Effectiveness of a movement and music programme on activity, sedentary, and sleep behaviours and motor and musical skills in young children: protocol for the MoviMusi cluster randomised controlled trial

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Abstract

The early childhood education and care (ECEC) environment is an important setting for providing children with daily opportunities for movement and music, supporting holistic child development in the early years. To date, there are no studies evaluating the implementation of a holistic programme in the ECEC context in the areas of movement behaviour and motor and musical skills. The main aim is to examine the effectiveness of a holistic movement and music programme on physical activity (PA), sedentary behaviour and sleep, motor skills and musical skills in young children (1–3 years). The secondary aims are to examine the impact of the movement and music programme on the perceptions of the educational community, as well as the barriers and facilitators they perceive in the process of baseline assessment, construction, and implementation of the movement and music programme in their own ECEC community. This cluster-randomised controlled trial (intervention and control groups) with public ECEC centres will be performed over a 24-month period. Baseline measurements will be taken in the first year of the project, and assessments to examine the effectiveness of the programme will take place 12 months after the baseline assessment. For young children the main outcome variables will be: (a) PA, sedentary time, and sleep time; (b) gross and fine motor skills; and (c) musical skills. The secondary outcomes will be: (a) PA and sedentary time during outdoor play and structured PA sessions; (b) play patterns during outdoor free play; and (c) movement and music behaviours after ECEC hours. For families, secondary outcomes will be: (a) perceived barriers and facilitators to PA in young children; (b) perceived barriers and facilitators to the inclusion of music at home; and (c) the means of transport to ECEC settings and barriers to active commuting. For ECEC educators, the secondary will be: (a) perceived barriers and facilitators for the inclusion of movement and music as curricular practices in the ECEC

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institution; (b) perceived impact of the implementation of the movement and music programme. This research project aims to fill a knowledge gap during a period of childhood that has rarely been explored, either nationally or internationally (1–3 years), and to position movement and music teaching practices as key contexts in the curriculum development of infant and toddler education.

Keywords Movement, Early childhood, Musical skills, Gross and fine motor skills

Introduction
Background
The early childhood education and care (ECEC) environment is an important setting for providing children with daily opportunities for movement and music, supporting holistic child development in the early years [27, 32, 58]. Toddler education requires specific training and sensitivity [38] that enable educators to differentiate between structured physical activity (PA) and free play opportunities as well as between the different sources of knowledge, barriers, and facilitators associated with them [38]. In the area of music education, some authors have found that following a musical play-focused professional development program, teachers learned how to scaffold and facilitate musical play, which improved their teacher efficacy and their overall music education offerings [19]. However, others authors have found that including music in the ECEC context is hindered by possibly insufficient and/or inappropriate initial and in-service training, as well as uncertainty and lack of confidence in implementing music activities [32]. Thus, the ECEC community needs further training and support in implementing both movement and music education in everyday practice [7].

Literature reinforces the importance of studying the combinations of PA, sedentary behaviours and sleep for health indicators [34]. Regarding PA in toddlers, international PA guidelines recommend 180 min/day of total PA [64]. Other institutions suggest that toddlers should have 30 min of structured PA, in addition to 60 min of unstructured PA per day [50]. Regarding sedentary behaviour guidelines, children 1–2 years of age should not be restrained for more than 1 h at a time and for 1-year-olds, sedentary screen time (such as watching TV or videos, playing computer games) is not recommended. For those aged 2 years, sedentary screen time should be no more than 1 h. Regarding sleep guidelines, young children should have 11–14 h of good quality sleep. Despite the fact some research has been done in this topic, yet very little is known about adherence to the 24-h movement behaviour guidelines in toddler populations. For instance, in two Canadian studies, adherence to general sleep and PA guidelines was high, but the majority of toddlers (2 years) were not meeting screen time guidelines [36, 39]. In the Australian context, Santos et al. [48] found that under 9% of the Australian toddler sample

met the overall Australian 24 h Movement Guidelines for the Early Years. The authors found that 96.5%, 79.7% and only 11.4% of the sample met the physical activity, sleep and sedentary behavior guidelines, respectively, suggesting that strategies to promote adherence to the 24-h movement guidelines in toddlers, particularly for screen time, are necessary [48]. By contrast, recently in Singapore, adherence to sleep time was around 82%, while low proportion of toddlers meeting the screen guidelines (38.8%) but only half of the sample met PA guidelines (50.1%) [46]. However, there is some evidence on barriers to and facilitators of PA in young children [24, 35, 56], as well that the need to raise awareness of activity, sedentary and sleep guidelines among parents of young children, suggesting that it is important to clarify early childhood educators' and parents perception of their role in movement behaviour concepts in early childhood [1, 4, 13]. Taking into account that adherence to these recommendations supports cognitive and motor development in toddlers [64], understanding the correlates of PA, sedentary behaviour and sleep will help researchers and practitioners on how to intervene to promote a healthy lifestyle from the early years.

In recent years some studies have examined the determinants of PA, sedentary and sleep behaviours in the early years [5, 47]. Others studies have analyzed the impact of the childcare environment on young children's PA levels and patterns [31, 65], in specific contexts such as free outdoor play [2, 23, 45], as well as the impact of active modes of transport on PA [37]. Research show that toddlers' sex (female versus male) was significantly positively associated with sedentary behaviour [16], despite the fact recent systematic reviews have been unable to identify any consistent correlates of sedentary time in young children [6, 44]. In a recent study few young children adhered to the sedentary behaviour and tummy time guidelines, whereas the majority meet sleep guidelines [30]. Recently, Zhang et al. [66] found that shorter nap duration and higher nighttime sleep ratio were associated with better cognitive development [66]. The literature shows that young children's levels of gross motor skills (GMS) are positively associated with cognitive development [62], but the prevalence of below-average motor skills in young children is higher than reported in normative samples [59]. In addition, studies show that

targeted development programmes can improve GMS in young children [61].

Other studies have examined how music education relates to children's everyday activities and developmental orientations in ECEC [19]. Music and singing are considered an important part of everyday education for young children [32]. When caregivers receive music training, the children in their care seem to increase their visual, vocal and physical engagement behaviours, and music training appears to be effective in improving caregivers' attitudes towards implementing music activities with young children [22]. Additionally, Peñalba et al. [43] analyzed the implementation of a musical workshop (Active Musical Room) in an early childhood education setting [43]. The authors found that involving musical materials and sound-producing objects can enhance the natural inclinations and exploratory drive of toddlers. Also, recently, several studies have shown that music training in kindergartens improves the development of inhibitory control [10, 26, 51]. Taken together, then, music and play may be among the best sources of early interaction, learning, and well-being [32].

The study
ECEC settings are important determinants of children's behaviour. Ecological models help to contextualise and explain how the different environments in which children interact on a daily basis (school, home, and peer relations) have the capacity to influence children's development [11]. To date, there are no studies evaluating the implementation of a holistic programme in the ECEC programme including the areas of physical activity, sedentary behaviour and sleep, as well their relationship with motor and musical skills. A pending line of research is the identification of the key correlates of changes in PA, sedentary behaviour and sleep throughout the early years [15], which would generate knowledge crucial to developing policy interventions that promote general wellbeing in young children. Thus, this study focuses on the importance of home and ECEC settings in the development of movement behaviour through a critical analysis of how curricular practices can be more effective in influencing children's holistic development.

Aims
The main aim is to examine the effectiveness of a holistic movement and music programme on PA, sedentary behaviours and sleep, gross and fine motor skills, and musical skills in young children (1–3 years). The secondary aims are to examine the impact of the movement and music programme on the perceptions of the educational community, as well as the barriers and facilitators they perceive in the process of baseline assessment,

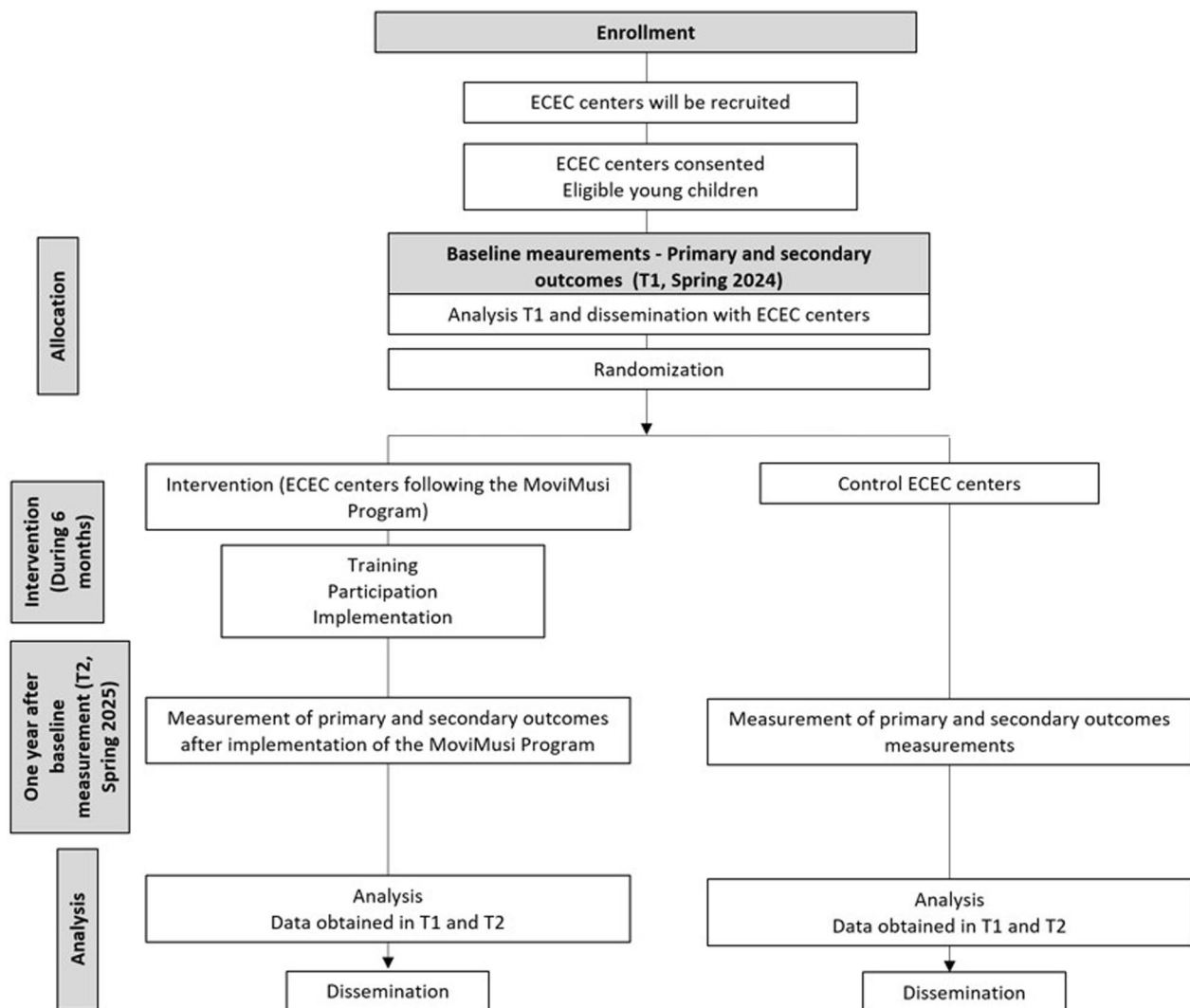construction, and implementation of the movement and music programme in their own ECEC community.

Methods
Design and procedure
This cluster-randomised controlled trial will be performed over a 24-month period (Register: A Movement and Music Programme in Early Childhood Education and Care. The MoviMusi Study Protocol). Trial registration number NCT06381687 (Date registered: April 23, 2024). Baseline measurements will be taken in the first year of the project (pre-implementation). At the end of year 1, public ECEC centres will be randomised to an intervention or control group by an independent researcher, using a computer-generated randomisation sequence. At the same time, the correlates of movement behaviour and the assessment of gross and fine motor and musical skills will be shared with the ECEC community). From there, and following a participatory approach between researchers and the ECEC community from the intervention group (principals, educators, and families), a holistic movement and music programme will be designed and implemented in the second year of the project. The development of the programme will follow three axes (training, participation, and implementation). The educational community's perceptions about the barriers and facilitators associated with the correlates of movement behaviours (PA, sedentary behaviours and sleep) will be taken into account, as will the results of the assessment of gross and fine motor and musical skills identified in the first year of the project (baseline measurements), with a special focus on the structured and unstructured opportunities for movement and music both in the ECEC settings and at home. During the second year, the holistic programme will be implemented. The development of the programme will follow the three axes outlined above and will be developed over 6 months. The main and secondary outcome variables will be assessed 12 months after the baseline assessments to measure longitudinal effectiveness. In the Fig. 1 it is presented the SPIRIT schedule of enrolment, interventions, and assessments.

Setting and participants
The study will take place in the capital cities of three Spanish regions: Valencia, Murcia, and Toledo, chosen because they reflect the diversity of the Spanish educational system. Official data show a population of around 800,000 people in Valencia, 500,000 in Murcia and 90,000 in Toledo. The inclusion criteria for participating institutions are: public ECEC centres, located in the metropolitan area of any the three study cities, catering to young children at all three levels of the first ECEC cycle (0–1 years, 1–2 years, and 2–3 years), and authorisation

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Fig. 1 SPIRIT schedule of enrolment, interventions, and assessments

to operate by the competent authority. Government records show that there are 40 public ECEC institutions in Valencia, 20 in Murcia, and 12 in Toledo. A letter of invitation will be sent to the Education Council and the ECEC institutions in each city, explaining the main aims of the project.

Sample size

The sample size for participation in the study will be calculated according to the following considerations. The primary outcome will be the mean amount of moderate to vigorous PA (MVPA) measured by accelerometry that children do during the school day in ECEC settings. Taking into account a previous study by our research group, which objectively measured PA using accelerometry [58], it was shown that young children (2–3 years) engage in an average of about 40 min (standard deviation [SD]

15.8) of MVPA during ECEC. Therefore, we expect that the movement and music intervention programme will increase daily MVPA by 8 min. Moreover, we know that the average class size in ECEC settings is 13 young children. Thus, for a significance level of 5%, power of 90%, standard deviation of 7 min, average expected difference of 8 min, cluster size of 13 young children, and an intra-class correlation of 0.35, and using the formula presented by Campbell and Walters [14] for comparing the means of two populations for cluster-randomised trials [14], we obtain a sample size for the three cities of 24 ECEC institutions (12 intervention group and 12 control group). For both groups, 5 ECEC centres will participate in Valencia, 4 in Murcia, and 3 in Toledo. Assuming that there are approximately 13 toddlers in each classroom, a total of 130 toddlers will participate in Valencia, 104 in Murcia, and 78 in Toledo. The inclusion criteria for the toddlers

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are: aged 14 to 22 months, regularly attending the ECEC centre, ability to walk independently, of typical development, and with parents who give their consent. We consider young children to be attending the ECEC centre regularly if they attend the ECEC centre at least 4 days a week and spend at least more than 6 h at the ECEC centre.

Randomization

The allocation of ECECs to the intervention versus control group will be randomised in a blinded procedure at the end of the first year, following the baseline assessment. Once ECEC centres meeting the selection criteria are identified, they will be randomised to one of the trial arms (SPSS version 28.0).

Experimental intervention: characteristics of the movement and music programme

A multi-component, multi-level programme (Movi-Musi) will be designed and implemented in each city by the 12 ECEC centres in the intervention group. After the baseline measurement and during 6 months, the research team and each ECEC centre in the intervention group will design the intervention programme individually. The programme will start 4 months after the baseline measurement. The intervention programme will be implemented for 6 months (with three axes—training, participation and implementation). Accompanied by members of the intervention team, the educational community will be empowered to identify areas for improvement and make the necessary changes in their centres. Following previous research suggesting that horizontal (non-vertical) and dialogic (co-designed) interventions are better for changing school culture in relation to the promotion of PA [21, 33, 63], there will be 12 interventions (one from each ECEC centre) trying to listen to the voices of educators and head teachers in their own unique realities. In addition, the intervention programme will aim to address the main barriers and facilitators identified during the first year (baseline assessment) in relation to movement and music curricular practices. The programme will have three axes:

(1) Training: Educators and families will actively participate in a series of seminars and training workshops on the promotion of PA as a healthy behaviour and the use of music as a didactic resource to strengthen holistic education both inside and outside ECEC. The main results of the baseline assessment of the personal, social and environmental correlates of PA, sedentary behaviour, and sleep will be shared with the educational community. Training activities will be implemented once the information from the diagnostic phase has been collected, i.e. 4 months after the baseline measurements.

(2) Participation: Each ECEC institution (intervention group) will be supported as they design a movement and music programme to offer children better opportunities to learn about the body, its possibilities of action, and musical skills. The training and participation axes will be implemented over a period of 2 months (at the beginning of the second year). The intervention, despite having general guidelines for all ECECs, will be flexible enough to allow each ECEC centre to identify their own needs and consider local sensitivities. We consider that this is the only way to ensure that each ECEC institution is sufficiently involved to benefit from of the project.

(3) Implementation: The specific actions of the Movi-Musi Programme will be put into practice in each ECEC institution. These specific actions will be implemented from the second year onwards and will run until the end of the second year. Finally, at the end of year 2 (12 months after baseline measurements), the effectiveness of the intervention programme on the primary and secondary variables will be evaluated, and the results will be shared with other ECEC institutions and educational authorities so that they inform the development of public policies in curricular design and teacher training.

Each of these axes will be coordinated by a member of the research team, who will be responsible for making the activities of each axis more dynamic, with the support of other members of the team. The primary and secondary outcomes will be assessed 12 months after the baseline assessments.

Control group

In the three cities, 12 ECEC institutions will participate in the control group. The centres will follow their usual curricular programme and will be visited to identify the curricular movement and music practices they are implementing, to assess the quality of the school environment and to measure PA, sedentary behaviour, sleep, and motor and music skills, at baseline and at the end of the study. The primary and secondary outcomes will be assessed 12 months after the baseline assessments.

Outcome measures
Primary outcome measure

The main outcome variables are envisaged: (a) total PA, MVPA, sedentary time, and sleep time; (b) gross and fine motor skills; and (c) musical skills.

Secondary outcome measures

For young children, secondary outcome variables are: (a) PA, MVPA and sedentary time during outdoor play and structured PA sessions; (b) play patterns during outdoor free play; and (c) movement and music behaviours after ECEC hours.

For families, secondary variables are: (a) perceived barriers and facilitators to PA in young children; (b) perceived barriers and facilitators to the inclusion of music at home; and (c) the means of transport to ECEC settings and barriers to active commuting.

For ECEC educators, the secondary variables are: (a) perceived barriers and facilitators for the inclusion of movement and music as curricular practices in the ECEC institution; (b) perceived impact of the implementation of the movement and music programme.

Finally, for the ECEC setting, the secondary variable is the quality index of the ECEC environment.

Instruments

Identification of sociodemographic variables

Families will be asked to complete an ad hoc questionnaire to collect sociodemographic data. The questions will be: Who is going to complete this questionnaire; How old are you? What is your sex? What is your age? What is the sex of your child? What is the age of your child? and What is the highest level of education achieved by the father/mother? The response options were: no studies, primary education, secondary education, bachelor's degree, vocational training and university degree. Parents will complete the questionnaire at each time point during the study (baseline and 12 months after baseline).

Anthropometric measurements

Height and weight will be measured using standardised procedures. Children will be weighed (kg) using a Seca 213 stadiometer (Seca GmBH & Co Kg, Hamburg Germany), without shoes or heavy clothing, and their height (cm) will be measured using a portable calibrated stadiometer (Añó Sayol SL, Barcelona, Spain) without shoes. The BMI z-score will be assessed using World Health Organization (WHO) reference data, and the children will be classified as underweight, normal weight, overweight, or obese, using reference data from Cole et al. [20]. Anthropometric measurements will be taken at each time point throughout the study (baseline and 12 months after baseline).

Measurement of PA and sedentary time

Accelerometry (ActiGraph wGT3X-BT) will be used to objectively assess PA and sedentary time. Children will wear an accelerometer for 1 week (weekend included) during ECEC hours. Toddlers will wear the accelerometer on their right hip from the wake-up time until they go to bed (at night). Parents will be instructed to how place the accelerometer on the children. Accelerometer data will be downloaded and converted to 15-s epoch files using ActiLife software (version 6.4, ActiGraph Inc, Pensacola, FL, USA). PA and sedentary time will be scored using Trost's cutoffs for 2-year-old children: the 15-s count range corresponding to sedentary time was 0–48 counts/15 s; for light (PA), 49–418 counts/15 s; and for MVPA, >418 counts/15 s [55]. Total PA was defined as any activity of light to vigorous intensity (Light PA + MVPA) [9]. PA and sedentary time will be measured at each time point during the study (baseline and 12 months after baseline).

Parents' perceptions of physical activity and sedentary behaviour

Parental perceptions of PA and sedentary behaviour will be collected through a parent proxy report using the Early Years Physical Activity Questionnaire (EY-PAQ) [8].The questionnaire is designed to measure habitual PA and sedentary behaviour after ECEC hours. The EY-PAQ is completed by the participant's parents and consists of questions about the home environment and whether the young children engaged in a particular type of PA and sedentary behaviour. The EY-PAQ has acceptable reliability and validity for measuring habitual PA and sedentary time in young children [8]. According to PA, parents report the average hours and minutes per weekday and weekend that their toddlers spend in active play (walking, running, playing with balls, dancing, etc. For sedentary behaviour, parents report the average number of hours and minutes per weekday and weekend day that their toddler spends watching television, videos, using a computer or portable device, playing sedentary games, reading, drawing and painting (artistic activities), and using passive active transport (car, bus, etc.). According to screen time, WHO regulations for children under 5 years of age [64] suggests no screen time for a 1-year-old and no more than an hour for 2-year-olds, with less time preferred. Scores will be dichotomized to distinguish children who followed recommendations vs. those that did not. Parents will complete the questionnaire at each time point during the study (baseline and 12 months after baseline).

Measurement of sleep time

Sleep behaviour will be measured by a parental report consisting of questions that provide useful information about the child's sleep behaviour using the Spanish adaptation of the Brief Infant Sleep Questionnaire to Spanish (BISQ-E) [17]. The BISQ-E has adequate validity and reliability characteristics for the assessment of sleep in young children. In particular, parents will be asked about the

child's nap(s) and nighttime sleep (duration and/or frequency) [continuous: time, duration (h/min), frequency (times per night)]. During school hours, the child's nap time is recorded by the ECEC teachers. Average hours per day for each sleep duration variable will be calculated across days with usable data. In addition, according to the sleep recommendation within the Australian 24-h Movement Guidelines for toddlers (11–14 h/d), the average total sleep duration will further dichotomized into categories (meeting the sleep recommendation, not meeting the sleep recommendation) [42]. Parents will complete the questionnaire at each time point during the study (baseline and 12 months after baseline).

Definitions of adherence
Adherence to the guidelines [54] will be calculated using the WHO guidelines on PA, sedentary behaviours and sleep for children 5 years of age [64]. As followed for other studies [39], adherence to the PA guidelines will be defined as at least 180 min of TPA each day, to the sedentary guideline as no screen time (1- and 2-year-old children) or ≤60 min per day (2-and 3-year-old children), and to the sleep guideline as receiving 11–14 h (1- and 2-year-old children) every 24 h. However, additional levels of adherence will be also calculated as restricting the use of restraint for no more than an hour at a time (such as in car seats or strollers, 1 and 2 years only) in the sedentary guideline. Adherence will be calculated at each time point throughout the study (baseline and 12 months after baseline).

Gross and fine motor skills evaluation
Participants' motor skills will be assessed using the Peabody Developmental Motor Scales (PDMS), 3rd edition [25]. The PDMS-3 is a standardised tool for assessing both gross and fine motor skills in young children [60, 62]. In addition, the PDMS-3 scale is a valid and reliable instrument for measuring gross and fine motor development in Spanish children aged 6 months to 5 years [3]. This test will be conducted as per PDMS-3 methodology [25], at baseline and 12 months after baseline.

Assessment of musical skills
Musical skills will be assessed using the MUSKITO (Musical Skills for Toddlers) scale. As there are few scales for measuring musical skills in young children, our research team is developing the MUSKITO scale (Bernabé-Villodre et al. in preparation). This process involved three stages, including content development, expert validation and pilot testing. The MUSKITO scale includes items covering different aspects of basic musical skills (listening, singing, instrumental interpretation, improvisation/composition and movement) [40]. The test summed score will be calculated by totalling scores from items 1–5 based on the fundamental musical process. Test-rest reliability will be assessed using the intraclass correlation coefficient (ICC) for the MUSKITO test and retest. Musical skills will be assessed at each time point during the study (baseline and 12 months after baseline).

Observational system for recording physical activity in children
The OSRAC-P is a direct observation system designed to collect information about children's PA and the contextual circumstances surrounding it [12]. The OSRAC-P system incorporates a momentary time sample procedure for collecting observed information. Using this procedure, observers will watch a child for a five second interval and, during the next 25 s, record one code for each variable. Five-second observation intervals are repeated every 25 s across a period to create an individual session for each focal child. We will use a modified version of the OSRAC-P to assess young children's PA and sedentary behaviour during unstructured outdoor play [57]. Previous research has found a positive relationship between mean OSRAC-P PA levels and accelerometry minutes of TPA engagement, suggesting that the OSRAC-P provides a valid estimate of PA levels during unstructured outdoor play [57]. To ensure the reliability of the observations during unstructured outdoor play time, independent coders will carry out an initial reliability test using a video tape of a different group of young children playing outdoors. Coders will be trained in an outdoor ECEC playground, recording intervals during the outdoor time, and the rate of intercoder concordance will bes calculated using Cohen's kappa coefficients for each OSRAC-P category. On the final observation day, upon entering the playground, the observers randomly selected one boy and one girl to be assessed. Observational analysis during unstructured outdoor play is conducted in the same week that the children use the accelerometers.

Assessment of school quality with regard to curricular practices in movement and music
We will apply the Infant/Toddler Environment Rating Scale (ITERS-R) [29], which was designed to evaluate the quality of the ECEC setting for children aged 6 weeks to 30 months. The ITERS-R covers different aspects of quality: physical layout, materials and activities, routines, supervision, interaction, and planning. Research has shown that the ITERS-R has a high average reliability and a high level of internal consistency [29]. School quality will be assessed at each time point throughout the study (baseline and 12 months after baseline).

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Modes of transport to and from ECEC institution

The modes of transport will be extracted from the valid and reliable "mode and frequency of commuting to and from school questionnaire" [18, 49]. In addition, this questionnaire has evaluated the modes of transport used to travel to and from ECEC by Spanish infants and pre-school children [37, 52]. The modes of transport used for commuting to and from school will be evaluated through the following question: 'In an average school week, on how many days does your child use the following modes of transportation to get to and from school? The response options will be: active modes (walking, biking, scooter) and passive modes (stroller, on the back of a parent's bike, public transport, school bus, and car). Parents will complete the questionnaire at each time point during the study (baseline and 12 months after baseline).

Barriers to active commuting

Barriers to active commuting will be assessed using the BATACE scale (*BArreras en el Transporte Activo al Centro Educativo* in Spanish (adapted version), translated as: barriers to active transport to educational centres). The developed scale has acceptable validity and good reliability to assess barriers to active commuting to school among Spanish young people [41]. This scale has been used to study the role of different barriers and neighbourhood characteristics, as perceived by parents, in active commuting to and from from early childhood education and care (ECEC) institutions in toddlers [37, 52]. Consistent with previous research [37, 52], we will calculate the total percentage of 'agree' and 'strongly agree' responses for each barrier to determine which are perceived to be the most important by parents. In addition, the items of each factor will be averaged. Internal reliability will be calculated for environmental/safety barriers and for planning/psychosocial barriers. Parents will complete the questionnaire at each time-point throughout the study (baseline and 12-months after baseline measurements).

Environmental characteristics

At each ECEC institution, the playground area (m^2) will be measured using maps from Google Earth and analysed using Geographic Information System software (ArcGIS 10.2). We will calculate playground density (toddlers/m^2) and total free play space (m^2) as has been calculated in previous studies [28, 53]. In particular, we will record the number of children present. In addition, total free play space will be divided by the number of children to obtain free space per child (m^2). Playground density will be dichotomized by using the 50th percentile for analysis purposes: "low density" ($\geq 8 \text{ m}^2$/child); and "high density"

($< 8 \text{ m}^2$/child). Environmental characteristics will be calculated at each time point throughout the study (baseline and 12 months after baseline).

Focus groups with educators

In each ECEC setting, educators will participate in two focus groups, one at baseline and another following programme implementation (12-months after baseline), to gather their perceptions about the place and purpose of movement and music practices in their classrooms. The following questions will guide the focus group: what opportunities are there during the school day for children to be physically active? What opportunities are there during the school day for children to be musically involved with the educator and with their peers? Which are the main barriers and facilitator educators perceiving regarding the music and movement practices during school hours?

Focus groups with families

In each ECEC setting, families will participate in two focus groups, one at baseline and another following programme implementation (12-months after baseline), to find out how they promote opportunities for movement and music practice, to the presence of music in their daily life and musical motor expectations, as well as their perceptions of barriers and facilitators to movement and music practice outside of school hours. The following questions will guide the focus group: what opportunities are there after ECEC hours for children to be physically active? What opportunities are there after ECEC hours for children to be musically involved in the home settings? Which are the main barriers and facilitator educators perceiving regarding the presence of music and PA practices in the home settings?

Identifying the role of the public administration in promoting movement and musical skills in ECEC

A content analysis of the official curriculum will be performed to analyse the strategies adopted by the authorities to promote movement and musical practices in ECEC. Similarly, at the end of each project year, representatives of the educational authorities will be invited to the meetings disseminating the results, where the outcomes of the different phases of the project will be shared.

Qualitative data analysis

The data from the focus groups will be analysed through a qualitative approach. Data from the audiotapes will be transcribed into a Word document immediately after conducting the focus groups. Two researchers will review all transcripts to search for and identify meaningful

quotes and responses. Each participant will be classified with their corresponding interview. A qualitative analysis of the transcript will be carried out by selecting units of analysis, coding them and then classifying them. Themes will be identified using a deductive coding scheme with pre-categorisation and categorisation of data. Pseudonyms will be used to protect the privacy of the participants.

Ethical considerations

Study approval has obtained by the Ethics Committee of the University of Valencia (UV-2023-3118978), respecting the Declaration of Helsinki. Once the centre's principal has been informed of the study, a meeting will be held with the educators. Parents will sign a written informed consent authorising their participation and that of their children.

Statistical methods

A descriptive analysis of the different study variables (means, standard deviations, percentages, etc.) will be carried out, as well as the associations between the aforementioned variables. A mixed-effects linear regression analysis of the study variables (PA, motor skills, musical skills) at baseline will be performed at the baseline measurements, taking into account the different socio-demographic variables to be analysed (e.g. gender, age, etc.). 12 months after baseline measurements (post programme intervention), a longitudinal mixed-effects model will be used to assess the main treatment effect on change in primary outcomes from baseline to after implementation of the music and movement programme, adjusting for baseline values, age, gender and BMI. Fixed effect predictors will be treatment type (holistic program/control group), and time (pre-/post-intervention). The random effects of cities, groups and participants will be included to estimate random errors arising from differences between treatment and control groups. Contingency tables and chi-square statistics will be used to analyse the direct observation of PA levels. Missing data will be imputed after checking that the missingness mechanism is completely random using multiple equation chain imputation. Finally, data analysis will be carried out by a different researcher from the one involved in data extraction. The data will be blinded for statistical analysis.

Discussion

Identification of critical points and contingency plan

The following potential challenges have been identified, and strategies to avert or overcome them devised. (a) The implementation of research and innovation programmes in cooperation with ECEC institutions must respect the internal culture of the centres. The research team will proactively inform the ECEC institutions that the intention of the project is not to impose specific curricular activities, but rather to support directors and educators in making their own decisions and adapting their educational activities and strategies. (b) The lack of commitment from families to complete the information requested in the questionnaires may be a challenge, highlighting the fact that the research project is the result of a collaboration between the ECEC sector and the university. (c) The loss of information collected through accelerometry may be a conditioning factor, as absences are quite common in the ECEC setting. Nevertheless, educators will be informed about the possibility to continue the measurements on later days, if planning allows it. (d) Although the research team members have close contacts with the public administration offices in each of the participating cities, the dynamics of communication with these authorities may have a different pace compared to the communication between university actors. (e) Implementing this project in three different capitals may be difficult. However, one member of the project team will be responsible for each city and will be accountable for performing the various measurements and activities of the project.

Dissemination

The dissemination of the project results will take place at three levels. The first level will take place at each ECEC institution, sharing both the outcomes of the baseline assessment and those of the evaluation of the implementation of the movement and music programme. At the second level, a joint social event will be organised to disseminate the results of the baseline assessment for the three cities. This event will be open to the public and free of charge. Similarly, when the schools have started to adopt the intervention programmes, the main characteristics of these programmes will be shared. At the third level, following the assessment at the end of the programme implementation, the impact of the programmes will be disseminated through a conference open to the public. Finally, the research team, in collaboration with the ECEC institutions, will prepare a set of guidelines for good practice to promote opportunities for movement and music, which can serve as an example for other ECEC institutions and for the development, implementation, and evaluation of population-level policies in ECEC settings.

Conclusion

Recognising that the early years of life are critical for motor, cognitive, and emotional development, this research project aims to fill a knowledge gap during a

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period of childhood that has rarely been explored, either nationally or internationally (1–3 years), and to position movement and music teaching practices as key contexts in the curriculum development of infant and toddler education. Carson et al. [15] suggested that a highly desirable line of future research would include the measurement of how interventions change the composition of physical activity, sedentary and sleep behaviours, as well as the development and evaluation of movement behaviour interventions with children aged < 3 years (i.e. infants and toddlers). Therefore, carrying out a baseline assessment; designing a holistic movement and music programme intervention through participatory means; and subsequently evaluating its impact on PA, sedentary behaviour and sleep, motor and music skills can generate knowledge to guide better curriculum practice and policy both nationally and internationally.

Author contributions
Conceptualization, V.E.M.-B., M.d.M.B.-V.; investigation in Valencia will be performed by H.V.-P., Y.C.G.-O., N.F.; and A.M.-R.; investigation in Murcia J.C.M-R., M.A.F-V., and J.M.A.-D.; investigation in Toledo J.D.-B., and F.G.; statistical analysis will be performed by D.A.M.-B., writing—review and editing, all the authors. All authors have read and agreed to the published version of the manuscript.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Regarding the ethical implication, the study will be conducted according to the guidelines of the Declaration of Helsinki and it has been approved by the Ethics Committee of University of Valencia (Ethical approval code- UV-INV_ETICA-2023-3118978). Furthermore, informed consent will be obtained from all participants involved in the study.

Informed consent
Informed consent will be obtained from all participants involved in the study.

Competing interests
The authors declare no competing interests.

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