, assuming also the long-term effects of PDA.

MATERIALS AND METHODS

Study design

The research was designed to assess the potential influence of a special, newly developed, regularly performed PDA on foetal and postnatal cognitive and motor development without causing any adverse gestational, foetal, birth, or neonatal outcomes. We used the STROBE statement to write our research article.

Setting

We conducted our research at the Department of Obstetrics and Gynaecology, Clinical Centre, University of Pécs, Hungary.

Participants

We recruited clinically uncomplicated primiparas and multiparas for our research. We defined the following inclusion criteria: age over 18 years, singleton pregnancy, 16th to 30th week of gestation, no mental disorders, no contraindication to PA. Exclusion criteria were non-compliance with the above conditions, lack of written informed consent, non-regular participation in the activity, engaging in any sports, occurrence of any foetal or maternal disorders before or during the research, or moving out of town, while in the case of children, preterm birth and any known abnormalities.

Volunteers were allocated into an activity (AG) and control group (CG) using convenience sampling. All AG subjects needed to undertake regular attendance at the sessions until the 36th week of pregnancy. All participants had received verbal and written information about the purpose and procedures of the study before any data collection or the activity was initiated. Members of the AG consulted their physicians about the activity and provided written informed consent along with CG members. Gestational age was determined based on menstrual history and ultrasound examination.

Variables

The primary outcome of the study was the safe implementation of the intervention during pregnancy without any adverse effects. The secondary outcome was the efficacy of the intervention. AG participants were exposed to a 20-week-long dance activity, CG were not. Any other physical and artistic activity or heterogenous groups could have been potential confounders or effect modifiers regarding the outcomes.

Ethical statement

The research was approved by the University of Pécs Clinical Centre Regional Committee for the Research Ethics, Hungary (April 21, 2017), No: PTE/6618. Data were treated anonymously. During the research, any identifying information was removed from the medical records and each participant was given a unique code. This was also linked to the appropriate infant and toddler tests. The study met institutional, national, and international guidelines for protection of human subjects concerning their safety and privacy. The research study was performed in accordance with the principles stated in the Declaration of Helsinki.

Procedures

The AG regularly attended a supervised group dance course, with the mean attendance of 19.56 ± 3.97 weeks, at the earliest from the 16th week of gestation. Members of the CG did not take part in the activities. We measured foetal heart rate (FHR) and umbilical artery impedance indices – resistive index (RI) and pulsatility index (PI) – before and during the sessions of the AG once a week and tested the infants' developmental progress at 5 weeks of age in both groups and at 33 months of age in the AG.

The PDA examined in this study was developed for this research by the lead author of this article who is a trained dance educator. The sessions were held by two dance teachers and supervised by four obstetrician gynaecologists. It is a unique dance method that combines various dance styles specifically selected for this population, including a wide range of movements, musical styles, and rhythms, as well as improvisation. It was a 60-min, twice-weekly, moderate-intensity dance activity, requiring a moderate amount of effort and noticeably accelerating the heart rate, without causing rapid breathing, as defined by the WHO [31]. We monitored the participants' heart rate and applied the talk test (the ability to converse with some slight effort during the exercises). Each session began with resting heart rate and blood pressure measurements for the participants. The active part of the lessons consisted of warm-ups with sitting and standing exercises, stretching, learning and performing steps and choreographies of the dance styles. Participants were encouraged to apply the learned movements on their own and improvise. Cool-down terminated the classes with a low-intensity free dance when we asked participants to imagine themselves as if they were dancing with their babies in their arms. Once a week, the classes were held at the clinic and once in the university dance studio.

Data sources

During the first meeting, participants completed a sociodemographic questionnaire. Information on childbirth and the neonatal data were collected from medical reports during the postpartum visit. To analyse infant and toddler cognitive and motor development, we used the

Bayley Scales of Infant and Toddler Development (Bayley-III). It is an individually administered instrument assessing developmental functioning from the age of one month. It evaluates cognitive, communication (receptive and expressive), and motor (fine and gross) skills.

The lead author conducted the testing with the involvement of the parents and the assessment with a psychologist. First the calendar age of infants was determined in days, no adjustment to prematurity was needed. In the follow-up research age was given in months. Scales consisted of tasks that children had to perform in different positionings during testing, with or without the involvement of certain objects. We calculated total raw scores for the scales from which we determined scaled and composite scores and then computed developmental age.

Throughout the research all mandatory laboratory health and safety procedures were complied with in the course of conducting the activity by performing ultrasound examinations and cardiac monitoring, and controlling the intensity and proper execution of movements, hydration, convenient room temperature, and clothing. No adverse event occurred throughout the research.

Bias

We paid close attention to address potential sources of bias. Medical records and tests were assessed by the lead author, four obstetrician gynaecologists, and a psychologist.

Study size

We determined sample size from similar previous research on prenatal PA and interventional studies. Due to the nature and length of the activity, the use of a larger sample was neither our goal nor feasible. Prenatal physical activity is low worldwide, therefore activating pregnant volunteers is a great challenge. At the supervised activity we examined due attention had to be paid to all participants, therefore the number had to be limited. It also required several months of regular participation, which could not be accepted by everyone. It was followed by an infant testing five weeks after birth and a toddler testing at almost 3 years of age, which also narrowed the number of participants, especially in a city with less than 150,000 residents. We targeted 25 participants and were satisfied to experience a larger number.

Statistical methods

We applied the IBM SPSS Statistics 25.0 and 27.0 for Mac (SPSS Inc., Chicago, IL, USA). Based on the results of the normality tests (Kolmogorov-Smirnov tests), we conducted a Mann-Whitney U-test, paired t tests and non-parametric tests (Wilcoxon) to detect statistical differences. In our study, quantitative variables are described with mean ± standard deviation (SD). Qualitative variables are presented with the number (n) and percentage (%) of participants. Statistical significance was accepted at $P < 0.050$.

RESULTS

Recruitment for the research lasted from 21 August, 2017 to 31 August, 2019. The 35 volunteers were allocated into an AG ($n = 20$) and a CG ($n = 15$). Four of them were excluded from the AG and five from the CG based on the exclusion criteria, as shown in Fig. 1. Therefore, the final

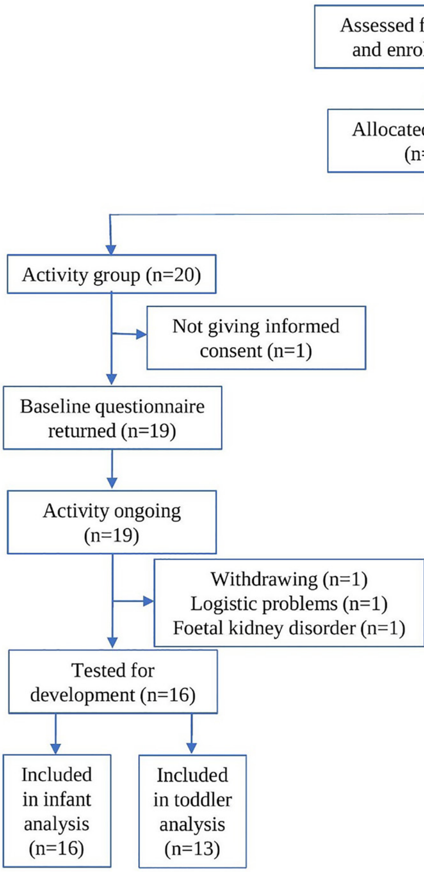

Fig. 1. Research profile–The diagram shows the research with detailed information on the excluded participants

sample consisted of 26 participants: 16 in the AG and 10 in the CG, all of whom took part in the infant testing, whereas 13 AG members participated in the toddler testing. The first meeting took place on 4 October, 2017 and the activity lasted from 11 October, 2017 to 28 June, 2019. Infant testing was conducted from 14 March, 2018 to 13 January, 2020, and toddler testing took place from 15 January to 15 March, 2021.

Table 1 presents sociodemographic and anthropometric measures of the participants in which the two populations appeared homogeneous. The only statistically significant difference was detected in the 36th week BMI of the groups. No significant difference was found in gestational, birth, or neonatal measures between the AG and CG, as shown in Table 2.

As a primary outcome, we demonstrated the safety of the activity. Our own measurements during the sessions and medical reports on birth and neonatal variables did not show any maternal, foetal, or neonatal disorders among the participants in the AG. Our measurements

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Table 1. Baseline characteristics of the intention-to-treat population: sociodemographic and anthropometric measures

	Activity group (n = 16)	Control group (n = 10)	P value
Age (years)	30.38 (6.46)	31.50 (5.42)	0.596 NS
Marital status			0.937 NS
- Living in a relationship	3 (18.75%)	2 (20%)	
- Married	13 (81.25%)	8 (80%)	
Type of residence			0.508 NS
- City	14 (87.50%)	10 (100%)	
- Municipality	1 (6.25%)	0 (0%)	
- Village	1 (6.25%)	0 (0%)	
Education			0.576 NS
- Vocational high school	1 (6.25%)	0 (0%)	
- High school	3 (18.75%)	1 (10%)	
- University	12 (75.00%)	9 (90%)	
Being employed	16 (100%)	10 (100%)	
Having prepared for pregnancy			0.846 NS
- No	2 (12.50%)	1 (10%)	
- Yes	14 (87.50%)	9 (90%)	
Number of children			0.636 NS
- 0	11 (68.75%)	8 (80%)	
- 1	3 (18.75%)	0 (0%)	
- 2	1 (6.25%)	2 (20%)	
- 3	1 (6.25%)	0 (0%)	
Family income (HUF)			0.056 NS
Below 100,000	1 (6.25%)	0 (0%)	
100,000–250,000	3 (18.75%)	0 (0%)	
250,000–400,000	9 (56.25%)	4 (40%)	
400,000–550,000	1 (6.25%)	5 (50%)	
550,000–700,000	0 (0%)	1 (10%)	
Over 700,000	2 (12.50%)	0 (0%)	
No smoking or alcohol consumption	16 (100%)	10 (100%)	
Living in a healthy environment			0.420 NS
- No	1 (6.25%)	0 (0%)	
- Yes	15 (93.75%)	10 (100%)	
Vitamin-rich, balanced diet			0.342 NS
- Always	4 (25.00%)	4 (40%)	
- Regularly	10 (62.50%)	5 (50%)	
- Often	0 (0%)	1 (10%)	
- Sometimes	2 (12.50%)	0 (0%)	
BMI (kg/m^2)			
- Initial	23.81 (4.12)	21.38 (2.11)	0.126 NS
- 36th week	28.94 (4.13)	26.07 (2.53)	0.045 *
Gestational weight gain (kg)	14.25 (3.30)	13.90 (2.88)	0.615 NS

Data are n (%) or mean (±SD). HUF = Hungarian currency. BMI = body mass index.
Notes: NS = not statistically significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Table 2. Baseline characteristics of the intention-to-treat population: gestational, birth, and neonatal measures

	Activity group (n = 16)	Control group (n = 10)	P value
Preeclampsia			1.000 NS
- No	16 (100%)	10 (100%)	
- Yes	0 (0%)	0 (0%)	
Placental insufficiency			0.254 NS
- No	14 (87.50%)	10 (100%)	
- Yes	2 (12.50%)	0 (0%)	
Length of pregnancy (weeks)	39.50 (0.97)	39.40 (1.17)	0.779 NS
Weakening of foetal heart sound			0.773 NS
- No	12 (75%)	8 (80%)	
- Yes	4 (25%)	2 (20%)	
Oxygen deficiency			0.429 NS
- No	15 (93.75%)	10 (100%)	
- Yes	1 (6.25%)	0 (0%)	
Complications during labour or childbirth			0.492 NS
- No	9 (56.3%)	7 (70%)	
- Yes	7 (43.8%)	3 (30%)	
Weakening of contractions			0.849 NS
- No	14 (87.50%)	9 (90%)	
- Yes	2 (12.50%)	1 (10%)	
Prolonged labour			0.555 NS
- No	13 (81.25%)	9 (90%)	
- Yes	3 (18.25%)	1 (10%)	
Surgical delivery			0.325 NS
- No	8 (50%)	3 (30%)	
- Yes	8 (50%)	7 (70%)	
New-born's birth weight (g)	3,419.38 (348.38)	3,494.00 (512.12)	0.792 NS
New-born's birth length (cm)	50.56 (1.86)	50.50 (2.72)	0.667 NS
Head circumference (cm)	36.58 (1.45)	37.45 (1.80)	0.294 NS
Chest circumference (cm)	37.50 (0.71)	37.00 (1.73)	0.157 NS
Apgar scores			
- 1 min	8.94 (0.25)	8.80 (0.42)	0.295 NS
- 5 min	9.94 (0.25)	9.90 (0.32)	0.732 NS
Days spent in hospital after birth	3.88 (1.78)	3.90 (0.57)	0.237 NS
Calendar age of infants at testing (days)	39.40 (1.51)	37.88 (2.78)	0.182 NS

Data are n (%) or mean (±SD).
Notes: NS = not statistically significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

show that FHR, RI, and PI increased during activity (Table 3). A significant difference was observed between mean FHR values at rest and during activity. The differences between the impedance indices were not significant.

As a secondary outcome, examining the efficacy of the activity, we detected a significant difference between the AG and CG infants in the cognitive, receptive and expressive communication, fine and gross motor subtests of the Bayley-III. Children in the AG performed better

Table 3. Foetal mean resting and in-activity measures before and during the sessions of the activity

	Resting measures (n = 16)	In-activity measures (n = 16)	P value
Impedance indices			
- resistive index	0.66 (0.06)	0.67 (0.06)	0.534 NS
- pulsatility index	1.05 (0.17)	1.06 (0.18)	0.776 NS
Foetal heart rate (beats per minute)	141.14 (6.32)	146.13 (6.14)	0.010 *

Data are mean (±SD).
Notes: NS = not statistically significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

than those in the CG on all scales. The developmental ages were 2.5–1.6 times and 1.1–0.7 times their calendar ages, respectively. The mean calendar age of the infants was 37.88 ± 2.78 days in the AG and 39.40 ± 1.51 in the CG at the time of testing. We determined mean developmental ages in days based on scaled and composite scores (Fig. 2).

In the follow-up research Bayley-III was applied in the AG when the children's mean calendar age was 33.46 ± 2.03 months. Mean developmental ages were significantly higher than their calendar age on all subscales. Children in all areas of development were 9 to 7 months before their age, as shown in Fig. 3.

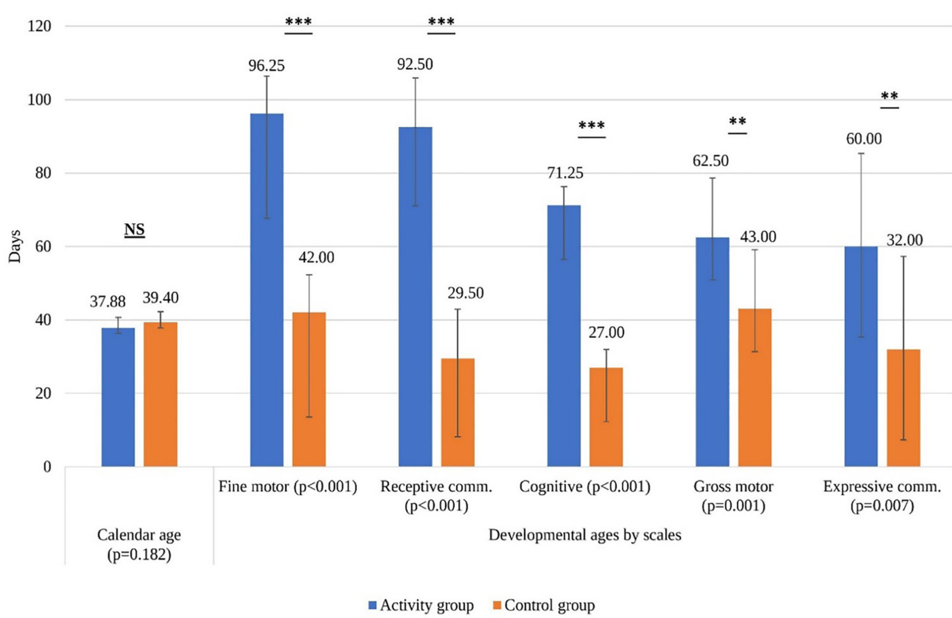

Fig. 2. Mean Bayley-III infant test results representing developmental ages by scales compared with calendar age in the activity (n = 16) and the control (n = 10) groups
Notes: NS = not statistically significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

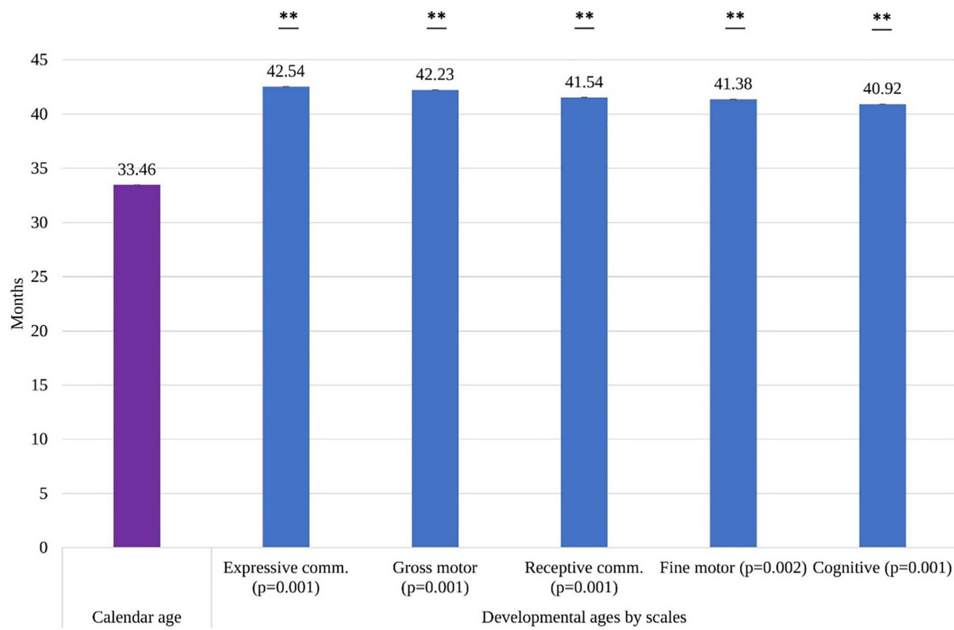

Fig. 3. Mean Bayley-III toddler test results representing developmental ages by scales compared with calendar age in the activity ($n = 13$) group. NS = not statistically significant, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

DISCUSSION

Our measurements and medical records showed that the supervised, regular, moderate-intensity dance activity was safe and well-tolerated in pregnancy and did not cause adverse gestational, foetal, birth, or neonatal outcomes.

We observed the growth in RI and PI and the significant increase in FHR values in a safe interval during activity, suggesting enhanced but not abnormal foetal movement and circulation. This finding supports the assumption that foetuses become more active due to the PDA.

We found that AG infants performed significantly better than CG infants on all examined scales of the Bayley-III. As toddlers mean developmental ages of the AG children were also significantly higher than their mean calendar age on all subtests. These findings suggest a more advanced cognitive and motor development in the AG children and a long-term impact of prenatal dance. Therefore, results lend credence to all our hypotheses.

The safe applicability of this PDA lies in the thorough and careful design of the method, the application of guidelines for prenatal PA, strict surveillance, and measurements. In terms of foetal development, complex effects may be assumed. We found that as participants became more active both physically and cognitively during the sessions, the foetal measures also reflected the same. Therefore, circulation and umbilical cord flow improved, contributing to an increase in the supply of nutrients and oxygen to the foetal brain. Their parent's dance involved their auditory, somatosensory, and vestibular systems simultaneously, since participants not only performed movements or listened to music separately but combined the two in synchrony, using varying rhythms, rocking, gliding, swaying, reversing, and turning steps while enjoying themselves. This may have caused the foetal brain to coordinate the impulses of the environment and the body, although we did not have the possibility to quantitatively measure these factors.

None of the participants engaged in any sporting activities during pregnancy, and we found no significant difference in their lifestyle, dietary, or socioeconomic factors. Parental, birth, and neonatal homogenous baseline characteristics of the two groups suggest that the children developed under similar conditions in the uterus, except for PDA as an environmental difference. Therefore, we assume that the differences can be interpreted specifically as a consequence of the dance activity.

As prenatal dance is an under-researched part of the scientific field, we could only compare our findings with partially overlapping studies. Examining dance as a PA, our findings are consistent with results of research that have discovered the safe applicability of sports and various moderate physical exercises during pregnancy [15, 32–35]. Systematic reviews on the impact of PA on foetal brain development are rare. Those investigating this found that expectant maternal exercise altered the offspring's brain and behaviour and that PA habits appear to have beneficial influences on pre- and postnatal brain development [6–10, 36].

Our study bears several strengths. First, we examined an area that has not yet been researched. The activity applied is a unique, novel, and innovative initiative. Second, the activity was not self-monitored but supervised, ensuring regularity, the same intensity and duration, standardized measures, and identical content for each AG member. Expert supervision was also essential for proper execution of movements, hydration, appropriate clothing, venue, and group dynamics. Third, there were no statistically significant differences between the two populations in terms of sociodemographic and anthropometric measures, birth and neonatal data, and difference was found only in the 36th week BMI values. Fourth, we analysed medical reports, resting and in-activity ultrasound measurements, and validated tests to detect safety, as well as infant and toddler development. Fifth, almost 3 years after birth, we conducted a follow-up research to investigate the long-term effects of the activity. Sixth, the same person led the testing with all participants to ensure standardization of the experimental protocol.

We acknowledge that our study bears some limitations. First, we could not carry out our research involving a physical activity control group. Therefore, we can conclude only that dancing is similarly beneficial to other types of physical activities. Although music, rhythm, and emotions experienced during dancing may offer additional benefits, this has not been proven. Second, we could not follow the CG and compared the results of toddlers of the AG to the general population of their age. Third, the number of participants was low. However, the remarkable effect of the dancing activity demonstrated by the significant difference in developmental ages between AG and CG infants, and between AG toddlers and general population may offer new, potentially useful information in this under-researched field.

Future investigations are necessary to strengthen and expand upon evidence-based research on the connection between PDA and foetal-postnatal cognitive and motor development. In addition to questionnaires and developmental scales, the use of safe neuroimaging technology to examine the brains of foetuses, infants, and toddlers may yield more impressive results. Increasing the number of participants volunteering for a randomized controlled trial would be useful in prospective studies. Assessing possible differences in the impact of dance and sports or dance and music during pregnancy on pre- and postnatal cognitive and motor development may also offer research potential.

Our findings suggest that PDA has a significant influence on the developing foetal brain and long-term effects on cognitive and motor development in infants and toddlers. Interpreting the results and benefits without any harms can help make prenatal dance a safe and joyful, novel, forward-looking, and innovative initiative. By encouraging childbearing parents to take part in such a joyous activity as dancing, a new mode of prenatal intervention could be introduced in clinical practice to increase the number of physically active expectant people for the benefit of their children's development. Our findings may also support future studies to concentrate on prenatal dance, while also identifying the mechanisms behind its effects.

Our mission is to inform parents about our achievements and encourage them to choose this activity as they can have a significant impact on the quality of future life of their children already in the uterus.

Author contributions: Beatrix Bánkyné Perjés: Conceptualization, Methodology, Investigation, Resources, Writing – original draft, Project administration. Gábor Mátrai, Bernadett Nagy: Investigation, Data curation. Daniella Erdei: Data curation. Alexandra Makai: Formal analysis. Viktória Prémusz: Writing – reviewing and editing. Kálmán András Kovács: Validation. József Bódis: Validation, Supervision.

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LIST OF ABBREVIATIONS

AG	Activity Group
Bayley-III	Bayley Scales of Infant and Toddler Development
BMI	Body Mass Index
CG	Control Group
FHR	Foetal Heart Rate
PA	Physical Activity
PDA	Prenatal Dance Activity
PI	Pulsatility Index
RI	Resistive Index

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